ASSESSMENT ON HEAVY GOODS VEHICLE CONSPICUITY BASED ON THE ROAD TRANSPORT ACT 1987

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SCHOOL OF CIVIL ENGINEERING
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By

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I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

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ABSTRAK

Di Malaysia, kemalangan yang melibatkan perlanggaran dengan lori rigid dan treler berkait rapat dengan isu kebolehtampakan. Kebolehtampakan merujuk kepada ciri visual kenderaan bermotor lain yang mengalihkan perhatian pemandu kepada mereka. Isu kebolehtampakan berkaitan dengan penandaan belakang dan komponen lampu pada kenderaan berat. Oleh itu, langkah-langkah keselamatan perlu diambil untuk meningkatkan kebolehtampakan pada fenomena psikologi yang dihadapi pemandu. Kajian ini dijalankan di Plaza Tol Jawi, Nibong Tebal, Pulau Pinang dari pukul 9.00 pagi hingga 5.00 petang selama tiga hari. Objektif pertama kajian ini adalah untuk menganalisis peratusan penandaan belakang kenderaan berat yang mematuhi MS 828:2011. Warna dan corak permukaan dicat, saiz, sistem pencahayaan, reflektor dan pendarfluor pada penandaan menentukan kebolehtampakan kenderaan. Kebolehtampakan kenderaan berat yang lebih baik hendaklah dilengkapi dengan penandaan reflektor. Lori rigid kotak dua gandar mempunyai peratusan tertinggi memasang penandaan belakang iaitu 96%. Kategori trak lain adalah antara 17% hingga 91%. Penandaan belakang jenis 5 tidak dipasang oleh mana- mana kenderaan berat, walaupun semua trak dan treler dengan berat Berat Dengan Muatan (BDM) 3500kg dan ke atas adalah diwajibkan memasang penandaan jenis 5 bermula pada 1 Julai 2019. Selain itu, kenderaan berat perlu dilengkapi dengan keperluan komponen lampu. Objektif kedua kajian ini adalah untuk menganalisis peratusan komponen lampu yang mematuhi MS ISO 303:2004. Hasil keputusan menunjukkan 93% lori rigid kotak dua gandar memasang komponen pencahayaan belakang yang mematuhi standard. Kesimpulannya, hanya lori rigid trak dua gandar mempunyai peratusan tertinggi pematuhan penandaan belakang dan komponen lampu belakang.

ABSTRACT

In Malaysia, accidents that involve collisions with rigid and articulated trucks were mainly related to the conspicuity issue. Conspicuity refers to the visual characteristics of other motor vehicles which direct a driver's attention to them. The effect of conspicuity is associated with the rear markings and lighting components on the heavy goods vehicles (HGV). Thus, increasing the visibility and conspicuity of the rear side of heavy goods vehicles may help to enhance safety measures that all GV drivers encounter. The study was conducted for three consecutive days at Jawi Toll Plaza, Nibong Tebal, Pulau Pinang from 9.00 a.m. to 5.00 p.m. The first objective of the study is to analyse the percentage of marking requirements that comply with the MS 828:2011. The colour and pattern of painted surfaces, size, lighting system, reflectorization, and fluorescent markings determine the conspicuity of a vehicle. The retroreflective marking needs to be installed on heavy vehicles for better visibility. The highest compliance level of marking requirement was 96%, which is a box truck, two axles. Meanwhile, other categories were between 17% to 91%. Rear end marking type 5 was not being installed by any HGVs, although all trucks and trailers with maximum gross vehicle weight (GVW) of 3500kg and above were compulsory to be marked with type 5 starting on 1 July 2019. In addition to rear markings, visibility of HGVs could be enhanced should they be equipped with lighting components as being required by laws. The second objective of the study is to analyse the percentages of lighting components installations on HGV rear-side that comply with the MS ISO 303:2004. Results show that 93% of box trucks two axles had installed rear lighting components that adhere to the standard. In conclusion, only a box trucks two axles have the highest percentage of compliance with the standard requirement of rear-end marking and lighting component.

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LIST OF ABBREVIATIONS

DG	**D**iamond **G**rade
GVW	**Goods V**ehicle
GVW	**G**ross **V**ehicle **W**eight
HGV	**H**eavy **G**oods **V**ehicle
JPJ	**J**abatan **P**engangkutan **J**alan
MIRA	**M**otor **I**ndustry **R**esearch **A**ssociation
MS	**M**alaysian **S**tandard
PUSPAKOM	**P**usat **P**emeriksaan **K**enderaan **B**erkomputer
REMs	**R**ear **E**nd **M**arking
RTD	**R**oad **T**ransport **D**epartment
UN	**U**nited **N**ation
VMS	**V**ariable **M**essage **S**ign
RUPDs	**R**ear **U**nderrun **P**rotective **D**evices

CHAPTER 1

INTRODUCTION

1.1 Background

As mentioned by International Transport Forum (2013), Malaysia has been listed as the third highest number of death caused by road accident since 2011(International Transport Forum, as cited in Ismail et al., 2015). Selangor has the highest rate of accidents and keeps increasing from 100 380 in 2008 to 154 958 in 2017. The total motor vehicle involved in road accidents by trucks or lorry rose from 48 250 in 2008 to 53 0438 in 2011 and decreased to 34 942 in 2015 due to the safety measures taken by the government. The Ministry of Road Transport and Highways has taken several safety measures to prevent road accidents and road accident fatalities. These include promoting awareness, establishing road safety information database, encouraging safer road infrastructure, including the application of intelligent transport and enforcement of safety laws (**Appendix A** (Ministry of Transport Malaysia, 2017)).

The World Health Organization (2013), singled out that accidents related to trucks were among the most critical cause of accidental deaths. A key aspect of trucks is their large size and weight, which pose a significant danger to other vehicles and their passengers in the event of an accident involving trucks (Elshamly et al., 2017).

As mentioned by Mohamad et al., (2011), three major factors contributed to road accidents are human, vehicle and road condition. However, the human element had caused the highest percentage of road accidents about 80 to 90% (Suraji and Tjahjono

2012), who pointed out that the main human factor as the behaviour of the driver. The action of truck drivers' effect on the ratio of truck accidents is the primary concern of many researchers. Truck accidents have many reasons; in some cases, lack of attention, including general inattention, misdirected attention, falling asleep, and distraction (McKnight and Bahouth, 2008). One of the most common sleep disorders which may also involve drivers is excessive daytime sleepiness which affects about 4 to 12% of the population and causes psychological stress and lack of productivity at work plus an increase in the risk of accidents (Souza et al., 2005).

Some truckers use illegal materials such as alcohol, cannabis, and cocaine (Doyle, 2013). Additionally, many researchers have subscribed to the belief that some drivers are involved in taking certain drugs to stay awake for a long time. If the driver is alert, visibility conditions could also play a significant role in avoiding accidents. Improving HGVS visibility would focus on the annual saving of lives, as conspicuity requirements could help to reduce and prevent the number of untoward collisions (Berces, 2011).

In this study, conspicuity issues may contribute to the rear end and under ride truck accidents. Rear end truck accident occurs when heavy vehicles travel in lower speed or stopped as compared to other vehicles. This high-speed differential between heavy vehicles and the other vehicles may lead to potential rear-end collisions. Thus, conspicuity plays a significant role, especially involving the accident at night. Poor conspicuity of the rigid or articulated truck at night where drivers failed to see truck turning off on the road, turning around and driving ahead of them. The truck can be made more conspicuous by having to mark both the sides and rear of commercial vehicles using retro-reflective markings.

Furthermore, underride crashes can be very dangerous for passengers in the vehicle that drives or rides near the truck. The driver should always control a safe distance between themselves and HGVs vehicles ahead of them (Ashenden and Associates, 2018). Generally, underride accidents occur when trucks move slowly or in the static condition being hit from behind with smaller vehicles that cannot slow down the vehicles and slides under the truck (Kirkendall,n.d).

1.2 Problem Statement

As mentioned by Cook (1999), accident data recommend that the conspicuity of HGVs and the following distance are contributory factors in accident causation. Accidents that were involved in a collision with rigid and articulated trucks are mainly related to the conspicuity issue. The issue of conspicuity is associated with the rear markings and light components on the HGVs. According to the data available for 2008-2010, accidents during night-time represent 42.1% of the total number of road death, hence decreased visibility might play a significant role as to why crashes happen (Berces, 2011). Thus, increasing visibility and conspicuity may help to improve safety measures for the benefits of road users. Furthermore, it could mitigate or reduce the severity and the number of road accidents, especially rear end and under ride collisions by following a recommended safe following distance. Therefore, this study is essential as it evaluates the compliance of the current HGV condition on marking requirement and lighting component based on the relevant standard.

1.3 Objectives

The objectives of this study were:

1. To evaluate the compliance of the current condition of HGV's on marking requirement by Malaysian Standard of rear and side marking specification (Second revision) (MS 828:2011).
2. To evaluate the compliance of current conditions of HGV's lighting components by the Malaysian Standard of Installation of Lighting and Light-Signalling Devices for Motor Vehicles and their Trailers (MS ISO 303:2004).

1.4 Scope of the Project

This project was carried out at Jawi Toll Plaza, Pulau Pinang. The research focuses on observation and analysis of seven (7) HGV's categories namely: cargo semi-trailer, tank trailer, box truck, garbage truck, dumper truck, and cargo truck to study their rear marking requirement and lighting component requirements bylaws in term of condition and availability. Five types of the rear and side markings were observed as specified by Malaysian Standard (MS) 828:2011. Meanwhile, the lighting components on the rear of HGVs included direction indicator lamp, stop lamp, rear position lamp, and reversing lamp is specified by Malaysian Standard (MS) ISO 303: 2004. Both factors could have effects on their on-road visibility.

1.5 Thesis Outline

This thesis has five (5) important parts and brief outlines of the study as the followings:

- Chapter 1 gives the introduction of conspicuity issues which may contribute to the rear end and underride truck accidents, problem statement, objectives and scope of research.

- Chapter 2 provided literature reviews on the standard, guidelines and acts which require the rear marking and lighting component on the HGVs. It also covers previous studies related to the studies.

- Chapter 3 described the methodologies applied in this research. Seven (7) types of HGVs were observed and analysed. Percentage of Rear End Marking and Percentage of Marking Compliance focused on marking requirement by considering types of marking from 'MS 828:2011 – Rear and side marking Specification (Second revision)'. Meanwhile, Percentage of Lighting Component and Percentage Lighting Compliance focused on the lamp on the vehicles by considering four types of the lamp on the rear of HGVs as required in 'MS ISO 303:2004 - Installation of Lighting and Light-Signalling Devices for Motor Vehicles and their Trailers'.

- Chapter 4 presents the result obtained from the assessment and analysis from seven (7) types of HGVs at Jawi toll Plaza, Pulau Pinang. Malaysian Standard and regulations were used as benchmarks to ensure the marking requirement and lighting component complied.

- Chapter 5 conclude the overall study on this research and summarise all of the findings while proposing a recommendation for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction Design of Vehicles

Design of vehicles mainly refers to the selected vehicle, the weight, dimensions and operating characteristics of which are used to establish highway design controls to accommodate vehicles of a designated type. The sizes of vehicles used in the design should be determined by analysing the trends in vehicle dimensions and characteristics (REAM, 2002).

2.1.1 Size of the Rear Truck and Car

Table 2.1 shows the classifications of dimension and turning characteristics for the passenger car, rigid truck, and semi-trailer (REAM, 2002).

Table 2.1: Classifications of Design of Vehicles (REAM, 2002)

Type	Wheel Base (m)	Front (m)	Rear (m)	Overall Length (m)	Overall Width (m)	Height (m)
Passenger Car	3.4	0.9	1.5	5.8	2.1	1.3
Rigid Truck	6.1	1.2	1.8	9.1	2.6	4.1
Semi-Trailer	9.1	0.9	0.60	16.7	2.60	4.10

2.1.2 Design of Heavy Goods Vehicle (HGV)

Heavy Goods Vehicles used in Malaysia are substantially rigid, articulated, and special commercial vehicles can be classified according to the type of axle shown in Table 2.2 (Road Transport Department, 2017). A rigid vehicle has two axle sets, a driver's position, a steering system, motive power and a single rigid chassis. Meanwhile, an articulated truck has two main parts. At the front is a tractor unit, carrying the engine and the driver. The two parts are pivoted together, or articulated, to make it easier to steer the long vehicle around corners.

Table 2.2: Classifications of Design of Heavy Goods Vehicles (Road Transport Department, 2017)

Category of Vehicle	**Permissible Weight (Tonne)**	**Criteria**
1. Rigid Vehicle – 2 Axles	16 – 18 tonne	Depends on wheelbase
2. Rigid Vehicle – 3 Axles	20 – 25 tonne	Depends on wheelbase & wheel spread
3. Rigid Vehicle – 4 Axles	25 – 27 tonne	
4. Articulated Vehicle – 3 Axle	26 – 30 tonne	Depends on wheelbase
5. Articulated Vehicle – 4 Axle	27 – 37 tonne	Depends on wheelbase & wheel spread
6. Articulated Vehicle – 5 Axle (1: 1: 3)	27 – 39 tonne	
7. Articulated Vehicle – 5 Axle (1: 2: 2)	28 – 40 tonne	
8. Articulated Vehicle – 6 Axle	34 – 44 tonne	
9. Articulated Vehicle – 7 Axle	34 – 51 tonne	
10. B – Double Vehicle (1: 2: 2: 2)	65 tonne	

2.2 Driver Eye Height

Driver eye height is one of the parameters used to determine the sight distance, such as stopping sight distance. However, some references only quote an overall value, which is the eye height of drivers of cars. Besides that, truck and lorry drivers commonly sit higher than car drivers, and so they can look farther (Bartlett, 2014). As mentioned in the REAM (2002), the eyes of the average driver in a passenger vehicle are considered to be l070mm above the road surface.

Bartlett (2014) have found different requirement values for drivers eye height since the people in some countries may be taller than the people in other countries. It seems that the required height for driver eyes in vehicles design was different. For example, generally, it is known that the European are taller than the Asian, but Table 2.3 shows the car driver eye requirements height in Bangladesh is higher than in the UK.

Table 2.3: Car Driver Height Table (Bartlett, 2014)

Country	The driver eye height (m)
UK	1.05
Australia	1.05
Bangladesh	1.20
USA	1.08
Afghanistan	1.20

It is noted above that geometric design standards give suggested values for the driver eye height for different types of vehicle, as shown in Table 2.4.

Table 2.4: Driver Height for Different Types of Vehicle (Bartlett, 2014)

Vehicle Type	**Suggested Eye Height**	**Range of Values**	
		Min	**Max**
Cars	1.08	1.00	1.20
Trucks	2.33	1.80	3.00
Buses	1.80	1.75	2.50

The observation angle is significantly larger for truck drivers than motorists in cars because of their larger vertical displacement from the headlights shown in Figure 2.1. According to Berces (2011), this causes a significant reduction in the amount of returned light received by the truck driver, compared to the light received by the driver of the car. In case of reading traffic signs, less reflected light means less driver ability to detect, recognise and react to a sign.

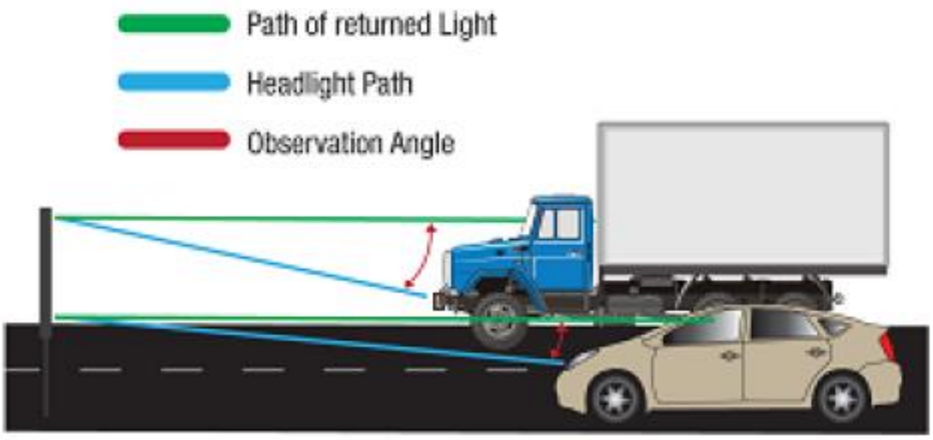

Figure 2.1: Observation Angle of the Driver (Berces, 2011)

2.3 Conspicuity Issues

2.3.1 Rear End Crashes Involving Truck and Lorry

Rear-end collisions can be categorised into (1), rear-end collisions where the truck is in static, and (2), when it is in involves it being in a moving condition.

a) Truck and Lorry in Static Condition

Factors affecting the visibility of a stationary heavy goods vehicle included brightness and conspicuity. Brightness issues are related to visible light. At night, the luminance of a truck parked on the shoulder depends on the truck's lights and retro reflective tape. Requirements for rear conspicuity rely on the colour and brightness of the surrounding environment (Roberts and Lynn, 2003).

b) Truck and Lorry in Moving Condition

Factors affecting the visibility of HGVs include insufficient visibility issues. Poor visibility caused by obstructions such as hazards may result in dangerous situations involving the driver himself as well as other road users. It may also see all or a portion of the view but not have sufficient visual cues to be able to assess the danger of collision. In the case of underride truck crashes, it may see the large truck as moving in their lane of travel, may misjudge the truck's speed and their closing speed or distance with the truck (Roberts and Lynn, 2003).

2.3.2 Accident Causation

a) Conspicuity Issues

Previous research determines that the highest proportion of traffic crashes is rear-ended crashes**.** China recorded the third highest rear-end crashes incidence among vehicle types (Traffic Management Bureau of the Ministry of Public Security of China, 2013). Based on analysis from accidents in Malaysia including HGVs, establish that the most typical types of accidents for the heavy vehicle are head on and rear end crashes with 33% and 28% respectively (Syukri, 2013). Conspicuity issues are related to the visual characteristics of other motor vehicles which direct a driver's attention to them. Based on previous research, The National Highway Traffic Safety Administration (NHTSA) in the United States of America (USA) determines that in a number of accidents involving trucks, the driver of the other vehicle may not have noticed the truck in time to avoid the collision, especially in nighttime (Morgan, 2001).

b) Perceptual Issues

Based on the previous study, Motor Industry Research Association (MIRA) indicated 13 accidents where the driver should have seen and recognise the truck in front but for some reason did not appear to do so. It is recommended that these may in part be due to a lack of perception of the speed of the following the vehicle in front too closely (Lawton et al., 2005).

2.3.3 Suggested Preventive Measures

a) Conspicuity Measures

The German Technical University of Darmstadt had also conducted an experiment of night time and day time accidents between a test group comprising 1000 vehicles equipped with contour markings and a control group of 1000 vehicles without such measures. In conclusion, after two years of the installations shows that 95% of nighttime collisions could have been avoided if trucks were equipped with retro-reflective visibility markings. The results of increased truck visibility determine that

41% reduction of rear-end crashes and 37% decrease of side impacts could be achieved by equipping with retro-reflective markings on heavy goods vehicles (Berces, 2011).

b) Perceptual Measures

The most common type of road accidents involved in rear-end crashes. Therefore, mitigation measures can be taken to reduce and prevent the number of collisions, specifically rear-end crashes, by recommending a safe following distance concept shown in Table 2.5 (Lertworawanich, 2006). Drivers should have enough distance that will allow them to stop if the car in front brakes.

Table 2.5: Recommended Following Distances (Lertworawanich, 2006)

Speed (km/h)	Recommended Following Distance (m)
80	50
90	52
100	53
110	54
120	55

2.4 Installation of Lighting Components MS ISO 303:2004

2.4.1 Lamp Specification

As mentioned in the MS ISO 303: 2004, lamp constituting a pair shall be equipped to the vehicle symmetrically with the longitudinal median plane. This assessment was based on the exterior geometrical form of the lamp and not on the edge of its illuminating surface. Besides that, a lamp constituting a pair shall be applied symmetrically to one another about the longitudinal median plane excluding about the interior structure of the lamp. Based on the lamp specification, it should satisfy the same colourimetric qualification and have substantially identical photometric characteristics. The lighting components on the rear of HGVs included direction indicator lamp, stop lamp, rear position lamp, and reversing lamp in Malaysian Standard (2011).

2.4.2 Rear Direction Indicator Lamp

The number of rear direction indicator lamps on the vehicle shall be two or four except for a single lamp. The extreme outer edge, E on either side of the vehicle, means the plane parallel to the median longitudinal plane of the vehicle and touching its lateral outer edge. D is the distance between the two vertical lines of the lamp. The maximum height above ground, H_1 shall be measured from the highest point, and the minimum height above ground, H_2 from the lowest point of the apparent surface in the direction of the reference axis as shown in Figure 2.2. Therefore, the dimension of the direction indicator lamp is as follows:

$H_1 \leq 1500$ mm (or 2100 mm if the structure prevents compliance with 1500 mm)

$H_2 \geq 350$ mm

$D \geq 600$ mm

$E \leq 400$ mm

The angles of geometric visibility determine the widest solid angle in which the apparent surface of the lamp is visible. For this International Standard, the horizontal angles are β_1, corresponding to the outbound, and β_2 corresponding to the inboard and the vertical angles are α_1 corresponding to up α_2 corresponding to down. Thus, the minimum angles of geometric visibility of the direction indicator lamp as follow:

α_1: 15°

α_2: 15°

β_1: 80° (or 45° if flashing rear side marker lamps are installed on the vehicles)

β_2: 45°

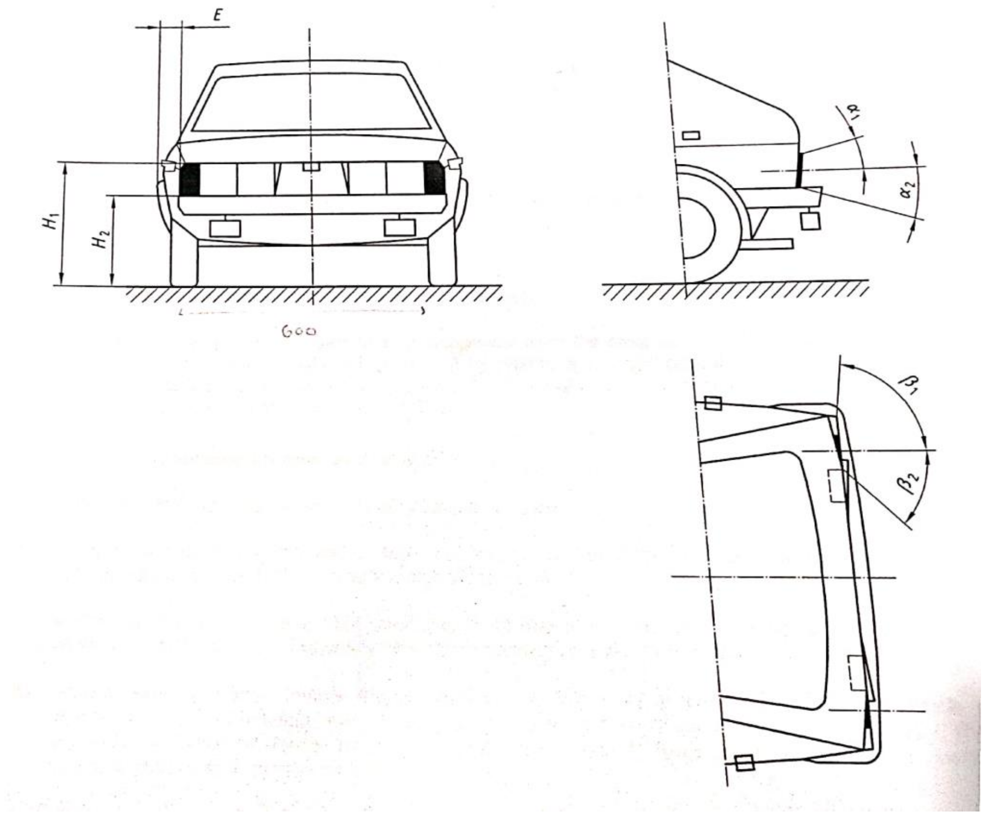

Figure 2.2: Rear Direction Indicator Lamp (MS ISO 303: 2004) (Malaysian Standard, 2011)

2.4.3 Stop Lamp

The number of stop lamp on the vehicle shall be two or four except for a single lamp.

Figure 2.3 shows that the dimension of the stop lamp on the vehicle is as follows:

$H_1 \leq 1500$ mm (or 2100 mm if the structure prevents compliance with 1500 mm)

$H_2 \geq 350$ mm

$E \leq 400$ mm

The angles of geometric visibility which determine the widest solid angle in which the apparent surface of the lamp is visible. The minimum angles of geometric visibility of the direction indicator lamp are as follows:

α_1: 15°

α_2: 15° (5° if $H_2 < 750$ mm)

β_1: 80° (or 45° if flashing rear side marker lamps are installed on the vehicles)

β_2: 45°

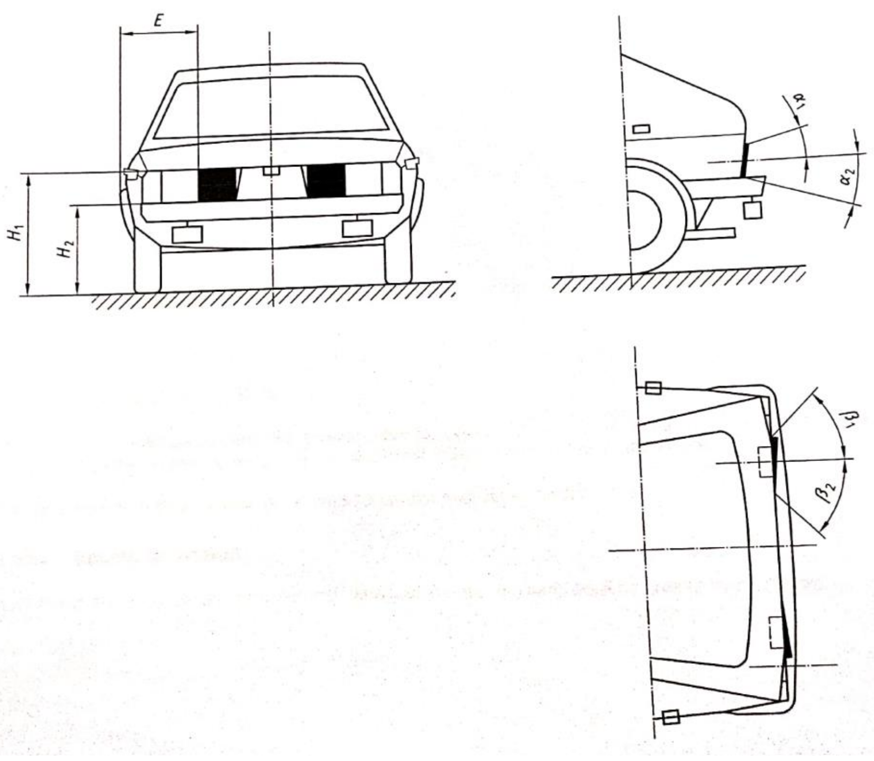

Figure 2.3: Stop Lamp on the Vehicle (MS ISO 303: 2004) (Malaysian Standard, 2011)

2.4.4 Rear Position Lamp

The number of rear position lamp on the vehicle shall be two or four except for a single lamp. Figure 2.4 shows the dimension of the rear position lamp on the vehicle is as follows:

$H_1 \leq 1500$ mm (or 2100 mm if the structure prevents compliance with 1500 mm)

$H_2 \geq 350$ mm

$E \leq 400$ mm

The angles of geometric visibility which determine the widest solid angle in which the apparent surface of the lamp is visible. The minimum angles of geometric visibility of rear position lamp are as follows:

α_1: 15°

α_2: 15° (5° if $H_2 < 750$ mm)

β_1: 80° (or 45° if side marker lamps are installed on the vehicles)

β_2: 45°

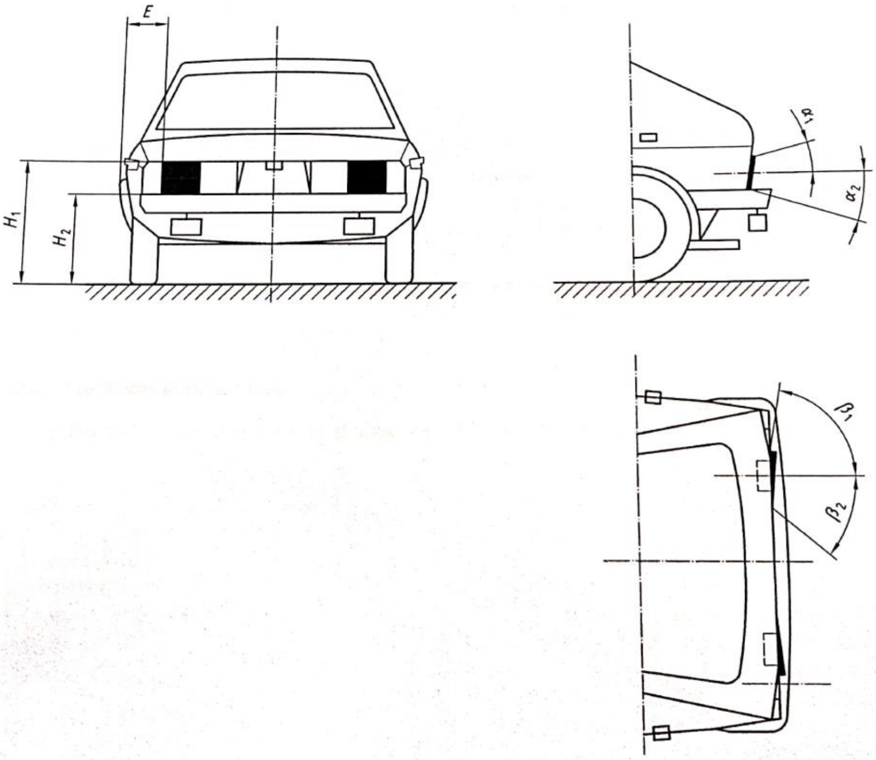

Figure 2.4: Rear Position Lamp (MS ISO 303: 2004) (Malaysian Standard, 2011)

2.4.5 Reversing Lamp

The number of reversing lamp on the vehicle shall be one or two. Figure 2.5 shows the dimension of the rear position lamp on the vehicle as follow:

$H_1 \leq 1200$ mm

$H_2 \geq 250$ mm

D: unspecified

E: unspecified

The angles of geometric visibility which determine the widest solid angle in which the apparent surface of the lamp is visible. The minimum angles of geometric visibility of reversing light are as follows:

α_1: 15°

α_2: 15°

β_1: 45°

β_2: 45° (30° for two lamps)

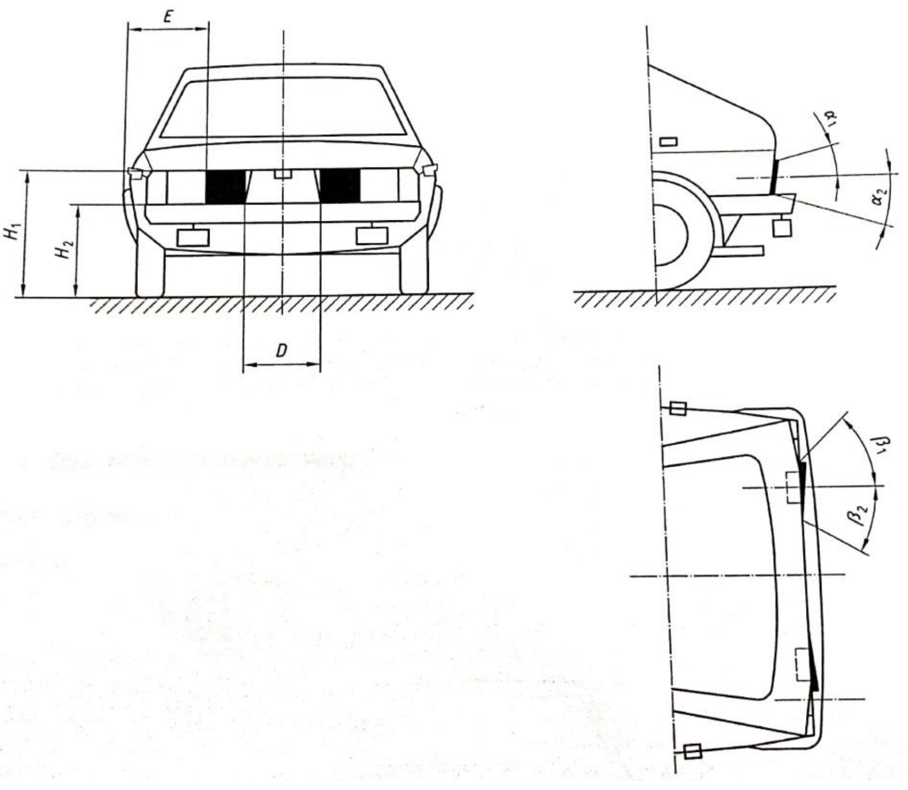

Figure 2.5: Reversing Lamp on the Vehicle (MS ISO 303: 2004) (Malaysian Standard, 2011)

2.5 Fog Warning System

The warning system has visibility sensors that automatically activate a Variable Message Sign (VMS) that posts an advisory speed when hazardous environment due to fog occurs. Fog detection and warning system consisting of a visibility sensor, which is a point detection device that utilises infrared technology to measure visibility distance and a VMS. The signing effect exists when the visibility distance is critical when less than 50m. Al-Ghamdi (2007) indicates that at a visibility distance of less than 50 m, the results of both visibility and a VMS appear to be significant. The other visibility distance categories are 50m to 200m, and over 200m, it can be categorised as light fog and excellent visibility respectively.

2.6 Lamp Characteristics

Mortimer (1970) researched the required intensity levels for red stop lamps to be viewed at 75 feet. The recommended values are shown in Table 2.6 below:

Table 2.6: Maximum and Minimum Values for Lamp (Mortimer 1970)

Condition	**Night** (candelas, cd)		**Day** (candelas, cd)	
Lamp size (inch^2)	**Minimum**	**Maximum**	**Minimum**	**Maximum**
12.6	80	190	300	2 300
18.0	95	230	380	2800

Mortimer et al. (1973) conducted an intensive survey of all car and truck signalling and marking research, including a few research related to rear signalling. Mortimer (1970) recommended a minimum daytime intensity of 300 candelas and a maximum night time intensity of 190 candelas for 12.6 in^2 lamp size.

2.7 Implementation of UN Regulations

The lighting components on the rear of HGVs included UN Regulation 6, 7, 23 and 38. UN Regulation 7 stated that it is required to install front and rear position lamps, stop lamps and end-outline marker lamps for motor vehicles and trailers. Rear position lamp is used to indicate the presence of the vehicle when viewed from the rear. Additionally, stop lamp serve a simple but essential function that is used to show to other road users at the rear of the vehicle that its driver is applying the brake. The stop lamps on the back of the vehicle may be activated by the application of a retarder or the same device. The intensities shall be determined with the filament lamps regularly alight, and the colour of the light emitted shall be red light (United Nations, 2012).

UN Regulation 6 applies to direction indicators for vehicles. Direction indicator can be defined as a device mounted on a motor vehicle or trailer when conducted by the driver, signals the latter's intention to change the direction in which the vehicle is proceeding. Directional indicator lamp has an important function as a safety function, and the colour of the light emitted inside the field of the light distribution grid shall be amber light (United Nations, 2014).

UN Regulation 23 applies to the reverse lamp for vehicles. Reversing light of the vehicle is designed to illuminate the road to the rear of the vehicle. This lamp is used to warn other road users and people around the car that the vehicle is about to move backwards. In general, the colour of reverse lights on the vehicle must be white, and these are based on UN Regulation 23 (United Nations, 2003).

As mentioned in the UN Regulations 38 requires provision concerning the approval of rear fog lamps for power-driven vehicles and their trailers. The scope of this regulation applies to rear fog lamps for certain vehicles. Rear fog lamp is required in making the vehicle more conspicuous from the rear by giving a red signal of higher intensity, and the colour of the light emitted inside the field of the light distribution grid shall be red light (United Nations, 2013).

2.8 Legislation Related on the Vehicles

2.8.1 Road Transport Act 1987

The regulation requires that all commercial vehicles go through routine inspection at PUSPAKOM every six months. All commercialized vehicles need to be checked to ensure it adheres to the requirement stipulated in the regulations. The routine inspection will help to avoid road accident and make some recommendation to improve the road safety of the road user.

As mentioned in the Road Transport Act 1987 section 66 is to regulate the lights that are to be installed in motorised vehicles, in respect of the nature of such lights, the positions in which they shall be fixed, and the periods during which they shall be lighted, or otherwise.

2.9 Rear and Side Marking Specification

2.9.1 Retroreflective in Malaysia

The implementation of MS 828:2011 has been enforced on 1 January 2017 and all heavy vehicles with maximum gross vehicle weight (GVW) 3500kg and above to be compulsory to install retroreflective rear marking in Malaysia. In July 2019 a legislation was made marking to MS828:2011 mandatory on new trucks and trailers with maximum gross vehicle weight (GVW) 3500kg and above have to be marked with side marking and also contour marking has to be from highly reflective materials which can guarantee better visibility during night and poor weather conditions. Buses also need to be equipped with reflective rear marking (Ibrahim, 2019).

Germany has presented a proposal that United Nations Economic Commission for Europe UNECE Regulation 48 should be revised, thus the installation of retro-reflective markings for a vehicle of categories M_3, N_3, O_3 and O_4 should be compulsory **(**United Nations, 2014**)**. Based on the Garis Panduan Kelulusan Jenis Kenderaan (Pindaan) 2015, UN Regulation 104 applies to retro-reflective markings for vehicles of category M_2, M_3, N_1, N_2, N_3, O_1, O_2, O_3, and O_4. For the definition of categories of vehicles can refer to **Appendix B**.

UN Regulation 48 concerns the type of approval of vehicles that set out installation requirements for vehicle light. Meanwhile, Regulation 104 contains performance requirements for retro-reflective markings for specific categories of vehicles**.**

2.9.2 Visibility and Conspicuity Markings

On 1 December 1993, heavy trailers were required to be equipped with red and white retro-reflective tape or reflex reflectors. Based on the study by Morgan (2001) presented these passive markings to be highly effective at preventing side and rear impact crashes in dark conditions. Morgan (2001) also reported that reductions in the range of 29-41%. The tape alerts other drivers to the presence, size, and shape of the trailer, thus providing drivers with additional time to react to the trailer. By increasing the visibility and conspicuity markings, it may be helpful to safety measures taken on the psychological phenomena that drivers encounter.

i. **Colour and Brightness:** Vehicle colour can affect brightness. During daytime and nighttime conditions, the vehicle colour chosen for commercial vehicles reflects as much light as possible (Roberts and Lynn, 2003). Increases in reflectivity results directly in an increase in luminance.

ii. **Photometric Specifications:**

The marking must achieve the minimum values for the coefficient of retroreflection. MS 828: 2011 mentioned the values of the coefficient of retroreflection R' in candelas per m^2 per lux for yellow and red shall be 300 candelas and 120 candelas, respectively in Table 2.7 and Table 2.8.