Passive safe light poles and support structures

Light poles and support structures

They do not need to be an obstacle

Summary

The development of passive safe light poles has been ongoing for more than 40 years, which is hardly surprising given the amount of traffic on the roads is increasing all the time. Despite preventive measures, it happens that vehicles, for whatever reason, fall off course and end up on the roadside. The most promising measure for a significant reduction in the number of fatal accidents on national roads is aimed at an obstacle-free roadside. Passive safe poles, as part of a: “forgiving verge”, can make a contribution to minimize the risk of (serious) injury.

In Europe, light poles must comply with the EN 40 standard. In addition, a crash test must have been conducted in accordance with the EN 12767 standard. The standard makes a distinction between the following: impact speed (50, 70 and 100 km/h), energy absorption category (HE, LE and NE), occupant safety level (A - E), backfill type (S,R and X), direction class (SD, BD en MD), collapse mode (NS en SE) and risk of roof indentation (0 and 1).

If you just want to make a safe choice, the use of a crash barrier is often a good solution. However, this is expensive and it does not always look good. If you decide to use passive safe light poles, you can choose from a number of different performance classes. The safest pole for a particular road situation depends on the permitted speed, the presence of other obstacles/objects and the possible presence of third parties. The safest pole is the best choice not just for the passengers of the colliding vehicle but also for other road users present.

At locations where there is a secondary danger behind the pole, HE poles are the best choice if it is not possible or desirable to use a crash barrier. Poles with an NE classification work very well if there is an “empty background”. The best performing NE pole can be achieved by using a shear-off mechanism. LE poles are often chosen as a compromise solution for county roads. LE poles often naturally possess the right qualities and so require no extra engineered solution, which is very cost-effective.

The standard for passive safety, the EN 12767, is basically developed to be able to compare passive safe solutions with each other by testing them in a consistent way. The test protocol in the EN 12767 standard describes how light poles must be tested for passive safety.

However, the practical situation will always deviate from the test conditions in all respects. Many non-standard situations can be encountered in the field. The main non-standard situations with respect to the test protocol involve the soil type, the vehicle, the installation of the pole and the collision angle. Environmental factors also influence the performance of the pole over time. That is why it is necessary to properly maintain light poles.

The EN 12767 standard makes a distinction between backfill type S (Soil), R (Rigid) and X (others). To rule out deviations in soil type (in comparison with the test), the influence of soil variables can be eliminated. For example, this can be done by installing the pole into an over-sized plastic tube or ‘sleeve’ or onto a rigid foundation.

Besides light poles, there are also other passive safe products available such as passive safe Traffic Signal Poles and Sign Posts. Alt these products contribute to make our roads safer.

If you make a well considered choice for passive safe poles, you can create lighting along the road without creating obstacles.

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Introduction

Every year too many people die in traffic. A traffic accident does not happen because only one thing goes wrong; it is usually a combination of various factors: characteristics of the road, the vehicle and people. A combination of carelessness or conscious risk behaviour of the road user and a road layout that offers little room for human error. The severity of the outcome of an accident is largely determined by the design of the roadside.

Passive safety in public spaces refers to the use of light poles, signposts, CCTV columns and other street furniture, which prevents people from being killed or seriously injured in road accidents. It is important to bring passive safety to the attention of the general public.

Since the introduction of the standard for passive safety, the EN 12767, it is possible to compare products (passive safe solutions) with each other. This document helps you to better understand the complex subject of passive safe light poles and other crash-friendly products, such as traffic signal poles and sign posts.

Hydro's extensive knowledge of passive safety through their participation in the Dutch standard committee EN 40 (the European standard for lighting columns) and presence in WG10 (the European working group responsible for writing and revising the EN 12767 standard), and years of experience in conducting crash tests have contributed to the publication of this white paper. Version 3.0 is based on the most recent developments concerning EN 12767.

In this publication we use the term EN 12767, which refers to the European standard for passive safety in general. The harmonisation of the European standard results in national standards, e.g. BS EN 12767, which can include a national annex (NA) to give more guidance to specific national preferences. For example for the UK this means we need to consider BS EN 12767.

In the preface, we first pay attention to the changes to the passive safety standard, and list the most important issues for you. Chapter 1 describes current standards regarding light poles and passive safety and discusses the differences between the various performance classes. Chapter 2 explains how you can use passive safe light poles. In practice, factors play a role that influence the performance of the light pole, which may cause it to not perform as expected. In chapter 3 you therefore read more about deviating situations. Chapter 4 discusses the collision safety of other structures. The advice at the end of the document will help you make a well-considered choice for passive safe poles.

Revised European norm passive safety

The standard for passive safety, EN 12767, is not static. The standard is continuously monitored and adjusted (approximately every 5-10 years). More knowledge, improved technology and practical experience lead to different views and new ideas and measures to better capture the performance of passive safe poles.

The EN 12767:2019 was published in August 2019. Taking into account a transitional period of six months, the revised standard is mandatory from February 2020.

The adjustment in the European standard for passive safety changes the notation of the required performance class for highway safety equipment, such as light poles and sign posts. An important adjustment in the EN 12767 are the performance classes. In the old standard EN 12767:2007 a performance class comprised a combination of impact speed, energy absorption category and occupant safety level, for example 100HE3. Other passive safe properties were described in additional text lines.

In the revised standard EN12767:2019 following properties have been added:

- backfill type of foundation for the poles
- collapse mode of the poles
- direction class – the angle at which a crash-friendly pole can be hit
- risk of roof indentation

An example:

100-HE-D-S-NS-MD-0

Adjustment in occupant safety level
The revised standard also includes an adjustment to occupant safety level, where the passive safety classes for occupants have been changed from a rating system using numbers (1 - 4) to one that uses letters (A - E).

In the old norm, the boundary values for occupant safety (Acceleration Severity Index-ASI and Theoretical Head Impact Velocity-THIV limits) for NE2 and HE3 were the same, even though the numbers did not match. This was confusing. Consequently, the revision has clarified the distinctions in occupant safety levels. In the new approach, the passive safety class for the occupants is disconnected from the energy absorption category. NE2 is now NE-C and HE3 has become HE-C.

In addition, a change has been made in the field of classifying the crash tests. In the EN 12767: 2007 every high speed test was accompanied by a low speed test. The revised standard looks at the collapse mode. If the collapse mode of the low speed test (35 km/h) and high speed test (e.g. 100 km/h) are the same, the tested product automatically also meets the intermediate high speed classes (50 and 70 km/h).

With the introduction of EN 12767:2019, not all crash tests have to be performed again. The data needed to be able to divide an aluminium pole into the new passive safe classes is already available, unless the crash test is very dated. The data was measured and analyzed during the impact tests and recorded in reports, videos and photos. In the notation according to the revised standard you can now see the data at a glance from the performance classes on the certificate/ DOP instead of having to request the test report first.

After publication and harmonisation of EN 12767, the notation of the performance class of (light) poles has become longer, but also clearer, so that a better choice can be made for the pole's behaviour.

Here are two examples, comparing the old standard with the new one:

100NE3 » 100-NE-B-R-SE-MD-0

100HE3 » 100-HE-C-R-NS-MD-0

The following designations (classes) can/must be included in the notation of a passive safe (light) pole following EN 12767:2019.

BS-EN 12767:	Version 2007 (old)	Version 2019 (since August 2019)
Performance class	3 characters (e.g. 100HE3)	7 characters (e.g. 100-HE-C-S-NS-MD-0)
Impact speed	50, 70, 100 km/h	50, 70, 100 km/h
Energie absorption	HE, LE, NE	HE, LE, NE
Occupant safety class)	1,2,3,4	A, B, C, D, E
Backfill type	See test report	S, R, X (soil, rigid, special)
Collapse mode	See crash test video's	SE of NS (Separation or No Separation)
Direction class	See product-details in impact-zone	SD, BD, MD (Single, Bi or Multi Directional)
Risk of roof indentation	See test report of high speed test	Class 0 or 1 (resp. <102 mm or ≥102 mm)

Table 1: Overview changes EN 12767

1. Standards for passive safe light poles

Light poles are subject to daily exposure. The poles must be strong enough to support the fixture and any other objects and to withstand the environmental factors. In case of roadside installation, passive safety also comes into play. Strength and passive safety are poaching on each other's territory. It is important to find the right balance. In this chapter we describe the current standards regarding light poles and passive safety.

Passive safety was a Scandinavian development in the 1980's and 1990's. In 2005 "TA89/05 Use of passive Safe Signposts, light poles and Traffic Light Posts to EN 12767" was published. The development of passive safe light poles has been ongoing ever since. Countries all over the world have different safety standards for light poles. Europe uses the EN 40 standard. In addition, a crash test must have been conducted in accordance with the EN 12767 standard.

1.1 EN 40

The EN 40 specifies the requirements to be met by every light pole. These properties are regulated in 'Annex ZA'. Annex ZA states that light poles must be provided with an identification and that an authorized Notified Body must have approved the product. Passive safety is also one of the mandated (mandatory) properties.

A Notified Body is a certification institute that is specifically recognized by the Accreditation Council for carrying out product inspections according to the applicable standards. The Accreditation Council performs the accreditation in accordance with the standard EN ISO/IEC 17065. They also accredit test institutes for carrying out crash tests in accordance with the applicable standard; EN ISO/IEC 17025. Only a Notified Body is authorized to issue manufacturers a product certificate.

For the product standards, EN 40 makes a distinction between the various materials :

- NEN EN 40-4: lighting columns – Part 4: Requirements for lighting columns manufactured from reinforced concrete and pre-stressed concrete
- NEN EN 40-5: lighting columns – Part 5: Requirements for steel lighting columns
- NEN EN 40-6: lighting columns – Part 6: Requirements for aluminium lighting columns
- NEN EN 40-7: lighting columns – Part 6: Requirements for composite lighting columns with fibre-reinforced plastics

EN 40	
EN 40-1:	Definitions and terms
EN 40-2:	General requirements and measurements
EN 40-3:	Design and verification
EN 40-3-1:	Specification for characteristic loads
EN 40-3-2:	Verification by testing
EN 40-3-3:	Verification by calculation
EN 40-4:	Concrete lighting columns
EN 40-5:	Steel lighting columns
EN 40-6:	Aluminium lighting columns
EN 40-7:	Composite lighting columns

Table 2: Overview of the full EN 40 standard

In the longer term, parts 40-1 and 40-2 will be merged into a new 40-1 as well as parts 40-4 through 40-7 into a new 40-2. Part 40-3 remains as it is.

1.1.1 EN 40-3-3

In order to determine whether a pole complies with the technical strength requirements, strength calculations must be carried out according to the EN 40-3-3. Standard light poles are calculated for a design life of 25-50 years. The calculation method for poles takes a number of different factors into account, such as materials, wind speed, wind pressure, terrain category and safety factors.

1.2 EN 12767

The EN 12767 is the European standard for passive safety referred to in the standard for light poles (EN40) and support structures (EN12899). The WG 10 working group produced the EN 12767:2019 at the request of the European Standards Committee for light poles (CEN TC 50), which in turn informs NEN. All European countries have a voice in the CEN TC 50/ WG 10.

The EN 12767 is basically developed to be able to compare products (passive safe solutions) with each other by testing them in a consistent way. The standard provides a common basis for crash testing of vehicles with objects or support structures for road equipment. The EN 12767 specifies performance requirements and defines levels in terms of passive safety to reduce the severity of injury to the occupant(s) or other traffic and road users in the event of an accident with an object or support structure for road equipment. The harmonisation of the European standard results in national standards, e.g. BS EN 12767, which can include a national annex (NA) to give more guidance to specific national preferences.

A Notified Body checks passive safety. As soon as the manufacturer has had low-speed and high-speed crash tests conducted by an accredited test institute in accordance with EN 12767, the Notified Body can assign the performance class. The accredited test institute and the accredited Notified Body are different independent organisations. If no tests are carried out, the product is automatically assigned to class 0 and for passive safety, a NPD (No Performance Determined) is noted on the DOP (Declaration of Performance)*.

** As a result of the European Construction Products Regulation, the supplying industry (manufacturers, importers and distributors) is obliged to provide a declaration of performance (DOP) for CE marked products since 1 July 2013.*

1.2.1 Crash tests

In the EN 12767, the test protocol describes how lighting columns must be tested for passive safety.The crash test uses a standard passenger car (mass 900 kilos) and can be carried out using different backfills. The most common backfills are Soil "S" and Rigid "R". In addition, the client can also submit a different backfill under type X. Chapter 3 discusses the foundation further.

1.3 Test conditions and performances

The test method for performing crash tests is described in the EN 12767. The standard distinguishes the following test conditions and performances:

- Impact speed
- Energy absorption category
- Occupant safety level
- Backfill type
- Collapse mode
- Direction class
- Risk of roof indentation

An example of a performance class is:

100-HE-C-R-NS-MD-0

1.3.1 Impact speed

The figures 100 (e.g. for motorways), 70 (e.g. for county roads) or 50 (e.g. for roads in urban areas) that are mentioned in the performance class refer to the high-speed impact test. For every high-speed test, a low-speed test at 35 km/h must also be conducted.

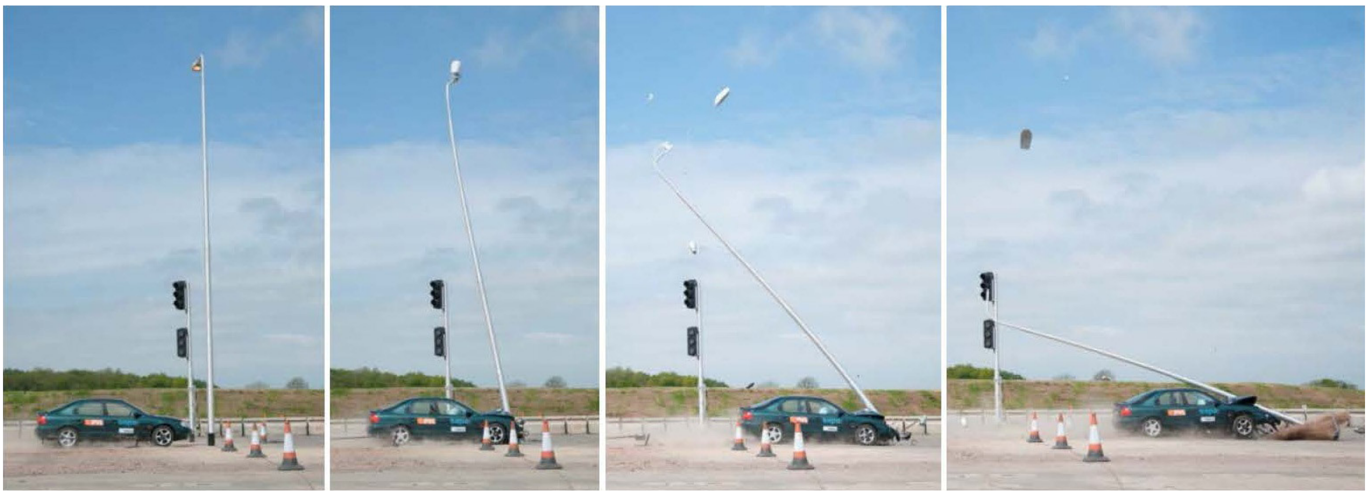
1.3.2 Energy absorption category

The standard divides the energy absorption category of passive safe structures into three categories, based on the degree of energy absorption. HE poles absorb as much energy as possible, NE poles as little as possible and LE poles are in between.

- High energy absorbing (HE): HE poles decelerate a vehicle the most but generally also cause the most damage to the vehicle which can result in secondary danger for the occupants. In addition, the occupant(s) will have to cope with a greater impact than in case of an NE/LE pole. The exit speed is between 0 and 50 km/h (for a test at 100 km/h), which means that the risk of secondary collisions with trees, pedestrians and/or other road users, for example, is reduced to the lowest possible level. The ultimate HE pole stops the car (NO exit speed) and at the same time achieves the highest possible occupant safety level.

- Low Energy absorbing (LE): LE poles are poles that usually bend naturally under the vehicle during a crash before they break off or are knocked down.

- Non Energy absorbing (NE): NE poles enable the vehicle to continue at a reduced speed after a crash. This reduces the chance of injury to the occupant(s) but increases the risk of a secondary accident if there are obstacles behind the light pole.



Crash test (demonstration) HE-C pole

1.3.3 Occupant safety level

Occupant safety is expressed in the values ASI (Acceleration Severity Index) and THIV (Theoretical Head Impact Velocity). The ASI indicates the deceleration rate of the vehicle. Compare it with G-forces. If a particular ASI value is not exceeded during a test, it can be assumed that occupants have not been seriously injured. The THIV indicates the speed with which the head(s) of the occupant(s) hits the dashboard. The levels A,B,C, D and E indicate the level of occupant safety. The best occupant safety is reached by level A. Level A is only achievable for such items as deformable bollards and not lighting columns, sign posts or signal poles.

Table 3 clearly shows which ASI en THIV values must be achieved in crash tests for the different performance classes. The exit speed also plays an important role in this. Table 4 shows which exit speed is permissible for which performance level.

Performance level	Occupant safety level	Speeds			
		Compulsory low-speed test 35 km/h		Speed class 50 km/h, 70 km/h and 100 km/h	
		Maximum values		Maximum values	
		ASI	THIV km/h	ASI	THIV km/h
HE / LE / NE	E	1,0	27	1,4	44
HE / LE / NE	D	1,0	27	1,2	33
HE / LE / NE	C	1,0	27	1,0	27
HE / LE / NE	B	0,6	11	0,6	11
NE	A	NO requirements	NO requirements	No ASI and THIV measurements	

Table 3: ASI en THIV values

Impact speed (km/h)	50	70	100
Performance level	Exit-speed = V_e (km/h)		
HE	$V_e = 0$	$0 \leq V_e \leq 5$	$0 \leq V_e \leq 50$
LE	$0 < V_e \leq 5$	$5 < V_e \leq 30$	$50 < V_e \leq 70$
NE	$5 < V_e \leq 50$	$30 < V_e \leq 70$	$70 < V_e \leq 100$

Table 4: Total overview performance level , impact speed and exit speed

The following should be taken into account for the safety of the occupant(s):

- There is a significant difference between the minimum and maximum THIV values for each level: a THIV of 26 is much higher than a THIV of 14, for example, even though they are in the same occupant safety class. Normally a higher THIV corresponds with a higher risk of occupational injury for the occupant(s).
- The exit speed can endanger pedestrians, but it can also be a secondary danger for the occupant(s). The residual speed is the speed of the test vehicle measured 12 meters after the collision point.
- An EXIT speed of 0 is better for those involved than an EXIT speed of 50 while they can fall in the same class (HE).

1.3.4 Backfill type

EN 12767 distinguishes between the foundation methods S (soil), R (rigid) and X (other).

Backfill type S is a standardized soil of a certain composition and density. When installing in the ground, you must take into account the fact that the soil does not have a homogeneous composition. There are different soil types with an existing groundwater level. These differ in all cases from what has been tested (backfill type S). In addition, the temporary presence of, for example, rain water also influences the composition of the soil.

In the case of backfill type R, the installation of light poles takes place both on and in a concrete foundation. Light poles that are installed on concrete have a base plate.

All types of foundations that deviate from backfill type S and R fall under type X in the standard. Examples are saturated soil, clay or gravel. While the S and R types are defined within the standard, type X is not, because X can differ per manufacturer and will therefore never be the same. It is not comparable. The new standard has added a push-pull test to be able to compare soil behaviour with local soils in the field.

Backfill type has a great influence on the performance of a pole and it must correspond with the practical situation in which the pole is placed. To avoid endless testing, a national annex is made in the BS EN 12767 which states that more stable foundation than used in the crash tests are acceptable too.

For more information on backfill type see section 3.1.

1.3.5 Collapse mode

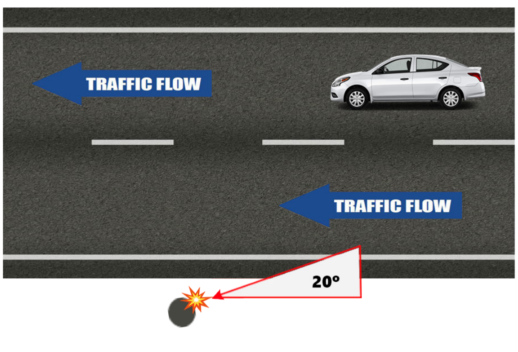
The norm includes two collapse modes: SE (separation) and NS (no separation). The collapse mode indicates how the pole behaves in the event of a collision. The collapse mode of an object can be different for a low speed than for a high speed. NS is always desirable, but technically not possible with some energy absorption categories (NE). In some cases, shearing of the pole (SE) is necessary to achieve the correct performance class. In other situations, flying objects are not acceptable (NS). The right choice depends on the local situation.

In the event of a collision, the collapse mode of lighting columns (belonging to the same classification) can differ substantially due to the design and material of the mast. This behaviour is apparent from the test report in accordance with EN 12767. The light pole manufacturer must be able to submit these reports (35 km/h and 100 km/h) as well as the accompanying videos from which much secondary behaviour can be derived (including dents, jumping-off pole parts or moving vehicles). It is also possible that the low speed test (35 km/h) and high speed test (e.g. 100 km/h) have the same collapse mode. In that case the tested product automatically also meets the intermediate high speed classes (50 and 70 km/h).

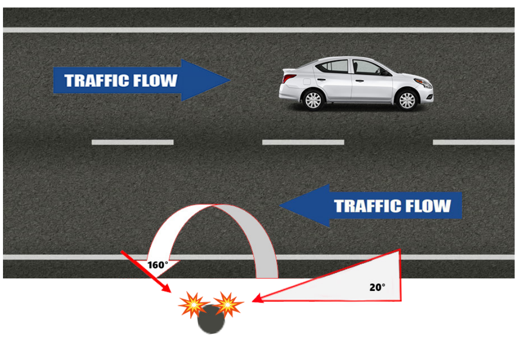
1.3.6 Direction class

Direction class indicates the angle at which a crash-friendly pole performs:

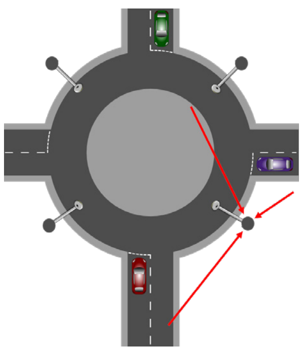
- Single Directional. SD poles can only be safely hit from one direction (20°).
- Bi Directional. BD poles also perform for traffic coming from the opposite direction (20° and 160°).
- Multi Directional. MD poles are not sensitive to impact angle and can be hit from all driving directions.



Single directional



Bi directional



Multi directional

Products that perform irrespective of direction of impact are to be preferred, given the unexpected and unforeseeable nature of collisions. The recommended performance classes are therefore (in order of preference) MD, BD and SD for all situations ((BS EN 12767:2019, NA.2.6 Direction of impact).

As such, the MD classification is the safest choice. Of course, this is from a technical point of view not always achievable. Direction dependency is caused mainly by systems within the pole, such as shear-off systems.

1.3.7 Risk of roof indentation

A collision with a pole can result in the formation of a dent in the roof of the vehicle, with risks for the occupant(s). The EN 12767 divides roof indentation into class 0 (not sensitive to dents) and class 1 (sensitive to dents). The limit is set to 102 mm (4 inches), in accordance with the American standard for passive safety (MASH).

The safest class is obviously class 0, but in combination with other crash-proof properties, this is not always feasible. Normally, the higher the energy absorption of the pole, the more the risk of roof indentation.

The national annex in the previous version of this standard, BS EN 12767:2007, recommended that products that, when tested, caused a roof deformation in excess of 150 mm should be avoided. It is therefore recommended that only class 0 (roof deformation less than 102 mm) should be specified (BS EN 12767:2019, NA.2.7 Risk of roof indentation)..

1.4 Specification test conditions and performances

The notification as in figure 1 is used to indicate the performance classes.

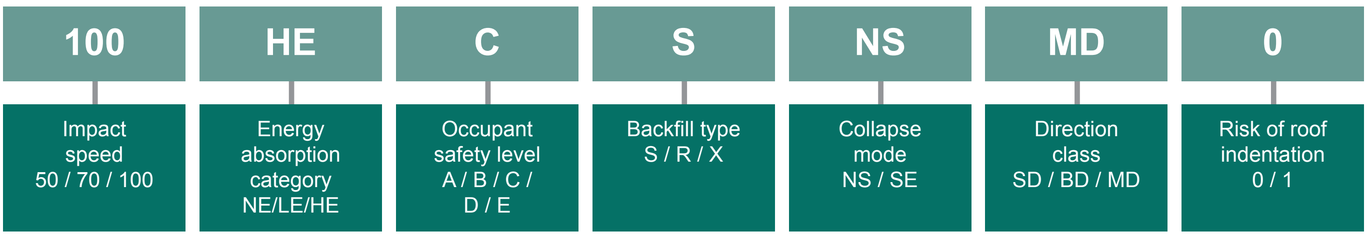


Figure 1: Notification performance classes

Not all performance properties always have to be filled in. This depends on the designer because in some cases the properties in a category may have no interest or impact on a project or multiple choices are allowed. In that case an applicant can insert 'NR' (No Requirement) for those properties.

Two examples:

- Performance class 100-HE-NR-NR-NS-MD-0. In this case NR means that the classes for occupant safety and backfill type have not been specified;
- Performance class 100-NE-B-NR. Here NR means that only specific requirements are set for impact speed, energy absorption category and occupant safety level. All new test conditions and performances are not required. This is not preferable and not the intention of the new standard.

An ideal situation is technically unattainable in practice. For instance. 100-HE-A-S-NS-MD-0 will technically not be feasible, as will 100-NE-A-S-NS-MD-0. It is therefore important to prioritize the most important test conditions and performance for the local situation.

Risks for third parties must in principle be assigned a (much) heavier weight than the risks for occupants.

This chapter explained the collision safety standard and the notation of the performance classes. But what test conditions and performance do you need to make the safest choice? Chapter 4 discusses the application of passive safe poles in practice.

LE-C aluminium light pole crashed in the province of Bergamo, Italy

> *“Passive Safety is the use of light poles, signposts, CCTV poles and other street furniture which doesn’t kill you or severely injure you when you drive into it. You walk away after an accident.”*
>
> *David Milne, a consultant who advises on passive safety in public spaces*

Example of an HE-C crash test

When the car hits the aluminium pole, the car decelerates and the pole folds until it breaks.

The extra features inside the pole causes further deceleration of the car a few milliseconds after the crash and and ensures that the demolished pole remains connected to its location, so that no flying object is created.

> *“For HE poles it is important to check the residual speed of a vehicle. An exit speed of 50 km/h is still an HE, but it is still considerable and can cause substantial secondary damage. Complete standstill is the ultimate HE result.”*
>
> *Bas van Boxtel, Technical manager, Pole Products*

Practical situation NE-B pole

A car crashed into a 12 meters high aluminium NE-B light pole on a rural road in the Netherlands. The light pole sheared off, as can be seen from the photographs. The pole was damaged, but the occupant(s) were uninjured.

The pole was stabilized in the ground with a concrete element, a so called TOAD.

> *"The THIV value (impact perceived by the occupant(s) range is the same for NE-C / LE-C and HE-C, namely between 11 and 27. The difference between these values is quite extreme. It cannot really be claimed that an NE-C pole has the same impact for the occupant(s) as an LE-C or HE-C pole. The THIVs of an NE-C pole are usually lower than an LE-C and HE-C pole. In practice, a better and feasible class for the occupant(s) is often chosen: NE-B."*
>
> *Bas van Boxtel, Technical manager, Pole Products*

Roof indentation is a test condition that is added to the notation of the performance class.

The photo on the left shows a crash test with an aluminum light pole in combination with Non Seperation (NS) and risk for roof indentation class 0.

The photo below shows a crash test with a standard steel light pole in combination with Non Separation (NS) and risk for roof indentation class 1.

The photos above show that in case of Non Seperation (NS) it is more likely that there will be dents during the impact. The mass of the pole plays a major role in this situation. The heavier the pole, the harder the impact on the roof.

Example of a crash demonstration with a passive safe aluminium light pole on a base plate

Reason for the demonstration:

- Demonstrate that the occupant(s) in the vehicle will not be seriously injured.
- Demonstrate that poles with a base plate can also be crash-friendly.

> *“The pole sheared off from the base at the moment of impact, with very little reduction in speed, taking the pole away from the place of impact. The base plate remained behind and could be dismantled and the pole was replaced safely and quickly.“*
>
> *Traffex Seeing is Believing 2018*

2. The use of passive safe light poles

The differences between the various performance classes are explained in the previous chapter. But in which road situation do you use which passive safe light poles? It is important to choose the right performance class for the different road situations. In addition, the positioning of a crash barrier must be considered in each particular situation.

2.1 Protection of poles

It may be necessary to protect a light pole (that has already been positioned) from the road by positioning a crash barrier. This depends to which extent the pole is an obstacle, but also what is behind the pole. If a vehicle gets off the road, the vehicle may end up in the area behind the road and pose a danger to the occupant(s) or third parties (such as an overpass or bridge). Light poles for which the obstacle effect remains within acceptable standards do not have to be protected. These poles can be positioned in the obstacle-free zone in the verge of the road. Passive safe poles can also be considered to save the installation of a crash barrier.

There is possible danger behind the poles, so a crash barrier is necessary.

There is less danger behind the pole. A crash barrier is not necessary if the pole is passive safe.

The easiest and safest choice is always to position a crash barrier. However, this is expensive, is esthetically not desirable and does not always fit. It also closes the sides of the road which can be a problem in a lot of local situations as well.

If it is decided not to position a crash barrier, passive safe light poles may be used. When considering the placement of a passive safe light pole, the risks that may arise if a vehicle gets off the road must also be taken into account. The vehicle can then end up in the zone behind it and pose a danger to third parties or to the occupant (s) (think of an overpass or bridge).

2.2 Determining the performance class

If you decide to use passive safe light poles, you can choose from a number of different performance classes. The safest pole for a particular road situation depends on the speed limit, and the presence of obstacles/objects (such as bridges/ walls) and other road users.

2.2.1 Non Energy absorbing (NE) poles

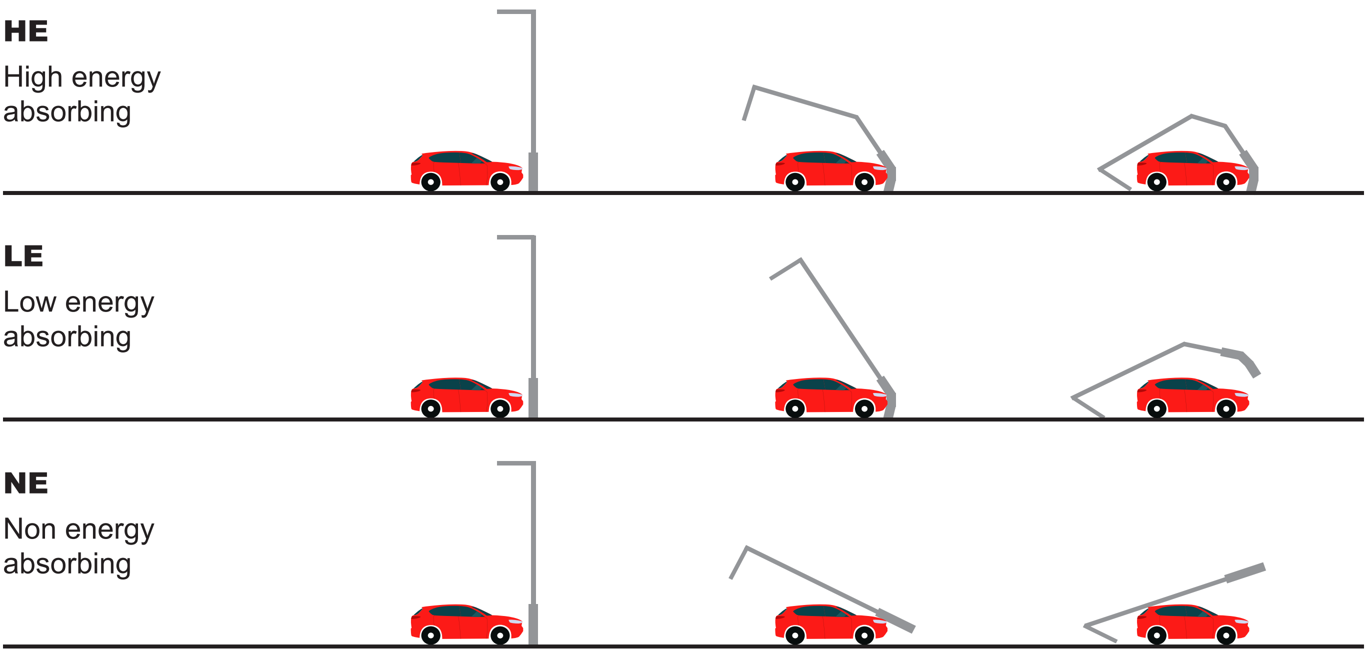
Poles with an NE classification perform excellently in the case of an "empty back field". The highest NE class (NE-C) can be achieved by fitting the pole with an additional shear off system. In addition, the backfill in which these poles are installed must be at least as stable as the backfill in which is tested. In bends, often side-ways collisions are realistic and NE-B will be the best performing class in these situations. NE poles are not recommended for roads along which pedestrians, cyclists or trees are located.

2.2.2 Low Energy absorbing (LE) poles

LE poles are often chosen between the two extremes: HE-C (formerly HE3) or NE-B (formerly NE3). In addition, an intermediate solution can be chosen: LE-C (previously LE3). LE poles often naturally possess the necessary passive safe qualities and require no extra engineered features, which makes them very cost-effective.

2.2.3 High Energy absorbing (HE) poles

Where there is an obstacle behind the pole, HE poles are the best choice if a crash barrier is not being used. The letter indication of the occupant safety level must be at the front of the alphabet as much as possible (HE-C is better than HE-D). HE- B would of course be even better, but is not technically feasible. Note: HE poles can still have an exit speed. The ultimate HE pole stops the vehicle.



Schematic representation of passive safe poles

In addition to the safety level for the occupant (s), the risk of indentation of the roof with HE masts is even more important. HE masts can hit the roof in a collision, posing great risks for the occupant (s). Safety level for the occupant (s) D in combination with risk of roof indentation class 0 is therefore a safer choice than safety level for the occupant (s) C in combination with risk of roof indentation class 1.

2.3 Secondary risks

In addition to the (limited) primary risks for occupant(s), a collision with a passive safe light pole can also pose secondary risks, with possible consequences for the occupant(s) and other road users (third parties). This is the case when the light pole (or parts of the light point) can land in traffic after a collision, as well as the risk because the vehicle may still be moving.

Given these risks, the installation of a crash barrier is a viable option. In this case, there are no special requirements for the passive safety of the light pole positioned behind that crash barrier.

Risks for third parties must in principle be assigned a (much) heavier weight than the risks for occupants.

2.4 Performance classes 100 km/h

In table 5 all performance classes are indicated for 100 km/h:

- If there is no risk of a secondary collision, a performance class from the top two rows is preferably chosen. For the occupant (s), 100-NE-B is the safest option, but if the back field is not 'empty' then concessions must be made. 100-LE-C or rather 100-HE-C are the best options.
- If the light pole has to brake a vehicle at a high speed to prevent secondary collisions, a performance class in the right hand column is preferably chosen.

Occupant safety level ↑

NE	LE	HE
100-NE-B-X-SE-MD-0 100-NE-B-R-SE-MD-0		
100-NE-C-S-SE-MD-0 100-NE-C-S-SE-MD-0	100-LE-C-S-SE-MD-0	100-HE-C-S-NS-MD-0
100-NE-D-S-SE-MD-0	100-LE-D-S-SE-MD-0	100-HE-D-S-SE-MD-0
	100-LE-E-S-SE-MD-0	

Safety level third parties →

Table 5: Hydro performance classes 100 km/h - For UK all classes are valid for Soil AND Rigid, see foundation disclaimer.pdf based on the NA to BS EN12767

The classification of a passive safe light is based on normalized situations. In practice, factors play a role that influence the performance of the light pole, as a result of which it may not perform as expected. In chapter 3 you can read more about deviating situations.

2.5 Performance class recommendations

The table below is part of the National Annex of BS EN 12767 and shows in order of priority the selection that best fits the situation.

Situation	Location	Type of support structure		
		Lighting column	**Sign or signal support (2)**	**Non-harmful support structure**
		Classifications listed (A, B, C, etc.) are in order of preference (1)	Classifications listed (A, B, C, etc.) are in order of preference (1)	
Non-built-up all purpose roads and motorways with speed limits >40 mph	Generally in verges of motorways, dual carriage-ways and single carriage-way roads	100:NE:NR:NR:NR:MD:0[3]	100:NE:NR:NR:NR:MD:0[3]	100:NE:A
	With significant volume of non-motorized users at the times when impact at the times when impact events occur	100:HE:NR:NR:NR:MD:0[3]	(A) 100:HE:NR:NR:NR:MD:0[3,4] (B) 100:LE:NR:NR:NR:MD:0[3,4] (C) 100:NE:NR:NR:NR:MD:0[3,4]	100:NE:A
	Where major risk of items falling on other carriage-ways below (e.g. at grade separated intercharges)	100:HE:NR:NR:NR:MD:0	(A) 100:HE:NR:NR:NR:MD:0[3,4] (B) 100:LE:NR:NR:NR:MD:0[3,4] (C) 100:NE:NR:NR:NR:MD:0[3,4]	100:NE:A or 70:NE:A
Built-up roads and other roads with speed limits >40 mph	All locations	(A) 70:HE:NR:NR:NR:MD:0 (B) 100:HE:NR:NR:NR:MD:0 (C) 70:LE:NR:NR:NR:MD:0 (D) 100:LE:NR:NR:NR:MD:0 (E) 70:NE:NR:NR:NR:MD:0[3,4] (F) 100:NE:NR:NR:NR:MD:0[3,4]	(A) 70:HE:NR:NR:NR:MD:0[3,4] (B) 100:HE:NR:NR:NR:MD:0[3,4] (C) 70:LE:NR:NR:NR:MD:0[3,4] (D) 100:LE:NR:NR:NR:MD:0[3,4]	100:NE:A or 70:NE:A
(1) Subject to the availability of compliant products that meet the specific needs of the particular situation (2) Includes supports for items of similar weight to that of the item supported in the test, such as variable message signs and speed cameras (3) Category MD is the most preferable in all situations, followed by category BD or category SD (4) Category NE can be accepted in any situation where the standard posts defined as 'deemed to comply' in Annex K are used				

Table 1: Overview changes EN 12767

Practical situation LE-C pole

A car crashed into an aluminium LE-C pole on the A29 Shripney Road (in the UK).

Because of the low speed of the car, its impact was “absorbed” by the LE-C pole.

Because the vehicle crashed into the pole at a lower speed than in the crash test, no seperation of the pole occurred.

“On paper, the choice of a particular type of passive safe pole in a particular situation seems logical. In practice, however, this has to be assessed for each location. The safest pole is the best choice for both the occupant(s) of the colliding vehicle and the other traffic and road users present.”

Bas van Boxtel, Technical manager, Pole Products

3. Practice versus test situation

In the EN 12767, the test protocol describes how light poles must be tested on passive safety. However, every collision situation in practice differs from the test situation. Chapter 3 explains the most important deviating situations that may occur in relation to the test protocol. In addition, abnormal situations may arise because the collision behaviour of a pole can change in the course of time due to environmental factors.

3.1 Backfill type

Every country has its own way of building foundations. There are many different soil types and installation techniques. They depend on the water levels and the extent to which the soil is compressed. In many countries, concrete foundations are used, but in some countries light poles are planted in soil. Backfill type S is a standardised soil with a specific composition and density. When positioning a pole in soil, it is important to remember that the composition of the soil is not homogenous. There are different soil types with different groundwater levels. In all cases, these are different to the soil that was tested (backfill type S). In addition, the temporary presence of rainwater, for example, can also affect the stability of the soil.

With a different soil type (e.g. composition, compaction, groundwater level, frost) the pole can unexpectedly be driven out of the ground or break off, and therefore not perform as in the crash test.

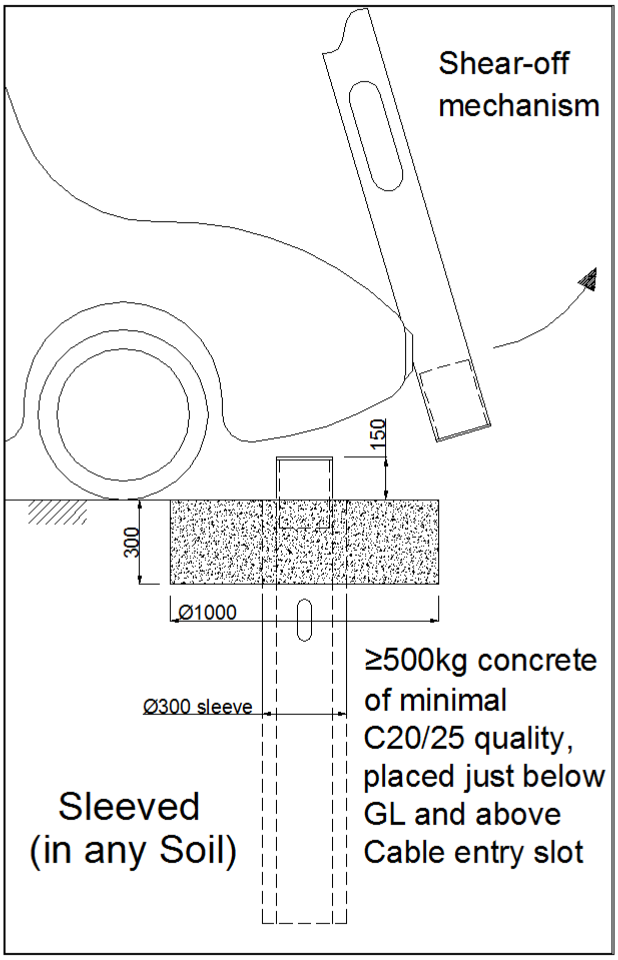
Sleeved foundation

To rule out deviations in the soil type (compared to the test determinants), the influence of soil variables can be minimized by installing the pole into an over-sized plastic tube or 'sleeve'. For shearing NE-B poles this can be done using a concrete element, for example. The element consists of at least 500 kg concrete of minimal C20/25 quality and creates a stabilising structure around a vertical pole.

By positioning enough concrete around an NE-B pole with a shear off construction (which was originally tested in backfill type S), all the variables in the soil are eliminated. This guarantees the NE-B classification.

Be aware that not all cases which use additional foundation stability will improve the performance. For example, an HE pole tested in backfill type S can perform worse in concrete, because it can break more easy during high speeds or not move away during low speeds.

For more information on foundations, see NA.5 of the national annex BS EN 12767.



3.2 Vehicle
The test vehicle described in the test protocol is a standard passenger car that weighs 900 kilos. A heavier/lighter vehicle can have a different impact on the passive safety of a pole. A result can be that an HE pole that is supposed to absorb the energy of the vehicle reacts in exactly the same way as an NE pole if a lorry, instead of a passenger vehicle, crashes into it.

3.3 Installation of the pole
The test protocol describes an impact height of a pole of 35 cm. If a pole has been installed too deep/shallow there are consequences for the behaviour of the pole during a crash. Possible consequence if a shear off system is installed in the ground (and not above ground according to the installation instructions) is that the pole might not shear of at all.

3.4 Collision angle
The standard specifies a possible collision angle of 20º (assuming that cars leave the road at an angle of 20º). In particular for directional sensitive objects (SD/BD), the behaviour may differ because the vehicle hits the object at a different angle.

Analysis of the registered accidents with (unshielded) light poles on highways shows that a significant part of the vehicles touches the object sideways and not frontally. That is why NE- B is usually preferred at highways entrances and exits where the car can hit the pole sideways in order to achieve the least possible amount of energy absorption. If there is a shear off construction in or on the pole, it is extra important that the pole is direction-insensitive (MD).

3.5 Collapse mode
The collapse mode can deviate in practice because differences with the test situation occur in the backfill type, the vehicle, installation of the pole, the speed and/or the collision angle. For example, in the event of a collision with a heavier vehicle, an object may break off earlier than in the test. And in the case of a situation where a pole has a shorter or longer ground piece, the pole may or may not be driven out of the ground.

3.6 Roof deformation
The roof deformation is determined under specific test conditions. Products (poles) can therefore be compared for dent sensitivity of the roof. However, in practice a different result will be visible, because the mentioned properties under collapse mode also influence the risk of roof indentation if these properties are different.

Example of a passive safe pole with a non-standard collision angle.

3.7 Maintenance and durability of passive safe poles and constructions

According to the EN 40, a light pole is calculated to have a life span of 25 years. During those 25 years, the light pole materials are subject to corrosion as a result of environmental factors, such as weather effects, stray electric currents, aggressive soil composition etc. That is why it is important to manage and maintain the poles properly.

To a greater or lesser extent, light poles almost always require maintenance and passive safe light poles are no exception. This depends on the types of materials used to manufacture the pole, the presence of coatings, type of root protection and the location of the pole. Regular cleaning, painting where necessary (see the manufacturer's maintenance instructions) and inspections are important to ensure that light poles remain in good technical condition.

Passive safe light poles are often supplied with constructions in or on the pole, so that they are eligible for NE or HE classification. These constructions may be located in the soil or on the outside of the pole or may be designed to be fitted on the inside of the pole. If and when dirt, water, salt or sand penetrate the construction and cause it to corrode, the pole will probably no longer perform as well as it did during the test.

For example, an HE pole that is locally affected by corrosion may lose its function, which means that the pole cannot 'absorb' a vehicle as effectively. The pole may then perform more like an NE pole, with all its consequences.

Another example: An NE-B construction may not shear off due to corrosion.

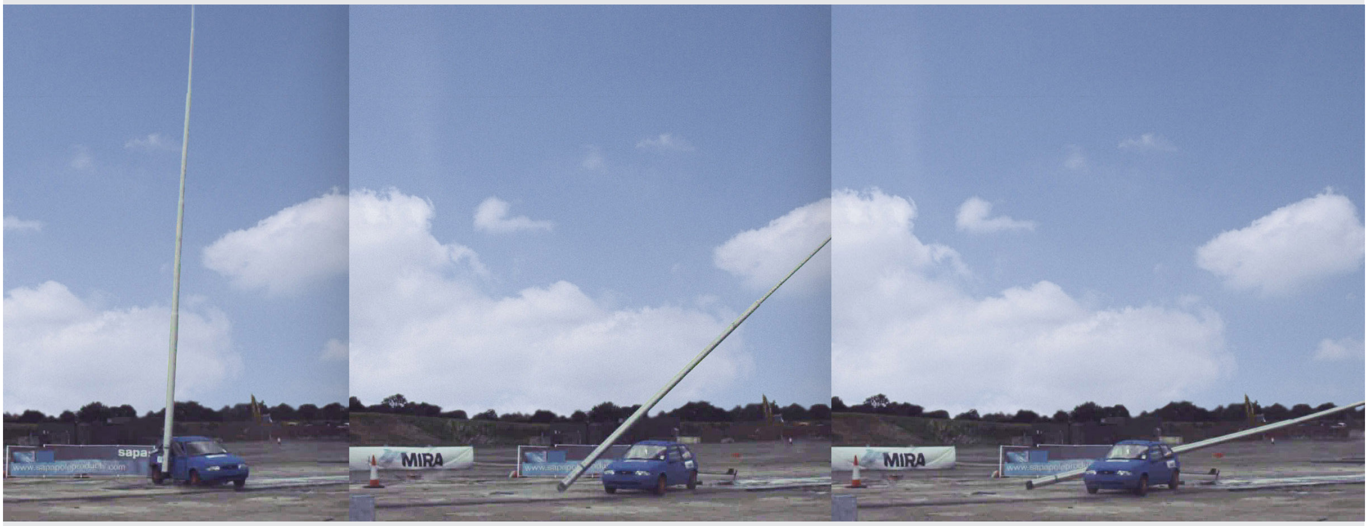
Note: There are several light pole tests in the market available to determine the condition of a light pole, especially the invisible root- section. The pole can be tested in order to postpone replacement of the pole at the end of its technical life. However, a light pole test is not indicative of a pole's shear off or energy absorbing behaviour.

Light pole in frozen soil

Even though the practical situation is different from the test situation, the EN12767 standard helps you to make the best possible passive safe choice.

Example of NE-B crash test, lateral collision

A Ford Fiesta crashed into an aluminium NE-B light pole from the side Fiesta (35 km/h). This is an informal crash test demonstration conducted in the UK that shows the shear off behaviour in case of a side impact.



Practical example with an LE-C pole

On the A66 in the UK, a car collided from the side with an aluminium LE-C light pole. The pole absorbed the impact of the collision, causing minimal damage to occupant(s) and to the vehicle. An HE-C pole would have been even better in this situation, because of the ditch behind the pole.

> *“All EN 12767 crash tests are conducted frontally, while side collisions (often at low impact speed) have much greater consequences for occupant(s).”*
>
> *Bas van Boxtel, Technical manager, Pole Products*

4. Other passive safe constructions

Not only light poles, but also other roadside objects can be passive safe. Examples of these objects are Traffic Signal Poles and Traffic Sign Posts. With around 15 percent of highway fatalities caused by vehicles striking roadside objects, it is important that the application of passive safe constructions is considered whilst designing traffic signal (or other) installations.

4.1 EN 12899-1

raffic Signal Heads and (Fixed) Variable Message Signs have their applicable Standards (see table 7), but for the structures used for these applications the relevant Standard is EN 12899-1. They need to be certified according to this Standard since July 2013.

For Passive Safety the EN 12899-1 refers to EN 12767. This means that the same crash classifications apply for these products as they do for light poles.

On the next pages, some examples of crash tests of other passive safe products are explained.

Products	Applicable standard
Traffic Signal Heads	EN 12368
Variable Message Signs	EN 12966
Fixed Vertical Message Signs	EN 12899-1

Table 7: Products and standards

Example of a demonstration of a crash of a vehicle into a Traffic Signal Pole

At Traffex Live in 2014, this 6m NE-C Raise and Lower aluminium passive safe Traffic Signal Pole was demonstrated. The pole was impacted by a 1500 kg Mondeo saloon car at 70kp/h.

The signal pole collapsed as designed, with minimal deceleration to the vehicle, thereby protecting any potential vehicle occupants from serious injury.

The demonstration also showed that the 8 kg push button box, mounted at windscreen height, does not constitute a dangerous object after a collision.

In the same test also the electrical disconnection was tested with a positive outcome.

The demonstration at Traffex Live 2014 of the passive safe traffic signal pole clearly proved the life saving capabilities of the pole, both in terms of passive safety, as well as avoiding the risk of electrocution. All electrics were isolated within the specified standard of 0.4 seconds of the impact. The ease with which damaged poles can be removed from the Retention Socket System, making this type of installation both cost effective and invaluable for Signal Maintenance organizations.

Example of a demonstration of a crash with a vehicle into a traffic pole

A crash demonstration at MIRA in England (May 2012) of a NE-C Shored-up multi-legged Sign Post clearly shows that the vehicle drives through the aluminum structure.
The test was performed with a 1500 kg (heavy) vehicle and a speed of 100 km/h. The board has a size of 4.5 m wide and 7.5 m high.

> *"Especially the big Sign Post structures can cause serious injuries when hit by a vehicle. This always needs to be considered when designing a road. It is not for nothing that the standard recommends a minimum mounting height of the signs of 2 meters."*
>
> *Bas van Boxtel, Technical manager, Pole Products*


Theatre Royal
Museum of
Road Transport
Darkstar Laser
Citadel
Hotel
Langtree Park
Stadium
The World
of Glass

Our advice

Nowadays, with over 31 million cars on the UK roads (with this figure still rising), it is vitally important to make the safest choices when it comes to public lighting and other roadside objects.

When the use of passive safe poles is considered, convince yourself that all criteria are met by making sure that:

- The product has a valid certificate (e.g. EN 40-6 or EN12899-1) that specifies the performance classe.
- The certificate has been signed by a Notified Body and is still valid.
- The applicable test reports (35, 50, 70 or 100 km/h) are available.
- The report of the low-speed test is available. In many cases, this is more critical than the high-speed test. For example, shear off constructions and absorption systems in the column will not always activate at low speed!
- The movies of the official crash tests are available. While watching the movies, you can often clearly see differences between the behaviour of the various shear off constructions and absorption systems. One HE pole will perform in a different way to another HE pole (e.g. exit can be 50 or 0 which differs a lot for secondary risk).
- The exit speeds and movies are available so that you can see the dents in the vehicle. After all, this secondary effect cannot be extracted from the performance class, but it can still cause very serious injuries to occupants

Besides checking the criteria, also think about the following when the use of passive safe poles is considered:

- Compare the local foundation situation with the test foundation.
- Make sure that the poles are installed carefully.
- Keep the ‘external’ shear off constructions clean.
- Follow the pole supplier’s maintenance recommendations.
- Choose the pole type that best suits the relevant road or road situation (environment).
- Make sure the poles are regularly checked on the effects of degradation (e.g. corrosion).

When you make a well-considered choice for passive safe poles by taking the above recommendations into consideration, the poles will increase the safety level without becoming an obstacle.

Crash test movies

Link crash test (YouTube)	Title	Description
Crash tests NE-B		
https://youtu.be/nuRKDM-ZiPE	Hydro crash test compilation NE-B	This movie shows crash tests of 35 km (low speed) and 100 km per hour (high speed) into a 15 meter 100-NE-B-X-SE-MD-0 certified aluminium lighting column from Hydro – Pole Products (fam 1). Overall view - close view – underground view.
https://youtu.be/rStyehiJLHc	Hydro crash demonstration NE-B Passive Safe vs Non Passive Safe lighting column	This movie shows a demonstration of a car crash into an NE-B certified aluminium lighting column from Hydro – Pole Products versus a Non-Passive Safe lighting column.
https://youtu.be/tGNDHCUaAEI	Hydro crash demonstration NE-B side impact	This movie shows a range of demonstrations of the side impact of a car crash at 35 km per hour into an NE-B certified aluminium lighting column from Hydro – Pole Products versus a steel column.
https://youtu.be/KTIQaZ5K30o	Hydro crash demonstration NE-B heavy vehicle	This movie shows a demonstration of a car crash with a heavy MASH-compliant vehicle into an NE-B certified aluminium lighting column from Hydro – Pole Products.
Crash tests NE-C		
https://youtu.be/zUIxOo76MIM	Hydro crash test NE-C (35 km/h)	Crash test 35 km per hour (low speed) into a 10 meter NE-C certified aluminium lighting column from Hydro – Pole Products.
https://youtu.be/lF_Jp69l4RA	Hydro crash test 70-NE-C-S-SE-MD-0 (70 km/h)	Crash test 70 km per hour (high speed) into a 10 meter 70-NE-C-S-SE-MD-0 certified aluminium lighting column from Hydro – Pole Products (fam 2).
https://youtu.be/KTIQaZ5K30o	Hydro crash test 100-NE-C-S-SE-MD-0 (100 km/h)	Crash test 100 km per hour (high speed) into a 10 meter 100-NE-C-S-SE-MD-0 certified aluminium lighting column from Hydro – Pole Products (fam 2).
https://youtu.be/58dIOnSMXeA	Hydro crash test 100-NE-C-R-SE-MD-0 (100 km/h)	Crash test 100 km per hour (high speed) into a 10 meter 100-NE-C-R-SE-MD-0 certified aluminium lighting column from Hydro – Pole Products (fam 2).
https://youtu.be/kK4DZjE7HWk	Hydro crash test NE-C (35 km/h) Neo Classic	Crash test 35 km per hour (low speed) into a 12 meter NE-C certified aluminium MSI Neo Classic lighting column from Hydro - Pole Products (fam 10).
https://youtu.be/YxhvoDBiLbY	Hydro crash test 100-NE-C-R-SE-MD-0 (100 km/h) Neo Classic	Crash test 100 km per hour (high speed) into a 12 meter 100-NE-C-R-SE-MD-0 certified aluminium MSI Neo Classic lighting column from Hydro – Pole Products (fam 10).

Link crash test (YouTube)	Title	Description
Crash tests HE-D		
https://youtu.be/XTesO-gM0tU	Hydro crash demonstration HE (70 km/h)	Crash demonstration MIRA 70 km per hour into a 12 meter HE certified aluminium lighting column from Hydro – Pole Products. Frontal view – inside car view – close view.
https://youtu.be/ZDev6Mo4_IY	Hydro crash test compilation HE	This movie shows crash tests of 35 km (low speed) and 100 km per hour (high speed) into a 12 meter 100-HE-D-S-NS-MD-0 certified aluminium lighting column from Hydro - Pole Products (fam 8-2). Overall view and close view.
Crash tests NE-C shored up		
https://youtu.be/J2UXe29i3DE	Hydro crash test NE-C (100 km/h) shored up multileg sign post	Crash test 100 km per hour (high speed) into an 100-NE-C-S-SE-BD-0 certified aluminium shored up multileg Sign Post from Hydro – Pole Products (fam 3).
https://youtu.be/zm8bnpd0PCE	Hydro crash test NE-C (35 km/h) shored up multileg sign post	Crash test 35 km per hour (low speed) into an NE-C certified aluminium shored up multileg Sign Post from Hydro – Pole Products.
https://youtu.be/vmtcAvnlbx8	Hydro crash demonstration NE-C (100 km/h) shored up multileg sign post. Backview	Crash demonstration MIRA 100 km per hour into an NE-C certified aluminium multileg Sign Post from Hydro – Pole Products. Backview
https://youtu.be/S-0cidm6fVk	Hydro crash demonstration NE-C (100 km/h) shored up multileg sign post. Frontview	Crash demonstration MIRA 100 km per hour into an NE-C certified aluminium multileg Sign Post from Hydro – Pole Products. Frontview
Crash tests NE-C Traffic Signal Poles		
https://youtu.be/4aYiyH4R_VU	Hydro crash demonstration NE-C (100 km/h) TSP, overall view	Crash demonstration MIRA 100 km per hour into an NE-C certified aluminium 4m Traffic Signal Pole with push button pedestrian control from Hydro – Pole Products. Overall view.
https://youtu.be/7KVzst6CNI0	Hydro crash demonstration NE-C (100 km/h) TSP, close view	Crash demonstration MIRA 100 km per hour into an NE-C certified aluminium 4m Traffic Signal Pole with push button pedestrian control from Hydro – Pole Products. Close view.
https://youtu.be/kjPSKvWSibU	Hydro crash demonstration NE-C (70 km/h) R&L TSP	Crash demonstration MIRA 70 km per hour into an NE-C certified aluminium Raise & Lower 6m Traffic Signal Pole from Hydro – Pole Products. Side view.

Sources

- BS-EN 12767:2019, Passive safety of support structures for road equipment – Requirements and test methods

- Publication SWOV 1977 “Obstacles along the road” (Dutch)

- Various articles published in specialist journals

Websites:

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  http://www.ukroadlighting.com/

- Road statistics:
  http://www.statista.com/statistics/299972/average-age-of-cars-on-the-road-in-the-united-kingdom/

- Nando:
  http://ec.europa.eu/enterprise/newapproach/nando/

- Traffex Live 2014:
  http://www.ukroads-traffex-live.com

- Traffex SIB 2018:
  http://www.sib.uk.net/

For more information

Would you like to know more about passive safe light poles or road structures?

Please feel free to contact us to make an appointment. We are also at your service to help if you have any questions about the new revision of the EN 12767. We are represented in the European Standards Committee for light poles CEN TC 50 and the related working group WG10 who produced the EN 12767:2019, and therefore closely involved in the standard.

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