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Norwegian Public Roads Administration

Road traffic safety equipment

Technical requirements

NPRA Guidelines Manual 062E

Directorate of Public Roads
Roads and Transport Department 2011

Road traffic safety equipment

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Norwegian Public Roads Administration Manuals

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This English version is a translation of the Norwegian text. In case of linguistic differences between the two versions, the Norwegian version is the valid one.

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Preface

A new edition of Manual 062 Road traffic safety equipment was published in 2005. The manual was then given the sub-title "Requirements relating to performance and materials", with the emphasis on performance requirements. In some product areas it was difficult to distinguish between the different requirements, and in this revised version it has been decided to change the sub-title to "Technical requirements". Although this covers the contents more appropriately, it is still performance requirements that are in focus.

Our aim with the manual is to achieve correct, good products throughout the road network, which in turn will create a functional, unified road environment with safe traffic. One of the key functions of Manual 062 is to specify the classes in the relevant European norms (EN) that are to be used on public roads in Norway.

The manual's target group is primarily personnel who are involved in planning programmes and procuring equipment, and the manufacturers. The manner in which the manual is used will vary considerably, depending on the responsibilities and tasks of the users. The manual can be used as a reference basis in connection with tendering, entry into contracts and training.

Manual 62 is to be updated continually, and the current version is available on the internet.
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The Norwegian Public Roads Administration, Directorate of Public Roads, December 2010

Responsible unit:
Roads and Transport Department/Traffic Management Section

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Introduction

The Directorate of Roads has drawn up these technical requirements for road traffic safety equipment. The purpose of the manual is to ensure satisfactory and consistent quality throughout the roads network. The manual therefore forms a good basis both for planning programmes and for procuring traffic safety equipment. Since purchases of this sort of equipment often take place through different procurement processes, the manual has been divided into 6 parts. This will also make it easier to update the book.

It is important to see each part in relation to relevant legislation, standards and other manuals, and references to these are given in each section. Requirements regarding other equipment may also be published in separate manuals – for example Manual 231, Rekkverk [Guardrails], and Manual 264, Teknisk planlegging av veg- or gatebelysning [Technical planning of road and street lighting].

Norway has committed itself through international agreements to observing current European standards (EN/CEN). The standards in question are referred to in the individual parts of this manual.

Validity, authority to deviate from requirements

The requirements in the manual apply to equipment and products on the national highways. It is recommended that the requirements be applied to other roads.

In some cases the guidelines may be deviated from. The meaning of the terms 'shall', 'should' and 'can', and who has the authority to deviate from the technical requirements, is set out in the table below. Before the appropriate authority agrees to deviate from the requirements, the consequences should be considered.

Verb	Meaning	Deviation
Shall	Requirement	Can be deviated from by the Director General or an authorised person in the Directorate of Roads. Reason shall be given for the deviation. Deviation is not possible from the following: - Requirements with a legal basis in laws, regulations and rules - Conditions of a nature that clearly excludes them from discussion
Should	Recommendation	Can be deviated from by the Regional Road Director or an authorised person in the region. Reasons shall be given for the deviation.
Can/may	Option/Example	May be deviated from on the basis of a technical assessment without special requirements for approval routines.

Procurement of products

In the specifications, clear requirements must be made of which products are to be procured and what quality is desired. For products covered by Manual 062, reference must be made to this manual. As a rule the manual refers to which class according to the NS-EN standards is desired.

Products covered by a relevant NS-EN standard shall be tested and approved for Scandinavian climate zones by an approved inspection institution unless otherwise specified in the specifications. In the latter case, it must be possible to submit documentation.

1 Fixed road traffic signs

1.1 General

1.1.1 Introduction

The Norwegian Public Roads Authority has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce damages in any accidents that nonetheless occur. Traffic signs are an important part of the system that safeguards road users in crossings and on stretches, and the requirements to their functional properties are high.

Part 1 contains technical requirements for permanent and temporary road traffic signs with reflective properties. In principle, all public road traffic signs shall have reflective properties. By road traffic sign is meant signs that have a fixed message and which are mounted at fixed points throughout the road network. A road traffic sign usually consists of the sign plate itself (aluminium/reflective sheeting/coating material), necessary clamps, the signpost or column and foundation. Part 1 concerns the sign plate itself and appurtenant reflective sheeting. The requirements also apply to externally and internally illuminated signs that have reflective sheeting.

Variable message road traffic signs are discussed in Part 2 of the manual, while safety support and fastening equipment are discussed in Part 5.

Economic concerns enter into the calculation when minimum requirements for the quality and strength of materials that are used for road traffic signs and their mounting are to be specified. Costs for production and installation must be in reasonable relation to the service life of the signs, and necessary maintenance must be able to be carried out in a rational, efficient manner. Among other things, this means that the many components that make up a sign must be standardised. To the extent that specific material specifications are given in this part of the manual, these are based on current technology and production methods. The Norwegian Public Roads Administration, however, is open to new and more cost-effective solutions that are at least of a corresponding quality. In the event, they must have special approval from the Directorate of Public Roads.

1.1.2 Validity

The requirements in this manual's Part 1 apply to permanent and temporary road traffic signs that are erected along new and existing roads. The requirements apply during the product's guarantee period.

By "product", we mean sign plate and appurtenant reflective sheeting. The guarantee period is 7 years for road traffic signs with sheeting class 1, 10 years for road traffic signs with sheeting class 2 and 12 years for road traffic signs with sheeting class 3. For technical

requirements beyond the guarantee period, reference is made to Manual 111 Drift og vedlikehold [Operation and maintenance], and the contracts that have been signed. The requirements apply to all national roads. For other roads, it is recommended that the requirements be applied.

1.1.3 International requirements

Norway is obliged by international agreements to adhere to current European standards. European standard NS-EN 12899 Fixed, vertical road traffic signs – Part 1 Fixed signs addresses the technical requirements for permanent and temporary road traffic signs.

1.1.4 Terms and definitions

For a traffic sign to be able to fulfil its task in road traffic, it must at all times, in daylight and in darkness, be visible and readable.

- By visible is meant that the sign must be able to be seen by the road user at an adequately long distance.
- By readable is meant that the sign's message must be able to be interpreted at an adequately long distance.

Visibility presupposes that the sign as a whole has a certain luminance, and contrast in relation to the surroundings. Readability also requires luminance, and in addition that the sign's symbol adequately contrasts with the surface of the sign itself. The problems of visibility and readability are most critical at night, because the only light source then is often the car's own headlights. This problem is met by covering the sign plate with a reflective sheeting, either alone or in combination with illumination. Road traffic signs can be internally or externally illuminated. Externally illuminated signs are normal signs with reflective sheeting, which have an external light source. Internally illuminated signs can be both with and without reflective sheeting.

In the following, a number of key concepts and expressions are explained

Luminance:	Luminance is a measure of how light a surface is (the surface of the sign). The unit of measurement for luminance is cd/m^2
Retroreflection:	The sign sheeting's ability to reflect light from vehicle headlights back to the driver.
Retroreflection coefficient:	Measurement of the sign sheeting's visibility in the dark. Unit of measurement for the retroreflection coefficient is cd/ lx/m^2.
Colour coordinates:	The colour of the sign sheeting is indicated as colour coordinates x, y in the CIE colour system.
Luminance factor:	The luminance factor indicates the material's ability to reflect light in relation to a perfect diffuse reflector, illuminated and observed under the same conditions. A perfect diffuse reflector has a value of 1.0.

1.2 Reflective sheeting

1.2.1 Selection of reflective sheeting class

All road traffic signs shall be retroreflective (except sign no. 570.2). Reflective sheeting for Norwegian road traffic signs are divided into three classes. These classes are determined on the basis of the reflective properties of the sheeting. It is important to clarify that the properties relating to the light technology of retroreflective sheeting are not necessarily linked to specific products or production methods. Fig. 1.1 shows the three classes that are used and typical retroreflection values for new road traffic signs (on delivery) with white sheeting in the various classes.

Class	Typical R' value (white sheeting)
Class 1	90
Class 2	230
Class 3	370–700

Figure 1.1 Classes for reflective sign sheeting. R' values are assumed to be measured at an observation angle of 0.33° and an approach angle of 5°.

However, product development can be expected that will make it possible to select different luminance levels independently of the production method. As of 2010, Class 1 glass beads come in plastic or micro-prisms, Class 2 can be had as glass beads in air or micro-prisms, while Class 3 only comes as microprismatic.

The requirements in Fig. 1.2 apply to the selection of class for retroreflective sheeting for road traffic signs with a fixed message, but also apply to signs with variable messages that are made with retroreflective sheeting.

The system is based on sign groups and two types of surroundings. Requirements for the selection of class of sheeting are indicated in Fig. 1.2. The figure indicates which sign groups shall be Class 1, Class 2 or Class 3 in the two different types of surroundings. Note that the definition of type of surroundings is linked to the nature of the settlement (urban/rural) and that road lighting has no effect on determining the type of surroundings. For example, a stretch of road that is sparsely populated by definition will be rural, even if there is road lighting along the stretch.

All temporary road traffic signs used to warn about road works shall have Class 3 sheeting. The same technical requirements for such temporary road traffic signs are made as for permanent road traffic signs.

Remember:

- Road traffic signs mounted on the same post and which apply to the same traffic direction shall have the same class of sheeting. It is the highest class of sheeting in the sign assembly that shall be used.

Sign grou	Type of surroundings	
	Rural	Densely populated/ city streets
All sign groups: - Signs placed on the side of the road (that are not illuminated) where the text or symbols are higher than 3.5 m above the carriageway. - igns hanging over the road that are not illuminated	Class 3	Class 3
	Klasse 3	Class 3
Danger warning signs (in general) - road work (110), distance to pedestrian crossing (140)	Class 2	Class 2
	Class 3	Class 3
Give way and priority signs, - signs 202, 204, 210, 212	Class 2	Class 2
Give way and priority signs, - signs 206, 208, 214	Class 1	Class 2
Prohibitory signs (in general)	Class 1	Class 2
- signs 334 (passing prohibited), 362 (speed limit)	Class 1	Class 2
- sign 302 (no entry)	Class 2	Class 2
Mandatory signs (in general)	Class 1	Class 1
- on traffic islands	Class 3	Class 3
Information signs (in general)	Class 1	Class 1
- pedestrian crossing sign (516)	Class 3	Class 3
Service signs	Class	Class 1
Direction signs	Class 1	Class 2
Supplementary signs: Same reflective class as the main sign	-	-
Indication signs	Class 3	Class 3
- background indication (902) and direction indication (904)	Class 2	Class 2

- On multi-lane roads in city areas (with competing light sources) at high speed, a higher class should be used than the table above requires (i.e. Class 2 or 3)
- In rural areas, on roads with AADT > 8000, a higher class of sheeting can be used than required by the table above.
- Tunnels:
  - In tunnels with lighting, all signs except indication signs shall be internally illuminated (except sign 570.2 which shall be after-glowing)
  - In tunnels without lighting, Class 3 sheeting shall be used

Figure 1.2 Requirements for the selection of reflective sheeting class) for road traffic signs.

1.2.2 Retroreflection

In the following tables, retroreflection requirements for the individual classes of sheeting are given.

- Class 1
- Class 2
- Class 3

The values measured shall not be less than the values specified in the respective tables, and for each colour at different entrance and observation angles.

The measurements shall be carried out on clean, dry sheeting.

Measurement shall be carried out with an instrument that satisfies the specifications given in NS-EN 12899-1, with appurtenant references. Retroreflection is calculated according to the following formula:

R′ = I/E (cd / lux / m²)

R′ = Retroreflection coefficient:

I = Amount of light reflected from 1 m² of the sample tested, measured in candela (cd)

E = Luminous intensity on the test surface measured in lux (lx)

A normal measurement is carried out at an observation angle of 0.33° and an entrance angle of 5° (standard geometry). See the following figures:

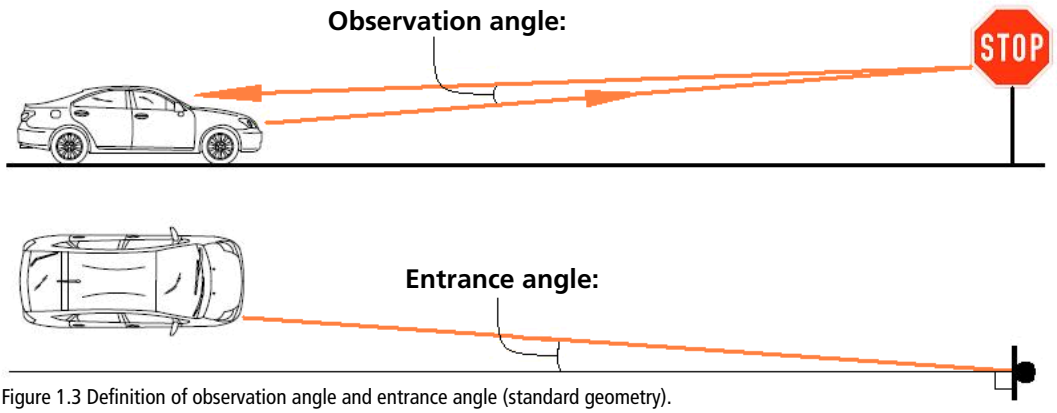


Figure 1.3 Definition of observation angle and entrance angle (standard geometry).

The following minimum requirements apply within the guarantee period. The shaded row in the tables indicates the values measured with instruments using standard geometry. The three following tables, Figs 1.4-1.6, apply for Classes 1, 2 and 3, respectively.

		NS-EN 12899-1 Class Ref 1 (cd/ lux/ m²)						
Observation Angle α	Entrance angle β	White	Yellow	Red	Green	Blue	Brown	Orange
0,2⁰ (12')	5⁰	70	50	14,5	9	4	1	25
	30⁰	30	22	6	3,5	1,7	0,3	10
	40⁰	10	7	2	1,5	0,5	#	2,2
0,33⁰ (20')	**5⁰**	**50**	**35**	**10**	**7**	**2**	**0,6**	**20**
	30⁰	24	16	4	3	1	0,2	8
	40⁰	9	6	1,8	1,2	0,4	#	2,2
2⁰	5⁰	5	3	1	0,5	#	#	1,2
	30⁰	2,5	1,5	0,5	0,3	#	#	0,5
	40⁰	1,5	1,0	0,5	0,2	#	#	#

Figure 1.4 Minimum retroreflection coefficient R' for Class 1 sheeting. # indicates values greater than zero.

		NS-EN 12899-1 Class Ref 2 (cd/ lux/ m²)						
Observation Angle α	Entrance angle β	White	Yellow	Red	Green	Blue	Brown	Orange
0,2⁰ (12')	5⁰	250	170	45	45	20	12	100
	30⁰	150	100	25	25	11	8,5	60
	40⁰	110	70	15	12	8	5	29
0,33⁰ (20')	**5⁰**	**180**	**120**	**25**	**21**	**14**	**8**	**65**
	30⁰	100	70	14	12	8	5	40
	40⁰	95	60	13	11	7	3	20
2⁰	5⁰	5	3	1	0,5	0,2	0,2	1,5
	30⁰	2,5	1,5	0,4	0,3	#	#	1
	40⁰	1,5	1,0	0,3	0,2	#	#	#

Figure 1.5 Minimum retroreflection coefficient R' for Class 2 sheeting. # indicates values greater than zero.

		DIN 67520:2008-11 (cd/ lux/ m²)						
Observation Angle α	Entrance angle β	White	Yellow	Red	Blue	Green	Fluoresc. yellow-green	Fluoresc. orange
0,33⁰ (20')	**5⁰**	**300**	**195**	**60**	**19**	**30**	**240**	**90**
	30⁰	165	110	33	11	17	130	30
1,5⁰	5⁰	15	10	3	1	1,5	12	4,5
	30⁰	9	6	2	-	-	7	2,5

Figure 1.6 Minimum retroreflection coefficients R' for Class 3 sheeting (Class RA3B). These shall be met. .

1.2.3 Daylight chromaticity and luminance factors

The following tables provide requirements with respect to luminance factors and daylight chromaticity (colour coordinates) for different colours and classes of sheeting.

All reflective materials that are used for road traffic signs shall meet these requirements.

The measurements shall be carried out with instruments that satisfy the specifications given in NS-EN 12899-1, with appurtenant references. The chromatic values (colour coordinates) shall lie within the corner points as specified in Figs 1.8-1.10.

NS-EN 12899-1				
Colours	Sheeting in Class 1		Sheeting in Classes 2 & 3	
	Min.	Max.	Min.	Max.
White	0,35	-	0,27	-
Yellow	0,27	-	0,16	-
Orange	0,17	-	0,14	
Red	0,05	-	0,03	-
Blue	0,01	-	0,01	-
Green	0,04	-	0,03	-
Brown	0,03	0,09	0,03	0,09
Fluorescent yellow-green	-	-	0,50	-
Fluorescent orange	-	-	0,20	-

Figure 1.7 Luminance factor requirements for sign sheeting in Classes 1, 2 & 3.

	NS-EN 12899-1 Class CR1							
Colours	Point 1		Point 2		Point 3		Point 4	
	x	y	x	y	x	y	x	y
White	0,355	0,355	0,305	0,305	0,285	0,325	0,335	0,375
Yellow	0,522	0,477	0,470	0,440	0,427	0,483	0,465	0,534
Orange	0,610	0,390	0,535	0,375	0,506	0,404	0,570	0,429
Red	0,735	0,265	0,674	0,236	0,569	0,341	0,655	0,345
Blue	0,078	0,171	0,150	0,220	0,210	0,160	0,137	0,038
Green	0,007	0,703	0,248	0,409	0,177	0,362	0,026	0,399
Brown	0,455	0,397	0,523	0,429	0,479	0,373	0,558	0,394

Figure 1.8 Daylight chromaticity in daylight for sign sheeting in Class 1.

	NS-EN 12899-1 Class CR2							
Colours	Point 1		Point 2		Point 3		Point 4	
	x	y	x	y	x	y	x	y
White	0,305	0,315	0,335	0,345	0,325	0,355	0,295	0,325
Yellow	0,494	0,505	0,470	0,480	0,513	0,437	0,545	0,454
Red	0,735	0,265	0,700	0,250	0,610	0,340	0,660	0,340
Blue	0,130	0,090	0,160	0,090	0,160	0,140	0,130	0,140
Green	0,110	0,415	0,170	0,415	0,170	0,500	0,110	0,500
Brown	0,455	0,397	0,523	0,429	0,479	0,373	0,558	0,394

Figure 1.9 Daylight chromaticity in daylight for sign sheeting in Classes 2 & 3.

The requirements for fluorescent products necessitate testing according to methods described in the CIE Publication 15.2 Colorimetry, 1986 (45/0 geometry).

	CUAP 2002							
Colours	Point 1		Point 2		Point 3		Point 4	
	x	y	x	y	x	y	x	y
Fluorescent yellow-green	0,387	0,610	0,460	0,540	0,438	0,508	0,376	0,568
Fluorescent orange	0,595	0,351	0,645	0,355	0,570	0,429	0,531	0,414

Figure 1.10 Daylight chromaticity in daylight for sign sheeting with fluorescent colours (Class 3).

1.2.4 Physical requirements

Light-reflecting surfaces shall be completely covered by light-reflecting material. Reflective materials shall not deviate noticeably in colour from the actual standard colours, whether they are seen in daylight or illuminated by vehicle headlights in the dark.

If reflective material of the same colour must be applied to several sections, no difference in colour nuance shall show among any of the sections.

One sided signs shall be single coloured with a neutral reverse, usually grey. Other colours may be used for the reverse when the colour is part of a common colour scheme for signs, posts and fixings along a stretch of road or in an area.

Figure 1.11 Example of an undesirable difference in colour nuance.

1.3 Illuminated road traffic signs

1.3.1 Visibility

When vehicle headlights are not an adequate light source to give road traffic signs with normal reflective sheeting the necessary luminance, illuminated road traffic signs are used. Internal or external lighting is used, for example when signs hang over the carriageway and for other signs that are considered to be especially important. For example, where it is difficult to achieve good visibility with normal sign sheeting and where the consequences of not seeing the sign are great.

In illuminated tunnels, all road traffic signs except indication signs (sheeting class 3) and 570.2 (after glowing) shall be internally illuminated. Marking sign 912 Motorway exit sign used in illuminated tunnels, should be illuminated.

Luminance level

Depending on the type of surroundings, internally illuminated road traffic signs shall fulfil minimum requirements as listed in the table below.

- For rural surroundings in densely populated areas, as well as tunnels, the minimum used shall be Class L1.
- In city/town streets and surroundings with strong competing light sources, Class L2 shall be used.

It is important that dimensioning also takes into account that the effect may decline over the light source's service life and that the signs will become soiled. The new value should therefore lie towards the upper limit, and the level should never be under the minimum value during the life of the sign.

	NS-EN 12899-1 cd/m²	
Colour	Class L1	Class L2
White	40 ≤ L ≤ 150	150 ≤ L ≤ 300
Yellow	30 ≤ L ≤ 100	100 ≤ L ≤ 300
Red	6 ≤ L ≤ 20	20 ≤ L ≤ 50
Blue	4 ≤ L ≤ 10	10 ≤ L ≤ 40
Green	8 ≤ L ≤ 20	20 ≤ L ≤ 70
Brown	4 ≤ L ≤ 10	10 ≤ L ≤ 40

Figure 1.12 Luminance classes for internally illuminated signs.

Measurement of luminance shall be carried out in accordance with the description given in NS-EN 12899-1. Externally illuminated road traffic signs shall have an average luminance of at least 450 lux.

Luminance contrast

The luminance contrast, K, expresses the ratio between the luminance levels of different contrasting colours. For the colours blue, red, green and brown, the relation in luminance to a white background will be (for both externally and internally illuminated road traffic signs):

$$5 \leq K \leq 15$$

Luminance evenness

Evenness in the level of luminance expresses the variation in luminance level over the entire surface of the sign for one and the same colour.

NS-EN Class	The sign height (m)	Max. ratios
U1	Over 3 m	1/10
U2	1–3 m	1/6
U3	Under 1 m	1/3

Figure 1.13 Requirements for luminance evenness, illuminated road traffic sign.

For externally illuminated road traffic signs, the requirement with respect to Class U2 applies, i.e. the minimum lighting strength on the sign plate shall be at least 1/6 of the maximum strength.

Figure 1.14 Examples of internally illuminated road traffic signs with bad luminance evenness.

1.3.2 Physical requirements

The complete structure (outer enclosure, installation equipment, door hinges, closing and locking mechanisms, equipment inside the armour) shall be adapted to the climate, usage and maintenance conditions it will be subject to, so that all functional requirements can be expected to be satisfied during its service life.

Internally illuminated signs, as a minimum, shall be of IP Class 55 (ref. NEK-EN 60529), but higher classes can be considered in each case depending on the surroundings in which the sign will stand, for example, in a tunnel.

1.4 After glowing emergency exit signs in tunnels – 570.2

Under normal conditions, sign 570.2 is illuminated by tunnel lighting, but in the case tunnel lighting is cut off, the signs themselves shall remain lit for a longer period.

Signs with after glowing properties are dependent on lighting to be able to function in an emergency situation. The requirement for lighting of after glowing signs is normally 25 lux with 3000 Kelvin fluorescent lamps. Lighting in some tunnels may be less than 25 lux, but even at lower levels of lighting, the after glowing signs shall satisfy the luminance requirements described below. To check lux values, a calibrated lux meter is used by placing it flat against the tunnel wall (at 1.5 m height) and the values read off.

It is important that dimensioning also takes into account that luminance may be reduced due to soiling of the signs over time. Required luminance values will therefore reflect this, and the values after installation should therefore lie towards the upper limit and the level shall never be lower than the minimum value during the lifetime of the sign. The following luminance values for after glowing signs are required:

New value after installation in normal tunnel lighting:
After 60 minutes: 15 mcd/m^2

Minimum value during the sign life:
After 60 minutes: 10 mcd/m^2

If a control measurement of signs in the tunnel is needed, this shall be carried out after installation in accordance with the description given in NS 3926:2009.

1.5 Sign plates

1.5.1 Material quality

Standard signs shall normally be made of quality 5052/5754 aluminium plates, while for extruded profiles, quality 6063/6061 is normally used.

Other qualities and materials can be used if they are of a quality corresponding to that specified for aluminium, but only after the Directorate of Public Roads gives its approval. The Directorate of Public Roads has carried out comparison testing using recycled aluminium of quality 3003 and 3015 H 18, and approves these for standard road traffic signs.

Sign 570.2 After glowing emergency exit sign
Salt water resistance aluminium with after glowing material shall be used for road traffic sign 570.2, which can be mounted flat on tunnel walls, on doors, beside or over doors. The symbol shall be printed on the sign plate and covered with a protective coat. The signs must be able to tolerate cleaning in accordance with normal procedures. The sign can be 1.0-1.2 mm thick.

Where signs are to be mounted away from the tunnel wall, or where it is preferred for other reasons, it is recommended that acid proof stainless steel (SS304) is used, after glowing material and symbol printed on and covered with protective clearcoat. The signs must be able to tolerate cleaning in accordance with normal procedures. The sign can be 0.5-0.8 mm thick.

The complete structure (the sign, fixing system etc.) shall be adapted to the climate, usage and maintenance conditions it will be subject to, so that all functional requirements can be expected to be satisfied during its lifetime. Signs with after glowing properties shall not emit toxic materials in fires, nor shall they be able to cause fires.

1.5.2 Surface treatment
The sign plate must receive surface treatment so that the sign lasts for its expected service life. Good adhesion must be ensured between the sign plate and sheeting. The methods used to accomplish this are for example chromatization, use of transparent lacquer and anodizing. Materials that present a danger to health and the environment shall not be used.

1.5.3 Design
Pointed corners on flat plates or on the side of the flange that is away from the road traffic sign shall be rounded off, with a minimum radius of 20 mm. Rounded corners are particularly important in areas with pedestrians and cyclists.

Signs consisting of several panels (extruded profiles) shall have mounted mouldings.

Plate thicknesses in mm for different signs and groups of signs are given in the figure on the next page, as well as whether they shall be made in VD profiles. More signs can be made in VD profile.

Sign no.	Sign size			VD profile
	LS	MS	SS	
	Thickness mm			
100–156 * [1]	2,5	3,0	3,0	
136			3,0	
138		6,0		
202	2,5	3,0	3,0	
204		3,0		
206–208	3,0	3,0		
210	2,5	3,0	3,0	
212	2,5	3,0		
214		3,0		
302–364	2,5	3,0	3,0	
366–368		3,0		
370–372	2,5	3,0		
376–378		3,0		
402–406	2,5	3,0	3,0	
502–505		3,0	3,0	x
508–511	3,0	3,0		x
512–514 [2]		3,0		
516	3,0	3,0		
518–522		3,0		
524–528		3,0		
530–539		3,0	3,0	x
540–550		3,0		
552 [3]	3,0			
555		3,0	3,0	x
556-558	3,0	3,0		x
560		3,0		x
570	3,0	3,0	3,0	
601–637	3,0	3,0	3,0	x
701				x
703				x
705				x
707				x
709				x
711				x
713 [4]				x
715				x
717				x

Sign no.	Sign size			VD profile
	LS	MS	SS	
	Thickness mm			
719				x
723.11–723.16		3,0		
723.21– 723.22		3,0		
723.31–723.41		3,0		
723.51–723.66		3,0		
723.71–723.73		3,0		
725				x
727				x
729	4,0	4,0		
731–745				x
749	4,0	6,0		x
751	4,0	6,0		x
753	3,0	3,0	3,0	
755	3,0	3,0	3,0	
757	3,0	3,0	3,0	
802–808	3,0	3,0	3,0	x
810	3,0	3,0	3,0	x
812		3,0	3,0	x
813	3,0	3,0	3,0	x
814-816	3,0	3,0		x
817	3,0	3,0	3,0	x
822	3,0	3,0		x
824		3,0	3,0	x
826	3,0	3,0		
828		3,0		
829	3,0			
831	3,0			
834	3,0	3,0		
902		3,0		x
904	3,0	3,0		x
906 [5]	3,0	3,0		
908		3,0		x
912		3,0	3,0	x
914 [6]		3,0		
916	3,0	3,0		
930		3,0		x

Figure 1.15 Plate thicknesses in mm and requirements for VD profiles.l

Note 1) Except 136 and 138 Note 2) Symbol on both sides Note 3) Can have symbol on both sides Note 4) Except small directional signs Note 5) US: 3.0 mm

Note 6) A vertical flange on the right edge of the right indication sign, seen from the direction of the traffic

Road traffic signs of profiled plates (extruded profiles)

Road traffic signs can be made of specially formed aluminium plates after specific approval is obtained from the Directorate of Public Roads. When signs are assembled from extruded profiles, the thickness of the material and the profile's design must as a minimum satisfy the requirements for strength that apply to signs made of ordinary plates and requirements that apply to posts, supports and fasteners.

Figure 1.16 VD profile.

To ensure standardization of fastening equipment etc., signs of this type are designed with a NPRA profile unless otherwise specified.

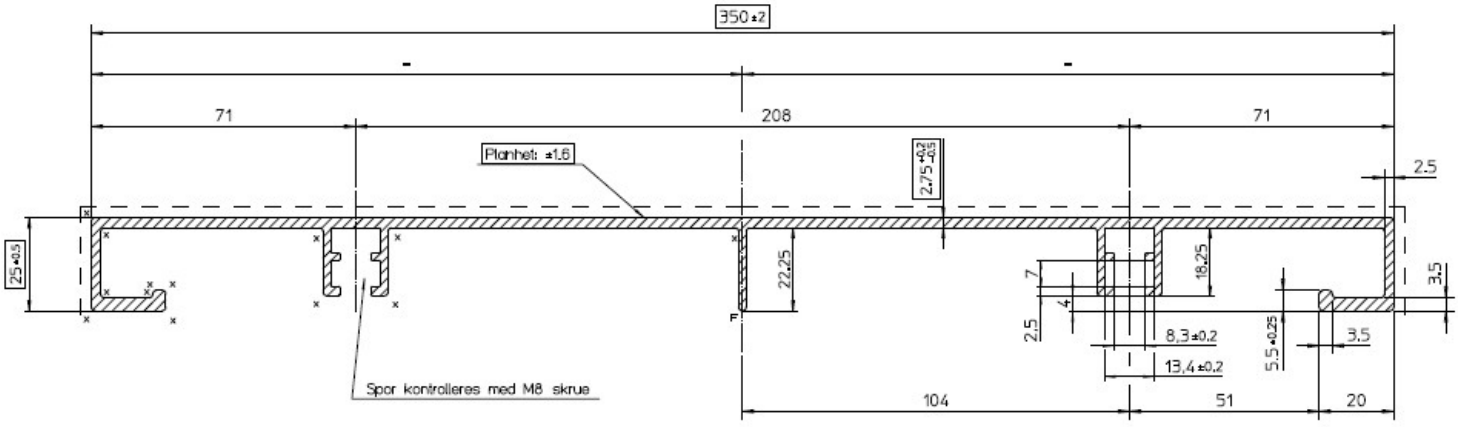


Figure 1.17 VD profile, here 350 mm width.

Sign 713 Directional sign

Directional signs shall be delivered complete with fixing devices and 2 pcs hoop clamps as shown in the example below. Hoop clamps 10 mm galvanized steel in accordance with NS-EN ISO 1461, in ST37 quality.

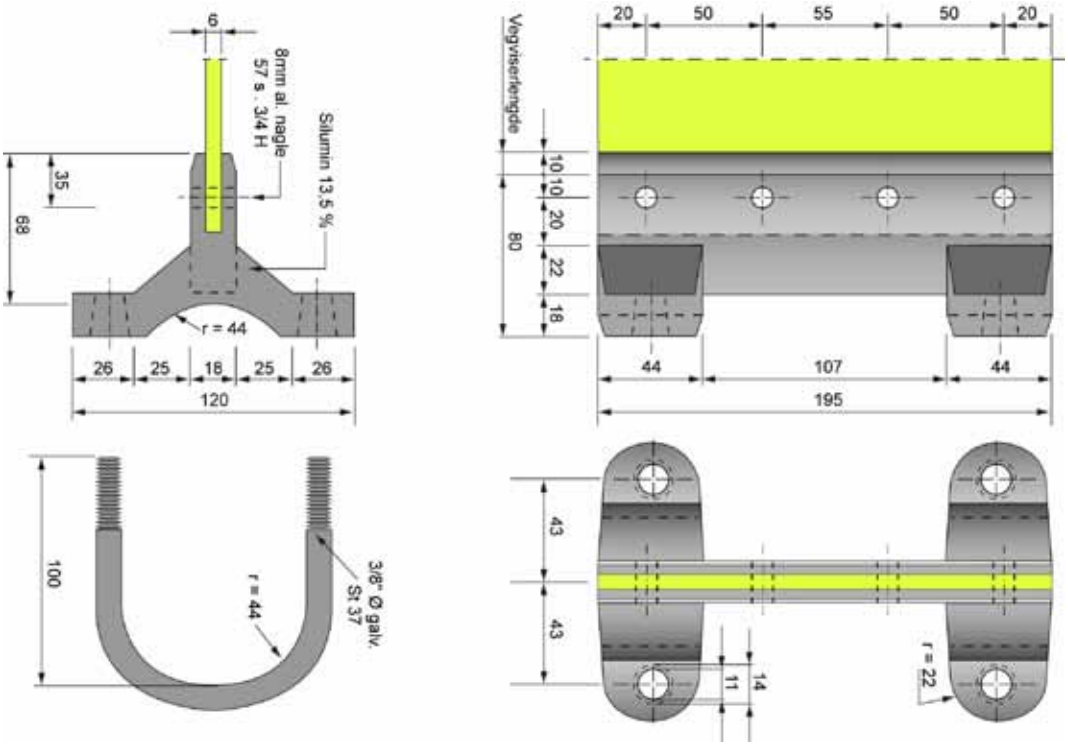


Figure 1.18 Example of the fixing system for directional signs.

1.6 Delineator posts

Delineator posts shall be flexible and able to resist snow clearance as much as possible.

If the guide post is of plastic, the plastic shall be UV stabilised.

White Class 3 (microprismatic) reflection sheeting shall be used on guide posts. Minimum retroreflection coefficient shall be 300 cd lux-1 m-2. The value applies at an observation angle of 0.33 ° (20′) and an entrance angle of 5°.

1.7 References

- Manual 050 Trafikkskilt del 1-5 [Road traffic signs, Parts 1-5] the Directorate of Public Roads 2007/08
- Manual 046 Planlegging og oppsetting av trafikkskilt [Planning and erecting road traffic signs]
- Manual 111 Drift og vedlikehold [Operation and maintenance], the Directorate of Public Roads
- Temahefte til Håndbook 111 [Booklet for Manual 111] the Directorate of Public Roads 2003
- NS-EN 12899-1 Fixed, vertical road traffic signs - Part 1 Fixed signs 2007
- CIE 15.2, Colorimetry
- CIE 54, Retroreflection definition and measurement
- NEK-EN 60529 Degrees of Protection Provided by Enclosures (IP Code)
- Common Understanding of Assessment Procedure (CUAP) - June 2002
- DIN 67520 November 2008
- The Standards Norway website: www.standard.no

2 Variable message road traffic signs

2.1 General

2.1.1 Introduction

The Norwegian Public Roads Authority has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce damages in any accidents that nonetheless occur. Traffic signs are an important part of the system that safeguards road users in crossings and on stretches, and the requirements to their functional properties are high. Part 2 of Manual 062 contains technical requirements for variable message road traffic signs and appurtenant equipment. The concepts are defined in section 2.1.4. This part of the manual must also be seen in context with Manual 050 Trafikkskilt (skiltnormal) [Road traffic signs] and Manual 053 Bruk av variable trafikkskilt [Use of variable message road traffic signs].

2.1.2 Validity

The requirements in Part 2 of this manual apply to variable road traffic signs that are erected along new and existing roads. The requirements apply within the guarantee period of the product. For technical requirements beyond the guarantee period, reference is made to Manual 111 Drift og vedlikehold [Operation and maintenance].

2.1.3 International requirements

The European standard NS-EN 12966 Road Vertical Signs - Variable Message Traffic Signs – Part 1: Product Standard treats technical requirements for variable message signs deals with technical requirements for variable message signs. Where requirements in the standard conflict with those in this manual, this manual applies. All electrical materials shall be made in accordance with European harmonizing standards (CENELEC) and approved by European testing institutions. Electrical materials shall meet EMC requirements in accordance with NS EN 50293.

2.1.4 Definitions and concepts

The following definitions apply in general for all types of variable message traffic signs, as well as for all technical equipment (controller, suspension equipment etc.) connected with the different types of variable message road traffic signs.

Matrix sign:	A variable message road traffic sign that changes its message with the help of individual elements that can be in one or more states, and so can create varying messages on the same sign front. For example: LED signs
Message:	A configuration consisting of symbols and/or text.
Equivalent surface:	The apparent surface of a luminous element when it is seen from a certain distance.
Phantom effect:	Reflected sunlight can result in the message on a matrix sign being visible, even when the sign is turned off.

Front panel:	The visible part of a sign consisting of the sign front and background screen when it is integrated on the front of a variable message sign.
Front screen:	Any transparent part of the front panel that protects the entire sign or parts thereof against water, dust etc.
Full matrix sign:	A variable message sign where one or more matrices cover the entire sign front and the text message is freely programmable.
Continuous sign:	A variable message road traffic sign that is similar to a fixed road traffic sign, but which can show different messages with the help of electro-mechanical devices. For example: prism sign.
Luminance:	Measurement in the SI system of how much light a surface reflects (cd/m^2).
Luminance ratio:	The relationship between luminance in on mode compared and luminance in off mode: $LR = (L_{on}-L_{off}) / L_{off}$
Matrix:	A grid with the elements' mid-points at the points of intersection. A matrix can cover the entire sign or parts thereof. X and Y axes can be orthogonal.
OPC:	**O**bject Linking and Embedding for **P**rocess **C**ontrol. The expression means achieving open linkability by means of open standards.
Prism signs:	Variable message signs where the message on the sign is varied by rotating the necessary number of prisms, where each prism side has a different message.
Sign front:	The visible part of a variable message sign that contains a message.
Sign casing:	Physical protection for variable message signs.
Controller:	Unit for the control and monitoring of one or more variable message road traffic signs and appurtenant sign lights and flashers.
Cabinet:	Cabinet that houses the controller.
Design:	CThe physical arrangement of letters (text) and symbols on the sign front.
Variable message road traffic sign:	A road traffic sign that can show a number of messages which may be changed or turned on or off as needed.

2.2 Common requirements

The following requirements apply in general to all types of variable message road traffic signs, as well as to all technical equipment (controller, suspension equipment etc.) connected with different types of variable message signs.

The complete structure (outer protection, suspension equipment, door hinges, closing and locking systems, equipment inside the protective unit) shall be adapted to the climate, usage and maintenance patterns it will be exposed to, so that all functional requirements can be expected to be met for **a minimum of 20 years.**

Corrosion issues shall be considered when selecting material qualities. Selection of

materials shall be made taking into consideration the prevailing climate conditions. Selection of material quality for assembly equipment (brackets, rails, plates, bolts etc.) shall be done on the basis of the science of engineering and building materials, including the structure the equipment is to be installed on, so that corrosion is avoided.

When selecting solutions, emphasis shall be placed on
- equipment designed for rational installation and implementation,
- low operational and maintenance costs,
- faultfinding and modifications that can be carried out rationally and without unnecessary hindrance to traffic,
- openness (supplier-independence)
- the possibility of communicating via VTS within the existing systems.

Where the structure the equipment is to be installed on may be electrically conductive, good, safe electrical connections to this structure shall be ensured. The equipment shall be prepared so that installation can take place rationally, without decreasing the enclosure rating or any corrosion protection.

All fastener details shall be adapted to the type of column/structure the equipment is to be installed on. Variable message signs shall be equipped with lifting lugs so that assembly/disassembly can be easily carried out.

It must be possible to attach signs to standard posts/columns, gantries or tunnel walls. Controllers shall be placed outside signs and columns.

Access to heating elements, motors etc. must be possible without having to disassemble other elements.

Lamps for signal number 1098 (yellow blinking signal) and 1094 (red stop blinking signal) that belong to variable message signs shall be placed above the message. These can be an integrated part of the sign casing.

Sign surfaces without information, such as the reverse side of signs, sign casings, frames and fastening equipment shall, unless otherwise specified, be of a neutral colour. The design shall be approved by the road owner before production.

Water shall be diverted from the top of the sign so that no water runs over the front of the sign.

Overhanging signs shall be designed so that icicles are not able to form under the sign casing.

Protection (IP) and temperature
Solutions for material quality, execution and construction shall be adapted to the climate and environment in which the equipment is to be placed, as well as the usage and maintenance conditions (service intervals and up-time) to which the equipment will be exposed, in such a way that the functional requirements and any requirements for protection and temperature will be adequately met throughout the equipment's expected service life. This means for example that the equipment shall tolerate the effects of direct sunlight, rainy weather and water jetting at the recommended 140 bar pressure.

Sign casings shall, unless otherwise specified, permanently satisfy the following minimum requirements for degree of protection provided by enclosures (NEK-EN 60529) and temperature tolerances:

English term	Ref. NS-EN 12966-1	Class in Norway	Comments
Temperature	8.2.1	T3	-40°C - +40°C outdoors and in tunnels. Shall tolerate water jetting.
Resistance to pollution	8.2.2	D1	
Protection provided by enclosures (IP rating)	8.2.4	P3	IP 55 outdoors IP 66 in tunnels

Figure 2.1: Classes according to NS-EN 12966-1.

For the IP rating of the controller, see section 2.3.1.

Columns/posts and foundations
Columns/posts for variable message road traffic signs shall designed so that cabling on or in the column can be done rationally.

Consideration should be given as to whether or not to cast the necessary number of cable drawing pipes in the foundation. Alternatively, the foundations should be prepared for cable insertion in some other way, but the cable shall not remain unprotected.

Reference is also made to Part 5 of this manual.

2.2.1 Electrical materials

The supplier shall comply with current Norwegian regulations, for example, the regulations relating to electrical low voltage installations (FEL) and NEK 400 Electrical standard on low voltage installations), FEU (the regulations relating to electrical equipment) and FM (the regulations relating to machinery)

Variable message road traffic signs shall be CE marked according to the CE mark register.

The equipment shall be adapted to the Norwegian mains grid, with the following nominal electrical data:

- Voltage: 1 phase 230 V AC, 3-phase 400 V AC or 230 V AC (localised). Tolerance requirements: 13% to +10%.
- Frequency: 50 Hz. Tolerance requirements: ±1Hz.

Drops in voltage (brownouts) will be tolerated; however, the original sign message should appear immediately after the sign is again functioning normally. Reference is made to NS-EN 12966-1 section 8.4.1.6.2.

2.2.2 Front screen

Front screens shall tolerate heat, maintain dimensional stability and be UV resistant where sunlight is an issue. Front screens shall be clear and coated with an antireflective agent. The screen shall not disturb the normal readability of the message.

2.3 Controller

The requirements in this section apply in addition to the requirements in section 2.2.

All controllers shall meet the requirements of NEK-EN 60439-1 Low-voltage switchgear and controlgear assemblies. Part 1 Type-tested and partially type-tested assemblies.

2.3.1 The cabinet

The electrical part of the cabinet shall be protected according to current regulations. The type of locking system shall be clarified with the road owner before it is ordered.

The cabinet shall be placed at a normal working height, outside of the carriageway (cf. Part 5 of this manual). The cabinet shall have double walls in cases where there is a risk of significant mechanical strain (for example, high speed snow ploughing). All cabinets shall have lighting, an electrical socket and a heating element to prevent condensation.

Degree of protection (NEK-EN 60529) shall be:

– Minimum IP 54 when all cabinet doors are closed, but minimum IP 66 when the cabinet is in a tunnel,
– Minimum IP 43 when the door to control equipment is open,
– Minimum IP 21 when the main door is open.

Precautions shall be taken to prevent dangerous contact voltage in the case of electrical faults. Local equalizer connections shall be considered. Local earth rods/earth electrodes shall be considered where the cabinet is to be mounted outdoors. The solution selected shall provide adequately low transition resistance to earthing.

All cabinets shall be dimensioned in size so that there will be a minimum of 30% reserve space for any later installation of equipment. The cabinet shall have space for storage of sufficient documentation in A4 format, in the form of a welded pocket on the cabinet door or similar.

2.3.2 Equipment in the cabinet

The cabinet shall contain all necessary equipment for

- manual and automatic/remote control of associated objects such as variable message signs, flashing lights and sign lights,
- monitoring of associated objects,
- monitoring of the cabinet's equipment and condition (protection/safety fuse burnouts, cabinet door open, voltage errors,
- communication with the master controller and monitoring centre,
- terminations and protection of linked cables and equipment.

All equipment shall be mounted on rails and nothing shall be screwed into walls of the cabinet. All equipment shall be durably and clearly marked in accordance to NEK IEC 60417. Equipment marking shall be in accordance with NEK EN 61346. Graphic symbols on screens shall be in accordance with NEK IEC 60617.

An easily available direct trip switch shall be located in the controller. It shall shut down all electricity to all available equipment both in the apparatus and out in the signs. Where local conditions require that the direct trip switch also function as the main fuse, selectivity between the first and the second safety functions shall be taken into consideration.

Automatic circuit breakers shall be used.

It shall be possible to diagnose faults in the matrix sign controller by means of a separate PC diagnostic program. Hardware and software must be upgradable. The control program shall be installed on a standardised memory card, and must be upgradable and reinstalled with the help of a PC. It must be possible to adapt and change software to the desired communications protocol.

The controller shall have a standardised interface, RS232 or similar, for connection to a PC, for example.

All cabinets shall contain surge protection for all phases, adapted to local conditions and upstream electricity grids. The need for surge protection for signals/electronics shall be assessed.

All actuating mechanisms and indication lights shall be supplied with symbols and/or Norwegian text. The equipment shall be marked in an easily visible place with the manufacturer's/supplier's name and production number.

Wires, terminal blocks etc. shall be arranged and clearly marked to indicate the voltage range to which they belong.

Signal cables shall be kept apart from power cables so that electromagnetic disturbances are avoided. All auxiliary relays shall be pluggable and have position markers.

Internal wire connections shall be placed in plastic ducts or similar. The ducts shall have a maximum 70% filling factor.

Each cabinet shall have terminal blocks for all ingoing and outgoing cables.

Interface with the overriding system
The controller shall be equipped with one or more standardised interfaces. If the controller is equipped with an Ethernet interface, an Ethernet protocol with OPC interface shall be developed (OPC: open connectability via open standards). The latest version of the Norwegian Public Roads Authority's process interface shall be used. The protocol between the OPC server and the controller shall be based on TCP/IP and UDP/IP. As a minimum, the controller must be able to exchange digital command and status signals (input and output) with the overriding system. The signals shall be arranged via floating relays which also are equipped with position indication and quenching diode.

Functions and parameters must be able to be changed by means of simple programming of the software.

The configuration data shall be stored in EEPROM or the equivalent, so that the data are not deleted in the case of voltage failure. The controller shall be equipped with a self-testing function. Should the controller detect faults, a status output for ERROR shall be activated. In case of an error in the overriding system or in communication with this system, the last sign position shall be maintained. In case of failure in the overriding system or communication with it, it must be possible to change the sign manually to any given position by means of a local control panel on or by the controller.

It must be possible to control free text signs locally with a laptop that has the necessary software.

2.4 Matrix signs

2.4.1 Different types

Matrix signs may be based on various technologies:

- Light-emitting (e.g. LED)
- Non-light-emitting

Figure 2.2: Example of a light-emitting up matrix sign.

The messages in a matrix sign are assembled using a number of elements, which may be light-emitting. The angle of dispersion of light-emitting elements can be controlled by means of lenses. The number of elements, angles of dispersion and sign size are determined on the basis of local conditions and the road user's visibility distance.

The design shall prevent the occurrence of phantom effects, i.e. when the sign is turned off, no message shall be seen under any circumstances.

2.4.2 Visibility requirements

The road user shall be able to easily read and understand the message on a variable message road traffic sign. This places requirements on how the text and symbols are designed and on lighting elements, which must not be too weak or too strong.

Signs based on light-emitting elements shall be designed with a dimmer function so that road users will not be dazzled when the surrounding level of light is low. The dimmer function shall be adapted to light conditions in the local environment. The dimmer function shall be based on a luxmeter. Dimming of groups of signs in an area should be controlled at the same level. The design of the messages for light-emitting matrix signs shall be based on the equivalent surface of the active elements.

The design requirements for matrix signs are found in Manual 050 - Part 1. Matrix signs may be constructed with messages where the colours are inverted. However, directional signs shall use colours corresponding to fixed signs.

Design of text, symbols and borders

Variable message road traffic signs shall show a sign surface that is the same size as that prescribed by the standard provisions for the fixed version of the sign concerned. For signs with text messages (for example information signboard 560) the necessary distance for readability, and thus the text height and sign size necessary, shall be assessed and inspected in the same manner as for fixed signs. See Manual 050 – Part 1, Appendix 1 for these standard provisions.

Symbols and text on matrix signs may, for practical reasons, have a somewhat lower level of detail than that on fixed road traffic signs. However, symbols and text must be rendered with sufficient exactitude to be easily recognised by road users. The quality of the font is dependent on line thickness and the size of spaces. The requirement is that, as far as possible, letters and numbers shall be perceived as continuous.

Widths of individual elements and distances between individual elements on a sign surface for this road traffic sign category shall also follow the standard provisions for fixed road traffic signs as far as possible (Manual 050, Part 1, Appendix 2: Traffic alphabet). Beyond this, reference is made to NS- EN 12966-1, Annex D for minimum requirements for the following: Distance between text and border and distance between words and lines.

Reference is especially made to NS- EN 12966-1, Annex D, for the following minimum values:
- Circle height and width of the circle stroke.
- Triangle side and width of the triangle stroke

Numbers shall have a height of at least 9 elements, however 10 elements or more are recommended.

Free text sign
Variable message road traffic signs that have messages other than those standardised for fixed traffic signs, fall under sign 560 "Information signs". Text heights and dimensions for this sign in particular are discussed under sign 560 in Manual 050, Part 3 (ref. Manual 050, Part 1, Appendix 1). The font shall be as close as possible to the Norwegian traffic alphabet. Of standard fonts, Arial is recommended. It is important that fonts that differ too much from the traffic alphabet are not used. For example, the small "g" shall not be placed entirely above the line.

Free text signs can be assembled using rectangular matrix modules. The matrix shall consist of a sufficient number of rows and columns so that all Norwegian characters may be reproduced with good legibility.

It must be possible to change the font size of letters and symbols. The free text shall be yellow in colour on a black background if the sign has inverted colours.

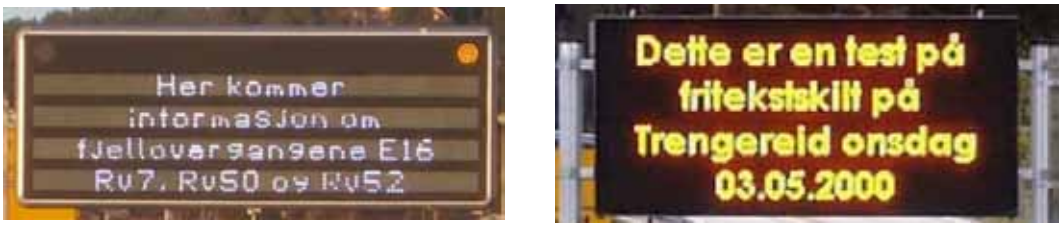


Figure 2.3: Example of incorrectly (left) and correctly (right) designed sign free text.

Class requirements

The tables in Figures 2.4 and 2.5 provide explanations and translations of some of the terms that appear in NS EN 12966-1. The tables are decisive for selection of parameter classes for photometric and physical conditions for variable message road traffic signs based on matrices. NS-EN 12966-1 sections 7.2, 7.3, 7.4 and 7.5 apply only to signs with light-emitting elements, i.e. visibility requirements for non-light-emitting, variable message signs, are found in NS EN 12899-1 and Part 1 of this manual.

English term	Ref. NS EN 12966-1	Class in Norway	Note
Colour	7.2	C2	
Luminance	7.3	L2,L3(*)[1]	Cf. fig. 2.5
Luminance ratio	7.4	R2	
Beam width	7.5	B1-3, B5	Cf. fig. 2.5

[1] L3(*) is a special class for light conditions in Nordic countries (low sun).

Figure 2.4: Classes according to NS EN 12966-1 for LED signs.

	Above the carriageway		Beside the carriageway	
	Luminance	Beam width	Luminance	Beam width
Straight sections	L3(*)	B1/ B3 [1]	L2	B3
Curves	L3(*)	B2	L2	B3
Ramps	L2	B3	L2	B3
< 2 lane	L3(*)	B3	L2	B3/ B5

[1] B3 with sign widths of over 3 m

Figure 2.5: Combinations of luminance and beam widths for LED signs.

Luminance on the sign front		Colour of the field of the sign front					
		White	White/ yellowl	Yellow	Green	Red	Blue
40 000 lx	Min.	6200	5270	3270	1860	1550	620
	Max.	31100	26350	18600	9300	7750	3100
4 000 lx	Min.	1100	935	660	330	275	110
	Max.	11000	9350	6600	3300	2750	1100
400 lx	Min.	300	255	180	90	75	30
	Max.	3000	2550	1800	900	750	300
40 lx	Min.	200	170	120	60	50	20
	Max.	1250	1065	750	375	315	125
≤ 4 lx	Min.	90	51	36	18	15	6
	Max.	375	320	225	115	95	37,5

Figure 2.6 Minimum and maximum luminance in cd/m² for class L2.

Luminance requirements
LED signs shall regulate the luminance automatically in relation to the luminance of the surroundings (measured on the sign face). There are therefore requirements for minimum and maximum luminance for luminance classes L2 and L3. Figures 2.6 and 2.7 give the requirements for luminance class L2 and L3 respectively.

The tables shall be read as follows: with a luminance on the front of the sign which lies between 40 lx and 400 lx, the luminance of a white field shall not be lower than 200 cd/m² or higher than 3000 cd/m² (L2).

Luminance on the sign front		Colour of the field of the sign front					
		White	White/ yellowl	Yellow	Green	Red	Blue
40 000 lx	Min.	12400(*)	10540(*)	7440(*)	3720(*)	3100(*)	1240(*)
	Max.	31100	26350	18600	9300	7750	3100
4 000 lx	Min.	2200	1870	1320	660	550	220
	Max.	11000	9350	6600	3300	2750	1100
400 lx	Min.	600	510	360	180	150	60
	Max.	3000	2550	1800	900	750	300
40 lx	Min.	250	213	150	75	63	25
	Max.	1250	1065	750	375	315	125
≤ 4 lx	Min.	90	64	45	23	19	7,5
	Max.	375	320	225	115	95	37,5

(*): Here the luminance of the surroundings may be required to be 10,000 lx for cases of low sun.
Figure 2.7 Minimum and maximum luminance in cd/m² for class L3.

Maximum change time, and time between visible changes in governing stages of luminance, is 5 seconds.

In general, luminance should be increased when stroke widths are narrow and reduced when stroke widths are broad.

2.4.3 Physical requirements

Free text signs can be assembled of rectangular matrix modules. Each module shall have a separate heating element. Power and signal cables shall be connected to the modules with the help of quick connectors. The modules shall be grouped in sections. Each section shall have a separate power supply unit. The sign shall be assembled keeping in mind easy accessibility and service friendliness.

2.5 Continuous signs

2.5.1 Different types

Continuous signs are divided into the following two main types:

- Mechanically variable signs (prism signs)
- Two-position signs
  - Position change by means of voltage/current (e.g. Dulf, LCD)
  - Position change by means of mechanical/manual operation

Mechanically variable signs (prism signs)

The message on the sign is varied by rotating the necessary number of prisms, where each prism side has a different message. Signs that are constructed so that each message is distributed over several parallel prism sides can be equipped with several motors. The motors shall then be synchronised.

The sign's total front panel shall not have significantly larger outer measurements than a fixed sign of a corresponding type.The motor must be strong enough to tolerate normal Norwegian winter conditions, but the sign shall be assembled with a safety mechanism that stops rotation if foreign bodies come between the prisms.

The motor's speed shall if necessary be variable to enable precise stops when positions are reached. The speed shall enable changes to the sign message within maximum 5 seconds.

If the electricity fails, it must be possible to rotate the prisms manually.

The sign motor and prisms shall not be placed in the same space. The space where the motor is located shall be easily accessible by means of a separate door/hatch. Terminal blocks for terminating external and internal wires/cables can be placed in the motor space or in a separate switch cabinet.

Controllers shall be placed outside the sign and column.

To ensure that letters and symbols appear coherently, the space between two adjacent flat elements (prisms) of the sign face shall not be greater than 5% of the diameter of the

Figure 2.8 Example of a mechanically variable sign/prism sign (with outside lighting).

largest circle that can be drawn using the points of the prism element, and maximum 12 mm. Cf. figure 2.9.

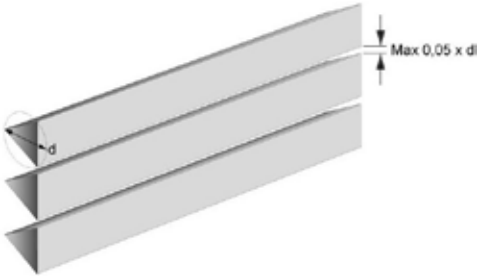


Figure 2.9 Distance between adjacent flat elements.

When changing a sign's position (command), the controller shall monitor the response from the position transmitter. Deviations of maximum ± 7° shall be accepted by the controller. If the correct response does not appear within a predefined time (e.g. 5 seconds), the status exit for ERROR shall be activated. The exit shall remain active until the error is corrected independently of the sign's position.

Sign lighting shall be designed and installed so that road users are not dazzled. If the lighting fitting contains several light sources, it shall be connected in such a way that not all light sources are extinguished because one source is faulty.

If the sign is equipped with a front screen, the light fitting may be placed behind the screen.

The design of the messages for continuous signs shall, with the exception of the breaks in the message surface that the structure itself entails, be based on the Norwegian Road Administration's Manual 050 Trafikkskilt [Road traffic signs] and 053 Bruk av variable trafikkskilt [Use of variable road traffic signs].

Two-position signs

For signs that change position by means of voltage/current, the sign's front plate when turned off shall appear as a neutral grey surface, with no visible message. Activating the sign's message is done by turning on the voltage/current.

In the event of electricity failure, it must be possible in the case of a curtain sign to rotate the curtain manually.

Figure 2.10 Two-position sign in active and passive positions.

The space where the motor is placed shall be easily accessible by means of a separate door/hatch. Terminal blocks for termination of external and internal wires/cables shall be easily accessible.

For signs that change position by means of a mechanical or manual operation, the sign's front plate in a closed position shall appear as a neutral grey surface, with no visible message.

In general: for all light-emitting two-position signs, the number of light sources shall be adapted to the size of the sign, so that luminance is even over the entire sign face.

2.5.2 Visibility requirements

Visibility requirements for continuous signs are the same as for fixed signs, and the traffic alphabet shall be used. With respect to requirements for sign sheeting, reference is made to Part 1 of this manual and NS- EN 129899-1. This applies to both selection of correct sheeting class, requirements for retroreflection, colours and luminance factors.

For light-emitting, continuous signs, there are requirements relating to luminance level, luminance contrast and luminance evenness. The requirements are found in Part 1 of this manual.

Variable road traffic signs shall show a sign surface that is the same size as the normal provisions dictate for the fixed version of the sign in question. For signs with text, the necessary reading distance and text height shall be assessed and decided in the same way as for fixed signs. For these normative provisions, reference is made to Manual 050 Part 1, Appendix 1.

Variable message road traffic signs that provide messages other than those that are standardised for fixed road traffic signs fall under sign 560 "Information sign". Part 3 of Manual 050 addresses text heights and dimensions for this sign in particular (refer also to Manual 050 Part 1, Appendix 1).

2.6 References

- FOR 1993-12-14 Forskrift om kvalifikasjoner for elektrofagfolk [Regulations concerning the qualification of electro professionals]
- FOR 1995-08-10 Forskrift om kvalifikasjoner for elektrofagfolk [Regulations concerning electronic equipment]
- FOR-1998-11-06-1060 Forskrift om elektriske lavspenningsanlegg [Regulations concerning electric low-voltage systems]
- NS EN 12966-1:2005 Road traffic vertical signs - Variable message traffic signs – Part 1: Product Standard
- NS-EN 12899-1 Fixed, vertical road traffic signs - Part 1 Fixed signs, 2007
- NEK IEC 60417 Graphical symbols for use on equipment
- NEK IEC 60529 Degrees of protection provided by enclosures (IP code)
- NEK IEC 61346 Industrial systems, installations and equipment and industrial products - structuring principles and reference designations
- NEK IEC 60617 Graphical symbols for diagrams
- NEK EN 50293 Electromagnetic compatibility - road traffic signal systems - product standard
- NEK EN 60439-1 Low-voltage switchgear and controlgear assemblies. Part 1: Type-tested and partially type-tested assemblies
- Manuals 050 Trafikkskilt (skiltnormal) [Road traffic signs (the sign standard)] Directorate of Public Roads, 2007/08)
- Manual 053 Bruk av variable trafikkskilt [Use of variable message road traffic signs] (Directorate of Public Roads, 2004)
- Manual 111 Drift og vedlikehold [Operations and maintenance] (Directorate of Public Roads, 2003)
- The Standards Norway website: www.standard.no

3 Road traffic control signal systems

3.1 General

3.1.1 Introduction

The Norwegian Public Roads Administration has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce injuries in any accidents that nonetheless occur. The signal system is an important part of the system that safeguards pedestrians in crossways and along stretches of road and the requirements made with respect to their functional characteristics are stringent. Part 3 of Manual 062 contains requirements for road traffic signal systems, i.e., signals for intersections and pedestrian crossings, traffic lane signals and other signals.

All work and materials in signal systems shall comply with current rules and regulations concerning electric low-voltage systems. All equipment shall be CE marked and shall satisfy the requirements of European standards that at any time apply in Norway. The provisions in these standards shall take precedence over those in this document.

All materials shall be made to ensure adequate performance when placed outdoors.

3.1.2 Validity

The requirements in Part 3 of this manual apply to road traffic signal systems that are set up along new and existing roads. The requirements apply within the product's guarantee period. For technical requirements beyond the guarantee period, reference is made to Manual 111 Drift og vedlikehold [Operation and maintenance], and any contracts that have been entered into.

3.1.3 International requirements

As far as possible and in order to operate with common requirements for equipment within the Nordic countries, an attempt has been made to harmonise requirements in Norway, Denmark, Sweden and Finland. The differences that are to be found are largely due to differences in climate, topography and regulations.

The work of revising the EN 12352 and EN 12368 standards has commenced within TC 226/WG4 (CEN). The harmonising document HD 638 is also under revision (CENELEC), and the document CLC/TS 50509:2007 "Use of LED signal heads in road traffic signal systems" is expected to be included in this standard.

3.1.4 Definitions and concepts

See Trafikksignalanlegg – Planlegging, drift og vedlikehold [Road traffic signal systems – Design, operation and maintenance] for a complete list.

Acoustic signal:	A sound signal that provides information to the visually impaired about what signal is shown in a pedestrian crossing.
Call:	Impulse from detector, push button, prioritisation system etc. with a demand to change the light to green.
Background screen:	An opaque plate placed around the lamp to increase the contrast and improve visibility.
Occupancy:	Portion of time that a vehicle is present on a detector.
Flow:	The traffic through an intersection from a specific entrance to a specific exit.
Detector:	A unit that gives an impulse to the controller when it is activated by a road user to give or prolong green signal time.
Local control:	Control of a signal system unaffected by other systems or by central control.
Signal group control:	A traffic-governed strategy where green time measurements are carried out separately for each individual signal group.
Signal head:	EUnit with insets for lamps and any screens.
Shuttle signal systems	Signal system with three-light-signals that is used for alternate one-way traffic regulation of single-lane road stretches.
Controller:	A unit in a signal system that opens and closes the individual light openings in the associated signal groups.
Fixed time control:	A form of control that uses a fixed sequence and fixed duration of time intervals.

3.2 Signal systems for intersections and crossings

3.2.1 Cabinet

The controller cabinet shall be dimensioned so that it has space for possible future equipment that may be necessary to use in the signal system. This can be equipment for measuring current, monitoring, prioritisation of public transport etc. The road owner also considers as much standardisation as possible desirable, even if the different manufacturers supply their own outer cabinet adapted to their product. The electronics should be specified to be based on standard measurements so that standard racks in outer cabinets other than the manufacturer's can be used. This will facilitate later renovation and replacement of equipment.

The electronic equipment shall tolerate 90% relative humidity over long periods and 100% relative humidity periodically without this leading to functional problems. Structures that may entail a danger of condensation shall therefore have a system for self-ventilation and self-drainage. Ventilation openings shall be equipped with dust filters and constructed in such a way that water penetration normally cannot occur. Cleaning the outside of the cabinet using water jets shall be possible without reducing operating safety. The enclosure ingress protection rating shall be minimum IP55 when all doors are closed, but there must be

possibilities for adequate ventilation so that condensate does not form and direct sunlight does not have a negative effect on the electronics in the cabinet. When the door to the actuating panel is open, protection shall be in accordance with IP43, and with the main door open, IP20.

Cable ends shall be at least 30 cm above the top foundation. The cabinet shall have coupling bars, clearly marked for all coupled leads. The bottom plate of the cabinet shall be equipped with dust-tight nipples unless otherwise specified in the tender documents.

The cabinet shall have separate doors for the operator control panel and the electronics part. The doors must open independently using different keys, but with only one key for each door. The doors must be able to be fixed in an open position. The type of lock system to be specified in the tender documents. The doors shall be recessed or constructed in such a way that hinders intrusion.

When the door to the operator control panel is open, only the service buttons that are mentioned in section 3.2.7 Operator control panel, shall be accessible.

The cabinet shall contain space for storage of adequate documentation in an A4 format, in the form of a pocket glued onto the door of the cabinet or similar.

The controller cabinet shall be made of impact resistant materials and shall have corrosion protection adapted to the climatic conditions where the cabinet is to be placed.

3.2.2 Controller

The controller shall be based on connection to 230V (-13%...+10%), 50 Hz (± 4%) alternating current and outdoor installation in cabinets, unless otherwise specified in the tender documents.

Main fuses (service fuses) shall be installed in a separate fuse box on the outside of the controller or according to the electricity provider's requirements.

The main fuses shall be dimensioned according to the consumption that the facility had when installed + 20%. Circuit fuses shall not exceed 10A, instead, two or more circuits shall be used. If a circuit fuse burns out, the entire system shall close down or go over to a flashing yellow light. Automatic fuses shall be used.

The controller shall be based on NS-EN 12675, Traffic signal controllers. Functional safety requirements.

English term	Ref. NEK-HD 638 S1	Class to be used in Norway	
		Class	Note
Driftsspenning/ Operating voltage range	4.2	A1	-13% - +10%
Switch off response voltage (V_{off})	4.3.1	B1	
Over voltage	4.4	D1	
Voltage dip	4.5	E3	
Mains frequency	4.6	F2	50Hz ± 4%
Terminations	5.1.1.6	H1	
Detection of missing signal	5.2.5.1	N0	
Detection of unwanted displays	5.2.5.2	P0	
Road Traffic Signal Systems	5.1.1.1.1	T1	
Maintenance equipment supply	5.1.1.1.2	U1	
PE wiring of external equipment	5.1.1.2.2	L1	
Accepted methods of earthing	5.1.1.2.3	M3	
Enclosure	5.1.1.3	V4	Jf 3.2.1.
Controller enclosure doors	5.1.1.7	J1	
Controller Signal outputs	5.1.2	K1	0,1A til 4A
Requirements of signal intensity for safety	5.2.2	AF1	
Requirements for signal states	5.2.3.3	AG4	Switch off 300 ms after failure.
Requirements for signal states	5.2.3.4	X1	
Fault loop impedance test	8.5.3	AA1	
Insulation of live parts to earth	8.6	R2	>0,5MΩ
RCD (residual current detector/ earth leakage breaker)	8.7	S1	30mA
Maintenance Testing Procedures	9.6	Y1	
Dry Heat	11, Table 3	AB1	40°C
Cold	11, Table 3	AE4	-40°C
Damp Heat, Cyclic	11, Table 3	AK2	
Solar Radiation	11, Table 3	AH1	
Random Vibration	11, Table 3	AJ1	1 time
Impact for Signals	11, Table 3	AC3	

Figure 3.1 Division into classes, Ref. NEK-HD 638 S1.

The controller shall have the following possible forms of control:
a) Automatic control (governed by traffic, time, or governed by time from the master control.
b) Manual control
c) Time-governed local program
d) Yellow flashing light
e) Turned off

The following prioritisations are made by the controller:
1. Operator control panel (hatch for police operation)
2. Controller
3. Master control

Lamp outputs shall be built up of semiconductors. Capacity shall be 600 W per colour per group, at 230 V. Relays or other galvanic divisions shall be used between inputs and outputs for any external copper cables.

All time measurements shall be carried out digitally with an exactitude equivalent to the mains frequency tolerances. The equipment shall tolerate 90% relative humidity over long periods and 100% relative humidity periodically without this leading to functional problems. The controller shall have inputs and outputs adapted to communication with the master controller/monitoring centre. The controller shall be equipped with one or more standardised interfaces, or as specified in the tender documents. Communication shall take place via serial interfaces.

The signal system shall be equipped with a calendar clock. The clock shall automatically change with respect to daylight saving time. The minimum number of program changes per day schedule shall be 20 and a minimum of 7 day schedules per week must be programmable.The controller for all signal systems for road traffic, except movable systems, shall satisfy the requirements of NEK-HD 638 S1:2001, Road Traffic Signal Systems. The supplier of the equipment shall be able to submit documentation that it has been tested by an independent, authorised European instance, and satisfies the requirements given in Figure 3.1.

3.2.3 Monitoring

The controller shall meet requirements for functional safety in accordance with NS-EN 12675 Traffic signal controllers / Functional safety requirements. Approval from independent institutions shall be obtained before the controller is put into operation, and the requisitioner of the controller can require that it be tested by an equivalent institution in Norway at the expense of the supplier if this has not been documented as having been done previously.

English Term	Ref. to NS-EN 12675	Class to be used in Norway	
		Class	Note
Green-green conflict	4.5.1 a	AA1	Changes to flashing yellow
Green-yellow conflict	4.5.1 b	AB1	Changes to flashing yellow
National signal regulations (infringement)	4.6 a	BA1	Goes dark
Standby mode (flashing signals)	4.6 b	BB1	Normal operation
Failure mode (flashing signals)	4.6 c	BC1	Goes dark
Frequency and duration of flashing yellow in standby mode	4.6 d	BD1	Normal operation
Frequency and duration of flashing signals during failure mode	4.6 e	BE1	Goes dark
Absence of a red signal on a specified signal group	4.7.1 a	CA1	Normal operation
Absence of the last red signal	4.7.1 b	CB1	Changes to flashing yellow
Absence of a number of red signals	4.7.1 c	CC1	Normal operation (Deviation from the requirement allowed in the case of LED
Absence of specified red signals	4.7.1 d	CD1	Normal operation (Deviation from the requirement allowed in the case of LED
Absent yellow or green signals from signal groups	4.7.2	CE1	Normal operation (Deviation from the requirement allowed in the case of LED
Compliance checking	4.8	DA1	Changes to flashing yellow
Stored times	4.9 a	FA1	Changes to flashing yellow
Time base frequency	4.9 b	FB1	Changes to flashing yellow
Minimum values of time settings	4.9 c	FC1	Normal operation
Maximum values of time settings	4.9 d	FD1	Normal operation
Duration of timings	4.9 e	FE1	Changes to flashing yellow
National signal sequences (infringement)	4.10 a	GA1	Changes to flashing yellow
Faults of external inputs	4.11	HA1	Normal operation. Faults shall result in the signal groups connected to the detector being given maximum green time or time in accordance with the local program.

Figure 3.2 Divisions into classes, NS-EN 12675.

States that are to be monitored and which the controller must show are listed in Figure 3.2. All errors shall be registered and logged in the controller. If the signal system switches over to a yellow flashing light, the controller shall indicate the cause of the error and when it took place. Such indications shall not be lost, even if the controller switches over to manual operation or the power supply fails.

Furthermore, the controller shall register when the error that took place is corrected and the system put into normal operation again.

If signal changes have not taken place during a programmable time, or from a received detector call in traffic control, the system shall go to flashing yellow, cf. Manual 142.

3.2.4 Yellow flashing light

In the case of disconnection due to a significant fault, the system shall show a flashing yellow light and signals for vehicles and pedestrian signals shall go dark. When switching manually to flashing yellow light, the controller's CPU shall continue normal operation. The blink frequency shall be 60 blinks per minute, with a 50% period interval.

3.2.5 Green flashing man

It must be possible for all pedestrian signal groups to have a green flashing man. The time shall be programmable. For setting times, see Manual 048. The blink frequency shall be 120 blinks per minute, with a 50% period interval.

3.2.6 The programmable part of the controller

After first-hand training by the equipment supplier's personnel, the road owner shall be able to change user parameters such as:

- minimum green times for each signal group
- maximum green times for each signal group
- closure times for all detectors
- delays for all detectors
- detector on/off
- detector surveillance on/off
- detector memory on/off
- calendar clock

The programmable part of the controller shall have a display that as a minimum clearly shows:

- output signal (red, yellow, green) for all signal groups
- registered calls from all detectors
- current signal group extension
- fault indications

3.2.7 Operator control panel

The operator control panel shall have:

1. A push-button to hold the current state (see 3.2.11 Manual control).
2. A switch or push-buttons for: signals "off", signals "on", flashing yellow "off" and flashing yellow "on". Signals "off" shall make the outer facility (signal cable) currentless.
3. A switch or buttons for "manual" and "automatic" control.
4. Indication of minimum:
   - connection failure with the master control
   - apparatus failure
   - current signal plan
   - lamp failure, detector failure etc.

All indicator lamps and switches shall be clearly labelled.

3.2.8 Local control

The controller shall be able to have several local programs that can be connected manually from the operator control panel. If connections to the master control fall out, it must be possible to program the controller whether it should switch to a flashing yellow light, a local program or local coordination.

3.2.9 Traffic dependent control

This type of control takes place according to the group control principle. Traffic control shall be found as a local program in the controllers, with the number of maximum times that are specified in the signal change schedule for the system.

Calls to the signal groups take place by means of detectors for vehicles and push-buttons for pedestrians. If there is no call to a signal group, it shall normally not come in. It must be possible to program delays of between 0 (= default value) and 10 seconds into all detector inputs.

The controller shall light lamps in the push-button units from the time when the call is received until the relevant group comes in. This also applies when system logic sends a message about a fixed call to a group.

The system logic of the controller must be able to perform the following operations:

1. Measure time intervals between vehicles.
2. Count vehicles that drive over the detectors while the signal is red in the direction con cerned and assign green time in relation to the vehicles counted.
3. Extend green time as long as the intervals between the vehicles are shorter than the set interval time. It must be possible to set the interval time to between 0 and 9 seconds. Ongoing extension of green time shall be indicated.

4. Assign a fixed minimum and maximum green time for each signal group. It must be possible to have several sets of maximum times for each signal group.
5. Assign privilege time for the signal groups.
6. Return to a specified rest phase. During the rest phase, the pedestrian signal turns green immediately on pushing the button if there is no call in a conflicting signal group. During the rest phase, it shall be possible to rest the system at any defined point in relation to the cycle and continue phase change after receipt of calls.
7. Control according to the LHOVRA principle, as described in publications from the Swedish Transport Administration, unless otherwise specified in the tender documents.
8. Make local green time modifications when under central control (UTC), when there is a prioritised call, by green messages from a central control being overridden in parts of or the whole cycle.
9. It shall be possible to change traffic controlled systems to fixed time control by switching a toggle to "manual" on the control panel. The green times shall then follow maximum times as specified on the signal exchange schedule, depending on the weekday/time of day. Pedestrian signals with push-buttons shall only come in after calls.
10. If one or more detectors are defective, the appurtenant signal group shall be given fixed calls and extensions.

3.2.10 Fixed time control

If the signal facility is to be fixed time controlled using more than one program, it must be possible to program these independently of each other. Switching between the different programs shall take place so that all minimum times for the signal groups are maintained. It must be possible to change green times while the facility is in operation. The current signal schedule shall be indicated on the control panel, see section 3.2.7 Operator control panel.

3.2.11 Manual control

The controller must be able to be operated manually, based on the local program, see section 3.2.8 Local control. Manual control takes place by means of a common button that is used to extend each phase. The button must be held in to extend the green time. If the button is released, the signal change shall take place immediately if the minimum time for all signal groups has been reached. If the button is not used, the signal facility is controlled by time or traffic.

3.2.12 Signal heads

Signal heads for use in signal facilities for intersections and pedestrian crossings shall meet the requirements pursuant to NS-EN 12368 Traffic control equipment. Signal heads, see Figure 3.3. Approval from an independent institution shall be obtained before the signal heads are taken into use. The person ordering the equipment may require that the equipment is tested by an equivalent institution in Norway at the supplier's expense if there are no documents to show that this has previously been done.

English term	Ref. to NS-EN 12368	Class or category to be used in Norway	
		Clas/Cat	Note
Signal head	4.2	IV	IP55
Environmental requirements	5.1	C	+40°C – -40°C
Luminous intensities of signal lights	6.3	2/1	Min. 200 cd/Max. 800 cd (unless otherwise specified)
Measurement method	6.4	A/B	
Distribution of luminous intensity	6.4	W	Unless otherwise specified
Maximum phantom signal	6.6	3	
Signal lights with symbols	6.8	S1	
Background screen of signal lights	6.9	C4	
Impact resistance	7, Table 9	IR3	

Figure 3.3 Division into classes, NS-EN 12368

Signal heads for signal regulated intersections and pedestrian crossings shall have semi-matte black fronts and shall be supplied complete with fittings for the relevant posts. The fittings shall make it possible for individual positioning of the signal head in a horizontal plane. It must be possible to lock the signal head in a selected position. The fittings shall be the same colour and quality as the posts or the signal heads. The style of signal symbols shall be as specified in Manual 048 Trafikksignalanlegg - Tekniske bestemmelser og retningslinjer for anvendelse og utforming [Road traffic signal systems – Technical provisions and guidelines for use and design].

Unless otherwise specified, the signal heads shall be supplied with screens of a normal length (length approximately equal to the lens diameter).

If incandescent lamps are used, they shall be lamps specially made for traffic signals. Lamps shall be correctly adapted to the reflectors' optical design. Signal heads with a diameter 200 mm and 300 mm shall be designed for up to 70W and 100W traffic lamps (230V), respectively, unless otherwise specified in the tender documents.

If light sources based on LED technology are used, they shall be designed to provide minimum 80% light intensity after one diode or possibly a group of diodes falls out.

Background screens shall be manufactured in a material that satisfies the requirements set for material used in signal heads. The screen must tolerate direct southern exposure for a minimum of 10 years without significant degradation of the colour.

Otherwise, the requirements specified in Figure 3.3 apply.

3.2.13 Detectors

Signal facilities can have detectors that register traffic. The type of detector, number and function is described in the tender documents.

Detectors must be able to perform one or more of the following functions:
- detect occupancy (presence),
- measure occupancy time,
- measure occupancy rate,
- count vehicles,
- measure speed,
- measure time sequences,
- detect direction,
- detect public transport vehicles,
- detect bicycles and motorcycles/mopeds.

See also Manual 142 section 2.8.3.

Push-buttons

Push-button units shall be designed so that it is clear what their function is. A symbol on the front shall denote the function. The unit shall be fed with the same current as the other signals installed on the column.

The unit shall be designed according to the column and to resist vandalism. It shall not be possible to open it or access the electrical connections without the use of special tools. It shall have rounded corners and edges.

The unit's basic colour shall be blue and it shall be equipped with an indicator lamp that emits a white or yellow-white light when the button is pushed. This light shall be clearly visible in daylight within a sector of minimum 120° in front of the unit (see figure 3.4), at a distance of minimum 10 metres. The lens shall be well protected against impact and other vandalism, and the light source shall be protected against vibration.

The unit shall have a minimum enclosure rating equivalent to IP55. It shall be earthed pursuant to current regulations concerning electric low-voltage systems. Documentation shall be provided that dangerous contact voltage will not occur during normal operation or in the case of faults in the push-button unit.

If the push-button unit is combined with an acoustic signal, it shall

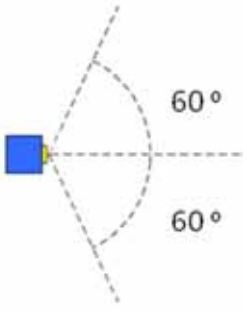


Figure 3.4 Visibility sector for the call signal.

also be equipped with tactile symbols that show the location of the pedestrian crossing. For pedestrian crossings over multilane roads or roads with refuge islands, the unit should additionally provide a tactile sketch that indicates in a simple manner the lanes and refuges that must be crossed. There can be more than one push-button on the unit to call for an extension of green time for pedestrians and/or to provide an acoustic signal.

3.2.14 Acoustic signal emitters

Acoustic signal emitters shall only provide sound signals when there is a green light in the appurtenant signal group pursuant to Manual 142 Trafikksignalanlegg – Planlegging, drift og vedlikehold [Road traffic signal systems – Design, operation and maintenance].

A "green" signal shall be given with an audio frequency of approx. 880 Hz. It must be possible to regulate the audio frequency between approx. 800 and approx. 2000 Hz. The pulse repetition frequency for the "green" signal shall be 3 Hz ± 0.2 Hz. The pulse shall be a sawtooth or square wave. The ratio between sound and pause shall be > 1.

If a sound is to be emitted on a red light, it shall have the same audio frequency as on green, but with a pulse frequency of 0.5 Hz.

If the unit must have a variable volume, this shall be specified in the tender documents. In this case, the volume is to be adjusted so that it lies between 0 and 5 db(A) over background noise, within minimum and maximum values of 30 and 90 db(A), respectively, at a distance of 1 metre.

It shall be possible to disconnect the acoustic signaller from the controller by means of a separate control wire in the signal cable.

If specified in the tender documents, the unit must be able to provide spoken messages if the signal system has gone to flashing yellow due to a monitoring error. The spoken message shall be in Norwegian and produced either automatically every other minute or when activated by the push-button. The text of the spoken message shall be approved by the Directorate of Public Roads.

The acoustic signal unit can either be combined with the push-button unit or be a separate unit. In this case it shall be located so that it does not look like a push-button unit to the pedestrian.

The speaker shall be protected against water penetration and the unit shall have an enclosure rating equivalent to IP55.

3.3 Temporary shuttle signals

3.3.1 General

Equipment for temporary signal regulation can be based on connection to 230V (-13% -+10%), 50 Hz (64%) alternating current or battery operated, and outdoor installation. The shuttle signal unit enclosure rating shall be minimum IP54, while posts/signal heads shall have a rating of minimum IP55. The equipment shall be easily mobile, but stable enough so that the draught from passing traffic does not turn it or move it out of position. All heavier parts of the equipment shall be on wheels and should be painted yellow (RAL 1007) for easy visibility. Access to the control unit shall be lockable. All operational faults shall be specified either in clear text or by means of indicator lights on a display in the control unit. Radio equipment shall be EMC tested, and all other equipment shall be CE marked. The signal sequence and start-up sequence shall be as for permanent signal systems, but the length of the all-red interval in the beginning shall be easily adaptable to the individual working location.

3.3.2 Posts and signal heads

Posts shall be yellow (RAL 1007). Signal heads shall have a semi-matte black front and shall be supplied complete with attachment fittings for the relevant posts. The signal heads, unless otherwise specified, shall be supplied with screens of a normal length (length approximately equal to the lens diameter). The signal heads shall satisfy the same requirements as signal heads in permanent signal systems. The style of signal symbols shall be as specified in Manual 048 Trafikksignalanlegg – Tekniske bestemmelser og retningslinjer for anvendelse og utforming (signalnormal) [Road traffic signal systems – Technical provisions and guidelines for use and design (the signal standard)]. The attachment fittings shall enable individual positioning of the signal head in a horizontal plane. It must be possible to lock the signal head in a selected position. The fittings shall be the same colour and quality as the posts or the signal heads.

Figure 3.5 Mobile shuttle signal system (example)

3.3.3 Detectors

Radar detectors shall meet the requirements of the European Telecommunications Standard EN 300440. The radar shall be robustly built and, as far as possible, have a discrete and vandalism-proof design. The unit shall have a minimum enclosure rating equivalent to IP55. The radar shall usually be installed on the top of one of the signal posts and it must be possible to adjust both in height and sideways. The radar shall only register vehicles that move towards the crossing. The radar should have a reach of minimum 60 metres and shall be triggered at speeds down to 5 km/h. The detector shall function satisfactorily without readjustments for temperature variations between -30 and +40°C and in direct sunlight.

Infrared detectors shall be robustly built and as far as possible have a discrete and vandalism-proof design. The unit shall have a minimum enclosure rating equivalent to IP55. The detector shall usually be installed on the top of one of the signal posts for the primary signal and it must be possible to adjust both in height and sideways. Alternatively, it can be placed over the carriageway. The detector shall register vehicles that are directly in front of the stop line.

Video detectors shall be programmable via screens that are connected to the controller either directly or via PC. The camera shall be placed so that the largest possible area upstream of the stop line is covered. As a rule of thumb, 1 metre height means 10 metres more visibility. The camera shall be installed so that even a strong wind cannot move it from its position, and the electronics shall have a stabilizing function so that small movements do not create problems for detection. The camera shall have a minimum enclosure rating equivalent to IP55.

3.3.4 Control and monitoring

The controller shall have the following possible control forms:
a) Traffic control
b) Manual control
c) Fixed time control
d) Flashing yellow light
e) Off

Traffic control will usually be the recommended control form. Detectors should be based on equipment that is easy to set and that is placed over the carriageway, preferably together with the signal head. When manually controlled, the system must be controllable by an operator located outside the carriageway. The system's dumping time and green time shall be easily programmable. Red/yellow shall be fixed at 1 second and yellow shall be able to be set at either 3 or 4 seconds. It shall not be possible to set any other time less than 6 seconds. As a minimum it shall be possible to program two sets of maximum times and the controller shall be equipped with a calendar clock to control program selection. The logic of the governing unit must be able to function even when signals out are turned off. After a power outage, the system must start up in the operational form it was in before the outage.

The signal system shall be continuously monitored to ensure that the red lights in the signal heads at both ends of the signal-regulated stretch function (red light monitoring), and that there are no conflicting green lights. If one of the units falls out or in the case of conflicting green lights, the system shall either turn off or go to flashing yellow lights. The electricity supply and communication equipment shall be continuously monitored. There should be equipment for the automatic notification of critical faults via mobile telephone or similar to the person in charge. The reaction time for the monitoring functions shall not be longer than 0,3 second.

3.4 Lane control signals

3.4.1 Signal changes

The signal's method of operation is addressed in Manual 048 Trafikksignalanlegg – Tekniske bestemmelser og retningslinjer for anvendelse og utforming (signalnormal) [Road traffic signal systems – Technical provisions and guidelines for use and design (the signal standard)].

When the signals are in operation, the diagonal yellow arrow shall flash at a frequency of approx. 40 blinks/min. (1 second light, 0.5 second dark).

English term	Ref. to NS-EN 12966-1	Class to be used in Norway	
		Class	Note
Colour	7.2	C2	
Luminance	7.3	L3*[1]	
Luminance ratio	7.4	R2	
Beam width	7.5	B3	
Temperature	8.2.1	T3	-40°C - +40°C
Resistance to pollution	8.2.2	D1	
Enclosure protection (IP rating)	8.2.4	P2 P3	IP 55 IP 56 (tunnel)

[1] L3* is a special class for Nordic light conditions (low sun).

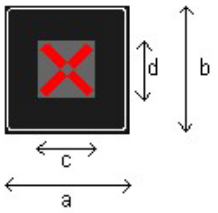
Figure 3.6 Class divisions, NS-EN 12966-1.

The change from one signal state to another shall take place within maximum 1 second.

3.4.2 Sizes

Lane control signals shall be installed on background screens, except in tunnels. The screen and signal shall have minimum sizes as shown in Figure 3.7.

In the case of a deviation from the minimum sizes, the Directorate of Public Roads shall be consulted.



	a	b	c	d
V > 80 km/t	1200	1200	500[1]	500[1]
V ≤ 80 km/t	1000	1000	400[1]	400[1]
Tunnel	-	-	300	300

[1] Also applies to the outside of the tunnel entrance.

Figure 3.7 Traffic lane signal sizes.

3.5 Yellow flashing signal

3.5.1 General

The requirements apply to both permanent and temporary signals and flashing arrows. The yellow flashing signal can be a single yellow flashing light or two horizontally placed, alternately flashing yellow lights.

Methods of use:
- Attention signal
- Emergency light
- Flashing arrow

3.5.2 Division into classes, NS-EN 12352

The various classes for environmental parameters are given in Figure 3.8.

English term	Section in NS-EN 12352	Class to be used in Norway	
		Class	Note
Luminous intensity	4.1.1	L6	On traffic cones etc. (2 sided)
		L7	On traffic signs, emergency lights
		L8M	Emergency light, [road barriers, (motorvay)]
		L8H	On traffic signs, flashing arrow (motorway)
Light emitting surface	4.1.2	P1	For all lights other than omni-directional
Colometric performance	4.1.4	Cyellow1	
		Cred	For signal on manual stop board
Retroreflectice devices	4.1.5	R1	
Photosensitive On/Off switches	4.2.1.2	A0	
Voltage indicator	4.2.1.3	I0	
Continuity of emitted light	4.2.2.1	F1 F2	Fixtures with steady light Flashing light fixtures
On-time	4.2.2.2	O1	
Mechanical strength	4.3.1	M3	
Temperature resistance	4.3.2.2	T2	
Secure fastening and locking	4.3.3	S2 S3	Secure fastening Secure fastening and locking

Figure 3.8 Class divisions, NS-EN 12352.

3.5.3 Blink frequency

- Individual yellow flashing lights shall blink at a frequency of approx. 60 ±5 blinks/min. and with at a blink duration of between 250 and 500 msec.
- Two flashing yellow lights used together shall blink alternately at a frequency of 110 ±5 blinks/min. and with a blink duration of between 250 and 500 msec.
- Emergency lights consisting of a series of flashing lights shall have an interval of approx. 200 msec. between activation of one flashing light to activation of the next in the series.
- A flashing light in an emergency light setup can either have a flashing light of normal duration so that the lights relieve one another, or have a prolonged duration so that the lights are lit successively in one sequence.

3.5.4 Dimming

Lights in classes L8L and L8H should be equipped with automatic dimming depending on the ambient light, as given in Figure 3.9.

Class	40 000 lx day-light	4000 lx weak daylight	400 lx dawn/dusk	40 lx lit road	0.4-4 lx dark
L8M	300–1200	150–600	75–300	37–150	20–80
L8H	1200–4800	600–2400	300–1200	150–600	75–300

Figure 3.9 Effective incandescence (cd) of yellow flashing lights depending on the light in the surroundings.

3.5.5 Flashing arrow

Flashing arrows (signal no. 1100) can be built up of a number of individual lights (class L8H). The number shall be adequate to clearly define an arrow symbol.

The light arrow shall extend over a square of minimum 1.6m x 1.6 m. The arrow should be connectable to equipment that makes synchronisation possible with similar symbols placed next to it, for example, a radio-controlled clock. The blink frequency shall be as specified in section 3.5.3.

3.6 Flashing red stoplight

Signal heads for flashing red stoplights shall satisfy the same requirements as signal heads in signal systems for intersections and pedestrian crossings.

Flashing red stoplights can have a light aperture of 200 mm (speed limit ≤ 50km/h) or 300 mm. Lights based on LED and lights placed in tunnels should be 200 mm. Used as an alternating flashing signal, the mutual distance between lights shall be 350 or 500 mm for light apertures of 200 and 300 mm, respectively.

When flashing red stoplights are used together with barriers, the signals shall begin to blink approximately 5-10 seconds before the barrier descends. The signal is normally placed on a background screen, but this can be omitted in tunnels, etc.

3.6.1 Blinkfrekvens

Individual flashing red stoplights shall blink at a frequency of approx. 60 ±5 blinks/min. and with a blink duration of between 250 and 500 msec.

Two flashing red stoplights used together shall blink alternately at a frequency of 110 ±5 blinks/min. and at a blink time of between 250 and 500 msec.

3.7 Electrical systems

3.7.1 Qualification requirements

Those who design, install and operate/maintain the electrical low-voltage systems shall meet the requirements in the Regulations concerning the registration of businesses that design, install and maintain electrical systems and the Regulations concerning the qualification of electro professionals.

The part of the control cabinet that requires professional expertise shall be locked and labelled: Access for qualified (BA5) or directed (BA4) personnel due to danger of electricity.

3.7.2 Documentation requirements

The finished system shall be delivered with certificate of compliance, risk assessment, final control documentation with FEBDOK calculations, arrangement drawings, single and multi-line circuit diagram, terminal diagram, component list and manual for management, operation and maintenance (FDV-manual). Buried cables shall be digitally registered.

3.7.3 Connections in posts

All connections in posts shall take place in sealed boxes (IP55) and not just with twist-sleeves or similar inside the post.

3.7.4 Protection

All protection shall be multi-polar with protection in all phases including N type conductors. Additionally, all protection for all outgoing circuits shall have earth-leakage circuit-breakers. Protection against electrical surges shall be considered for all incoming and outgoing cables, for both power and telecommunication cables. The risk assessment shall provide an answer to whether the protection shall be monitored.

3.7.5 Power/high-voltage cables

Cables between controller and signal post should have a conductor area of minimum 1.5 mm^2. PFSP cables shall be used unless otherwise specified.

3.7.6 Signal/low-voltage cables

Signal cables to power system operation should have a conductor thickness of 0.6 mm or 0.9 mm depending on the distance. An unscreened cable with revolved pairs of good quality is recommended. Where the cable will lie in a damp environment, consideration should be give to using vaseline-filled cables (MXLE 0.6 mm).

3.7.7 Detector cables

The feed cable for the loop detector can be of various types, and depends on the distance from the loop to the detector amplifier. The cable shall satisfy the requirements the detector amplifier sets and/or as specified in the tender documents.

3.7.8 Fibre-optic cables

Fibre-optic cables for transmitting signals shall be single mode. The cable shall be enclosed in a cable conduit with a separate search thread

3.7.9 Electrical installation on and in the road surface

The producer/supplier must document that the selected installation method is at least as safe as the standards and meets the safety requirements of the Regulations concerning electric low-voltage systems. The documentation shall be delivered together with the certificate of compliance. Fittings and other equipment shall meet the requirements of the Regulations concerning electronic equipment and be CE marked. A certificate of compliance shall be issued that confirms that the product meets current product standards.

If this cannot be done, the system shall be built according to NEK 400 as a SELV system according to installation method nos 1, 2, 57, 58, 59, 60, 71, 72 or 73 in Table 52C. The cover over the cable must be at least 60 mm. Furthermore, the cable must tolerate cold and re-asphalting, i.e. temperatures from -30 to +160°C, and somewhat higher if the asphalt is caste, approximately 200°C. The ability to conduct power in accordance with the cable manufacturer's information and max. ambient temperature of +30°C. Thermal conductivity for asphalt is 1 to 1.5 W/m°K. The system shall be disconnected during asphalting, and shall be checked after asphalting is complete and before voltage is restored. The cable must be able to tolerate the expected stress and not be weakened by chemical effects from the asphalt. The termination of the cable shall be class IPX7 or better. The conduit in or under the asphalt shall be drawn in and measurements recorded on a digital drawing.

Planning and installation shall only be carried out by a business that meets the requi-

rements of the Regulations concerning the qualification of electro professionals and is registered at the Directorate for Civil Protection and Emergency Planning (DSB) in the respective work areas.

Furthermore, an FDV manual shall be compiled stating the frequency of system checks, what shall be checked, detailed test procedures, what values are acceptable and measures for re-asphalting, vehicle fires, fuel leakages and other accidents (unforeseen events) near the system.

3.7.10 Earthing systems and protective circuits

A separate earthing system including earth electrode shall be established for each system. Documentation shall be provided that dangerous contact voltage cannot occur during normal operation or in the case of faults.

Earth wires of copper with a minimum cross-section of 25 mm^2 shall be used. The earth wires shall run from a trench outside the pipe, through all post manholes to the control cabinet.

Cf. Section 2.8.2 of Manual 142 Trafikksignalanlegg – Planlegging, drift og vedlikehold [Road traffic signal systems – Design, operation and maintenance].

3.8 References

- FOR 1993-12-14: Forskrift om kvalifikasjoner for elektrofagfolk [Regulations concerning the qualification of electro professionals]
- FOR 1995-08-10: Forskift om elektrisk utstyr [Regulations concerning electric equipment]
- FOR 1998-11-06 no. 1060: Forskrift om elektriske lavspeningsanlegg [Regulations concerning electric low-voltage systems]
- FOR 2002-11-02: Forskrift om registrering av virksomheter som prosjekterer, utfører og vedlikeholder elektriske anlegg [Regulations concerning the registration of businesses that design, install and maintain electrical systems]
- NS-EN 12352 Traffic control equipment. Warning and safety light devices
- NS-EN 12368 Traffic control equipment. Signal heads
- NS-EN 12675 Traffic signal controllers. Functional safety requirements
- NEK 400:2002: Elektriske lavspenningsinstallasjoner [Low-voltage electrical installations]
- NEK-HD 638 S1:2001 Road Traffic Signal Systems
- NEK CLC/TS 50509:2007 Use of LED signal heads in road traffic signal systems
- NEK EN 50293 Electromagnetic compatibility - road traffic signal systems - product standard
- ETSI EN 300 440 Electromagnetic compatibility and Radio spectrum Matters (ERM)
- Manual 018 Vegbygging [Road building]
- Manual 048 Trafikksignalanlegg – Tekniske bestemmelser og retningslinjer for anvendelse og utforming (signalnormal) [Road traffic signal systems – Technical provisions and guidelines for use and design (the signal standard)]
- Manual 111 Drift og vedlikehold [Operation and maintenance]
- Manual 142 Trafikksignalanlegg – Planlegging, drift og vedlikehold [Road traffic signal systems – Design, operation and maintenance]

4 Warning and protection equipment

4.1 General

4.1.1 Introduction

The Norwegian Public Roads Authority has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce damages in any accidents that nonetheless occur. Head on collisions and driving off the road are the predominant types of accidents in which many people are killed and injured. Measures directed especially towards these types of accidents will therefore be very important. Part 4 of Manual 062 contains technical requirements for the purchase of equipment that is to be used in work zone areas. A distinction is made between the following terms:

Warning: The purpose of warning is to provide road users with notice that roadwork is in progress and how driving must be adapted accordingly. Usually, equipment is used that is defined in the Regulations concerning road traffic signs (traffic signs, road markings and traffic light signals).

Protection: The purpose of protecting a location is to close off the work area so that neither the workers nor the road users are injured if the warning is not heeded. Protecting a site is additional to warning in cases where this is necessary.

4.1.2 Validity

The requirements in Part 4 apply to the products that are discussed in the manual and set up along new and existing roads. The requirements apply within the products' guarantee periods. For technical requirements beyond the guarantee period, reference is made to Manual 051 Arbeid på og ved veg [Work on and alongside roads] and Manual 111 Drift og vedlikehold [Operations and maintenance].

4.1.3 International requirements

Equipment for warning and for the protection of work locations is covered in part by the same European requirements applying to permanent equipment, and in part by specific European requirements for temporary equipment.

With respect to requirements for energy-absorbing protection equipment for vehicles (TMA: Truck Mounted Attenuators), classifications developed within the National Cooperative Highway Research Program (NCHRP) shall be used.

Where European standards require that product types be CE marked to have commercial access to the market, this will also apply to Norway.

4.1.4 Definitions and concepts

Sign design:	Symbol design, colours, board widths, text heights and sign sizes.
Sign surfaces:	The part of the traffic sign that contains the message to road users.
Sign plates:	The physical medium that the sign surface lies on.
Traffic cone:	A three-dimensional object with a conical shape that consists of one or more parts including a base plate, a conical body and one or more retro-reflecting surfaces.
Traffic cylinder:	A three-dimensional object with a shape that is primarily cylindrical, consisting of one or more parts including a cylindrical body and one or more retro-reflecting surfaces.
Carriageway reflectors:	A horizontal, traffic guiding device that reflects incoming light with the help of retro-reflectors in order to warn, guide or inform road users.
Longitudinal protection:	Comprises equipment that is used alongside the work location to distinguish the work location from the area that is used by pedestrians or motorised traffic.
Transverse protection:	Comprises equipment that is used across the carriageway in front of the work location in order to create a buffer zone between any vehicles that have not paid attention to signage in front of the work location and the work location itself with equipment and persons who are working on the road.

4.2 Warning equipment

4.2.1 Road traffic signs

General

The general technical requirements for fixed road traffic signs and sign support structures (cf. Manual 062 Part 1 and Part 5) also apply to signs, support structures and foundations that are used to warn of roadwork, if not otherwise specified in the following provisions.

Using signs, markings, signals etc. that are similar to or may be confused with equipment corresponding to that described and defined in the regulations concerning road traffic signs is prohibited.

Placing company logos or similar on reflecting parts of warning equipment is not permitted.

Sign surfaces

Sign design (symbols, sign size) shall be as specified in Manuals 050 and 051, and no colours other than those specified in Manual 051 shall be used.

All signs shall have Class 3 reflective sheeting, except signs 362/364 for traffic exiting the work area. The sheeting shall satisfy all requirements for sheeting on fixed signs, cf. Manual 062, Part 1.

Sign plates

Sign plates shall either satisfy requirements for fixed signs or be of such a quality that in use they are nearly planar, and such that wind or passing traffic does not cause movement of the sign face that makes understanding the message more difficult.

Figure 4.1 Folding sign (example)

Sign support structures

Sign support structures shall satisfy the requirements of Manual 062 Part 5 unless otherwise specified in this section.

Stability requirements: Signs that are used to warn of roadwork shall tolerate wind loads from passing traffic and normal wind and weather conditions without overturning, turning around or being moved sideways.

Foundations: Movable foundations placed on the ground can be used if the requirements for stability are satisfied. Foundations in areas with pedestrian traffic shall be designed, marked or located such that there is no danger of tripping pedestrians, even pedestrians who are visually impaired.

The foundations can be:

- able to be run over, i.e. max. 20 cm high and designed so that there is no danger of damage if they are run into or over, or:
- not able to be run over. They shall in this case be marked and if necessary protected if they are to be placed within the road's safety zone.

Posts and fastening devices: Requirements in Manual 062 Part 5 shall be satisfied, except that fastening devices that are easier to open when setting up or dismantling the sign may be used.

Special requirements for side edges and back sides: If signs or sign equipment are located such that there is a danger that road users or road workers can hit the sign equipment's back side, the sign post or the sign's back side shall be made visible with retro-reflective tape in red, orange or fluorescent yellow-green. It shall not be possible to confuse such markings with ordinary signing.

Equipment to cover signs

Covers and cover plates: Sign covers shall be made of a water-resistant material and preferably be grey or another neutral colour. In special cases, the cover may be printed with another sign symbol (e.g. parking regulation) and in this case may be white or light grey. Cover-plates are used to cover the whole or parts of a sign. The plate shall have airspace between the sign and the cover-plate. Use of cover-plates shall not damage the sign sheeting on the sign that is covered.

Orange tape:
To indicate that parts or the whole of an information, service or direction sign does not apply, orange tape with black borders on each side can be used. Each of the borders shall have a width equivalent to ¼ of the tape width, so that the orange field is equivalent to half the tape width.

The tape width depends on the height of the text on signs with text:

Text height mm	105–175	210–280	350–
Tape width mm	50	75	100

Figure 4.2 Widths of tape to nullify a sign's message.

The tape shall adhere to the sign sufficiently so that with normal use it does not detach from the sign. At the same time, the sign sheeting must not be damaged when the tape is removed.

Orange tape shall only be used according to the rules given in Manual 050 Part 1 and in Manual 051.

4.2.2 Warning panel

Description

A warning panel is a combination of barrier marking and yellow flashing lights (signal 1098) and possibly other traffic signs or a flashing arrow (signal 1100). It can be installed as a separate portable unit, as part of a trailer or directly on a work vehicle. A warning panel as a separate unit or installed on a trailer shall, as a minimum, consist of two signs (no. 930 Barrier marking), one placed high and one placed low.

Two alternately flashing yellow lights (signal 1098) shall be placed on the topmost sign. These shall not overlap the barrier marking or other elements of the warning panel, but can be part of a flashing arrow.

Between the two no. 930 barrier marking signs, other public traffic signs and/or a light arrow (signal 1100) may be placed. Traffic signs or illuminated arrows placed on the sign panel must not overlap each other or the two no. 930 signs, and shall remain inside the warning panel's outer edges. These traffic signs shall always be covered or removed when they are not in active use and while being transported.

The yellow flashing signals shall not be in use when a flashing arrow (signal 1100) is used. The arrow shall extend over a square of at least 1.6 m x 1.6 m.

Requirements for lights on warning panels are given in Section 4.2.5.

When both signal 1100 and sign 404 are shown on the warning panel, an automated check should be made that these always show the same direction of traffic.

On the back of the warning panel, there may be a symbol indicating the direction of signal 1100 / sign 404, but this shall be designed in such a way that it cannot be confused with a signal or message to drivers.

Warning panel on trailers and similar

Warning panels can be installed on trailers, trailer-equipment or similar if these satisfy the requirements given in regulations concerning this type of vehicle.

The sign structural support shall provide the warning panel with adequate stability during operation and when transported.

When the trailer or unit is parked, but not in active use, one barrier marking shall be visible.

During transport, there shall be at least one barrier marking visible.

Warning panel on vehicles

The warning panel can also be installed directly on vehicles or motorised work equipment. All elements on the warning panel do not need to be in the same vertical plane, but road users who approach the panel shall have a visual impression that they are.

Warning panels shall not be wider than the vehicle they are attached to. If technical conditions dictate, the two barrier markings may have different widths, but in this case, the outer edges of the equipment they are mounted on shall be marked according to regulations.

Figure 4.3 Warning panel on a motor vehicle with crash cushion.

Examples of warning panels are shown in Figures 4.4 and 4.5. Tolerance requirements for the given sizes are ± 0.1 m.

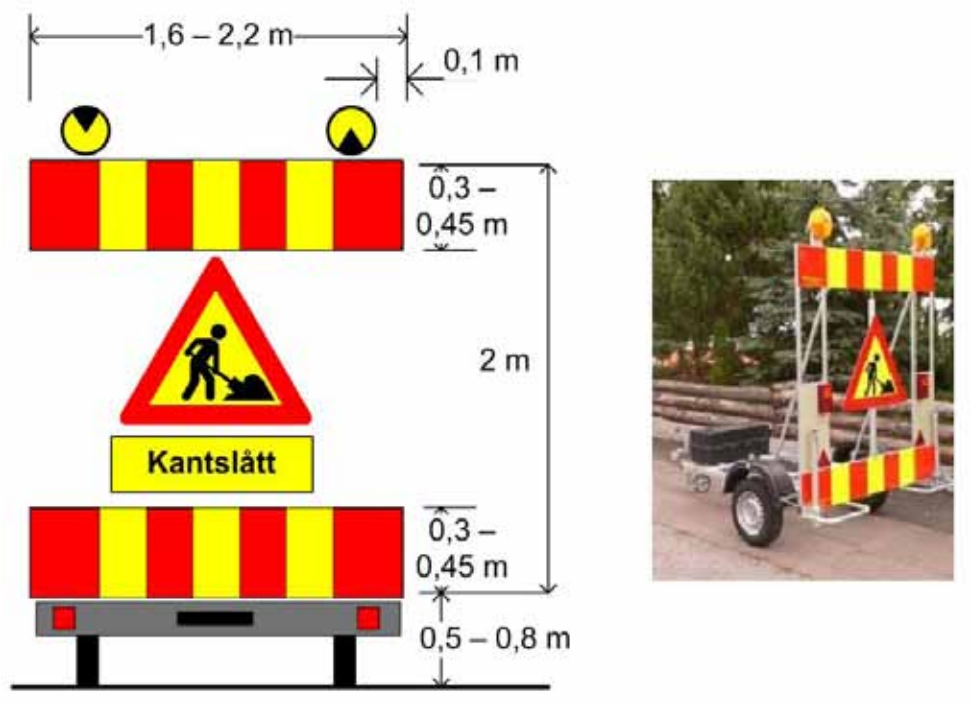


Figure 4.4 Examples of warning panels, normal size.

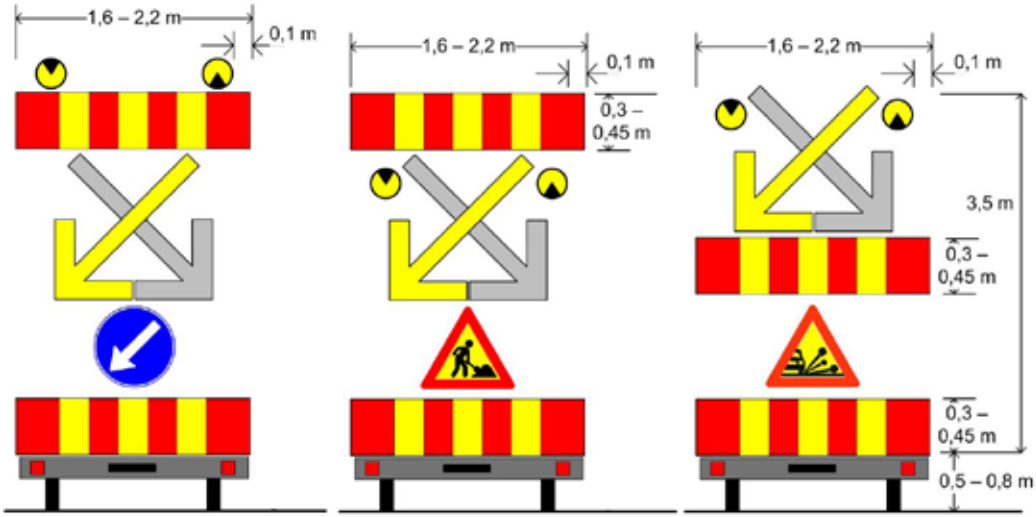


Figure 4.5 Examples of warning panels, large size.

English term	Refer to NS-EN 13422	Class to be used in Norway	
		Class	Note
Category B cone	3.5	B	
Category B cylinder	3.9	B	
Shape of cones	4.1.1.1	S1	
Dimensions of traffic cones	4.1.2	W2	
Performance of retroreflective surfaces in wet conditions	6.1.2.6	WT0	

Figure 4.6 Category/Class divisions, EN-NS 13422.

4.2.3 TTraffic cylinders and cones, temporary delineators

Traffic cylinders and cones

Traffic cylinders and cones shall satisfy the requirements of EN-NS 13422, with classes as given in Figure 4.6.

Both traffic cones and traffic cylinders shall be category B, i.e. only parts of the cone/cylinder body shall have a retro-reflective surface. The retro-reflective surface shall make up at least 20% of the cone or cylinder height and shall be placed in the area between ½ H and ¾ H, measured from the ground.

The retro-reflective surfaces shall meet the requirements for colour and luminance for fluorescent yellow-green colour in Part 1 of Manual 062. The non-reflective surfaces on the cone body shall meet requirements for colour and luminance in NS-EN 13422. When new, the retro-reflecting surfaces shall meet the requirements for retro-reflective coefficient R' in Part 1 of Manual 062. Cones or cylinders with a height of less than 450 mm shall not be used.

The cones shape shall comply with Class S1, i.e. the angle between the cone surface and the vertical shall be 10° (± 2.5°) for at least the upper 75% of the cone height. The lower 25% over the cone base may have an increased angle of between 7.5° and 14.5°.

The cone's minimum weight including the base shall comply with Class W2:

Height (mm)	Weight (kg)
>900 ≤ 1000	6,0
>750 ≤ 900	4,0
>500 ≤ 750	1,9
>450 ≤ 500	1,8

Figure 4.7 Weight requirements for cones in relation to cone height.

Temporary delineators

Sign 906 delineators can be used to delineate between traffic lanes or to limit traffic lanes, and the sign can be reduced in size although it may not have a height less than 450 mm.

Such signs shall be designed so that impact with them does not present a danger of injury. They may be mounted on low lying guide rails that can be installed in a continuous series. The requirements for traffic cone and cylinder stability shall be met for such use (cf. NS-EN 134422).

Figure 4.8 Example of delineators mounted in series on guide rails.

It is permitted to use delineator markings that resemble sign 906, but which are smaller than the minimum requirement for this sign, and with only one yellow-green reflecting diagonal stripe, for attachment as markers on railings and other protection equipment. This diagonal stripe shall have the same direction that sign 906 would have.

4.2.4 Signalling board

Signalling boards shall be designed as shown in Figure 4.9. Total length shall be a minimum of 40 cm and the diameter of the sign part shall be a minimum of 20 cm.

One side of the disc shall be a red colour that satisfies the colour requirements for traffic signs. The other side shall be a neutral colour.

The red side shall be covered with Class 3 reflective sheeting. In order to improve visibility in the dark, the red side may have a circular red light that may be easily turned on and off, with a diameter of at least 5 cm.

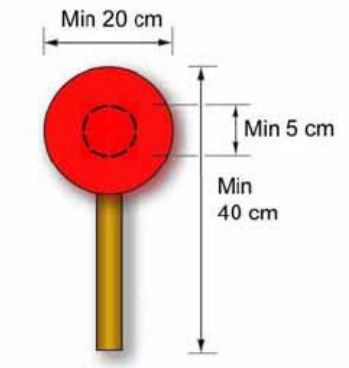


Figure 4.9 Signalling disc.

4.2.5 Lights

See Part 3, section 3.5.

4.3 Protection equipment

4.3.1 General

Protection equipment shall physically prevent road users from entering roadwork areas or areas meant for other road users, thus preventing damage to equipment and structures and/or injury to workers or road users. Protection equipment shall also be designed and used so that it does not increase, but rather decreases the extent of injury or damage in the case of accidents. A risk assessment shall always be carried out, cf. Manual 051, to establish the need for use of protective measures and to decide what type of equipment should be used.

Transverse protection devices

The purpose of transverse protection is to create a buffer zone between the protection itself and the work location with equipment and persons working on the road. Use of warning devices alone (delineators and warning panels) is not regarded as transverse protection.

Transverse protection is considered to be:

- Equipment on the carriageway.
  - Vehicles (at a low speed)
  - Standardised equipment meant to function as protection
- Equipment on the vehicle: buffer vehicle (Truck Mounted Attenuator)
- Equipment on fixed objects: energy-absorbing guardrail terminations and similar

Longitudinal protection against moving traffic

Longitudinal protection against moving traffic is always guardrails that are used to prevent road users driving alongside the work location from:

- Vaccessing the work area
- Vaccessing temporary areas for pedestrians and bicycle traffic,
- Vaccessing temporary areas for oncoming traffic.

Guardrails may also be used in front and at the end of the work location as transverse protection, but must then be designed so that collision does not result in increased injury or damage. The guardrails shall be designed and used according to rules given in Manual 231 and special rules for longitudinal protection given in Manual 051. A list of approved guardrails is given at www.vegvesen.no/Fag/Publikasjoner/Vegnormaler/Rekkverk+og+master/Godkjente+rekkverk.

Protection against pedestrians and bicycle traffic

Protection between the work area and pedestrians and bicycle traffic shall as a minimum tolerate being inadvertently hit by vulnerable road users without being moved significantly and without injuring the road user. Protection shall not be a danger or great inconvenience to visually impaired and blind persons.

4.3.2 Transverse protection devices located on and beside the carriageway

This is equipment that by its design, method of attachment and weight stops vehicles without inflicting damage or injury to vehicles and road users, and without the devices or vehicles leaving the buffer zone and causing damage or injury to equipment, workers or other persons.

Standardised equipment on the carriageway

Before such equipment is used, the results of tests carried out must show that the equipment satisfies the general usage requirements for such equipment. The equipment shall be approved by the Directorate of Public Roads or a corresponding Nordic government department. The equipment shall only be used in accordance with the conditions that were used in the tests.

Figure 4.10 Protection equipment placed across the carriageway, with warning equipment.

Standardised equipment on guardrail terminations or in front of fixed objects

Guardrail terminations shall be designed in accordance with Manual 231. If possible, energy-absorbing equipment pursuant to the requirements in Section 9 of Manual 231, should be used in front of fixed objects that if collided with may pose a danger, or other equipment that is documented to function as protection in this type of situation.

4.3.3 Transverse protection devices mounted on vehicles

Vehicles or work equipment with warning panels

Vehicles or work equipment may be used as protection devices across the carriageway in the case of temporary work or work that moves along slowly at low speed. In this case it should be placed on the carriageway at a distance from the work area which will provide an adequate buffer zone. The weight of the vehicle or work equipment determines the length of the buffer zone.

The safety of the driver of the vehicle carrying the protective device in case of collision must be considered if the driver sits continuously in the vehicle. Consideration must also be given to the injuries that may be sustained by the driver and passengers of a vehicle that collides with the vehicle/device functioning as transverse protection. As a minimum, lorries must have a special collision barrier at the rear to prevent the vehicle colliding with the protection vehicle from behind coming under the bed of the lorry or similar.

Warning panels may be directly mounted on the vehicle or motorised device that is being used as protection. This must be effected in such a way that ordinary lamps are not covered and the driver maintains an adequate view.

Vehicles with energy-absorbing equipment

When working on highly trafficked or high-speed roads, transverse protection should consist of a heavy vehicle that, in addition to the warning panel, is equipped with energy-absorbing equipment that reduces the damage to colliding vehicles and the driver of the warning panel vehicle. Such equipment shall have undergone testing as described in NCHRP Report 230 or 350 in accordance with Figure 4.11, and in addition be approved by the Directorate of Public Roads or a corresponding Nordic government department. Approval will be based on documentation from an ISO approved test facility.

	Test number	Notes
NCHRP Report 230	50 and 51 and 54	Large vehicle (2041 ± 136 kg), 0° on the centre line, 97 km/h Small vehicle (1134 ± 45 kg), 0° on the centre line, 97 km/h Large vehicle (2041 ± 136 kg), 10 - 15° on the centre line, 97 km/h
NCHRP Report 350	3-50 and 3-51 and 3-52 or 3-53	Small vehicle (895 ± 25 kg), 0° on the centre line, 100 km/h Large vehicle (2000 ± 45 kg), 0° on the centre line, 100 km/h Large vehicle (2000 ± 45 kg), 0°, offset the centre line, 100 km/h Large vehicle (2000 ± 45 kg), 10°, offset the centre line, 100 km/h

Figure 4.11 Test NCHRP 230/350.

The equipment shall only be used in accordance with the manufacturer's guidelines. Minimum width: 1.75 m.

A list of approved equipment is found here: http://www.vegvesen.no/Fag/Veg+og+gate/Drift+og+vedlikehold/Arbeidsvarsling/Pekerside

Figure 4.12 Energy absorbing equipment on vehicles (examples).

4.3.4 Longitudinal protection against moving traffic

Longitudinal protection against moving traffic shall meet the requirements in Manual 231 Rekkverk [Guardrails] and special requirements for railings for roadwork in Manual 051. Among other things, this applies to the determination of the safety distance (A) and safety zone width (S) in manual 231, and special requirements concerning longitudinal protection

for moving traffic in Manual 051. Guardrails that are used in connection with road work should be strength category T1, T2 or T3 for temporary situations, dependent on site conditions. Guardrails that satisfy the requirements for normal situations (N1, N2) may also be used. Equipment that does not satisfy the requirements of Manual 231 shall not be used.

Figure 4.13 Longitudinal protection devices (examples).

4.3.5 Longitudinal protection devices to protect vulnerable road users

The rules in section 2.10.3 Gang- og sykkelveg langs bilveg [Walkways and cycle paths beside r oads] of Manual 231 shall be used if walkways and cycle paths or pavement are relocated due to roadwork and the construction work has a duration of more than 5 workdays. For walkways and cycle paths near construction sites, the Manual's section 2.12 applies similarly.

In the case of short term work, visual markings and preferably a lighter physical protection device shall be used as a minimum. There shall be a guide edge for canes used by the blind and visually impaired, and it must tolerate:

– the visually impaired coming into contact with the protection device with no danger of injury to the person or damage to the protection device.
– that pedestrians and cyclists, whether intentionally or not, come into contact with the protection device without it turning over or being moved.
– limited attempts at vandalism.

Figure 4.14 Protection devices for pedestrians and bicycle traffic.

4.3.6 Visual markings on protection equipment

Use of road traffic signs and similar

Protection devices should be combined with warning equipment that makes them particularly visible for the intended road user groups. As a rule, such warning equipment shall be sign equipment cf. section 4.2.1, e.g. delineators, traffic cones or traffic cylinders.

Other equipment may also be used as warning equipment, for example waffle board barricades and different types of horizontal markings, if they satisfy the requirements given in this manual

Waffle-board barricades and similar

Waffle-board barricades can be used to support horizontal markings, for example barrier boards shaped like sign 930. A waffle-board barricade should not be used alone as a barrier across the carriageway.

Waffle-board barricades and barriers can be used to delineate the work area where risk assessment has shown that there is no need for guardrails or heavier barrier devices across the road. Waffle-board barricades and barrier planks shall not be used for moving traffic where the speed limit is higher than 40 km/h.

Waffle-board barricades shall mainly be red and in addition shall have some fluorescent yellow/green fields. On each side, there shall be at least one such yellow/green field with retro-reflecting properties corresponding to Class 3 sign sheeting. These fields shall be a minimum of 20 cm^2 large.

Waffle-board barriers shall meet the requirements for stability for traffic cones of a similar height. In addition, special consideration shall be given to consequences should the blind or visually impaired walk into the equipment.

If other equipment is used to support visual markings, this shall either be adequately visible in daylight (distinctive colour) and in the dark (reflective) or the equipment that is held up must be correspondingly visible. Such equipment shall also have a stability corresponding to traffic cones and in normal use must not present a danger to road users.

4.4 Personal protective equipment

4.4.1 Workwear

All workers who work on public roads that are open for general traffic shall use protective clothing in accordance with NS-EN 471 High visibility warning clothing. Protective clothing shall, alone or together, meet the requirements of Protection Class 3

4.4.2 Jacket for manual traffic direction

To enhance the visibility of personnel who direct traffic manually in connection with roadwork, a certain type of jacket shall be worn that manifests the special function the wearers have vis à vis drivers. The jacket shall be used by everyone who directs traffic except on-duty police. This type of jacket shall only be used when manually directing traffic.

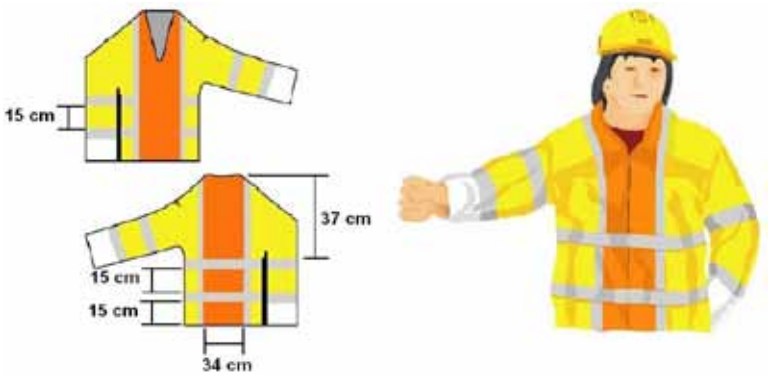


Figure 4.15 Jacket for manually directing traffic (measurements for size "L").

The jacket shall satisfy the same requirements as other workwear, cf. the previous heading. The jacket shall have a fluorescent orange mid-piece and side panels and sleeves of fluorescent yellow. Additionally the jacket shall have white cuffs. The yellow and orange fields shall be separated by 5 cm reflective bands going over the shoulders and down both in front and in back on the jacket. Two reflective bands shall also go around the trunk of the body. The sleeves shall have two reflective bands around the sleeve at the same height as those on the jacket itself. The lower reflective band shall be between the yellow and the white part of the sleeve.

Such jackets shall not have extremely visible logos or other departmental or company markings. However, a logo not larger than 3 x 9 or 4 x 6 cm may be permitted on the left sleeve.

4.5 References

- FOR-2005-10-07-1219 Forskrift om offentlige trafikkskilt, vegoppmerking, trafikklyssignaler og anvisninger (skiltforskriften). [Regulations concerning road traffic signs (road markings, traffic light signals and directional devices)]
- FOR-1994-10-04-918 Forskrift om tekniske krav og godkjenning av kjøretøy, deler og utstyr (kjøretøyforskriften) [Regulations concerning technical requirements and approval of vehicles, parts and equipment (the vehicle regulations)]
- FOR-1998-11-06-1060: Forskrift om elektriske lavspenningsanlegg [Regulations concerning electrical low-voltage facilities]
- NS-EN 12352 Traffic control equipment. Warning and safety light devices
- NS-EN 12676 Passive safety of support structures for road equipment
- NS-EN 1317 Road restraint systems
- NS-EN 1436 Road marking materials
- NS-EN 1463-1: Retroreflecting road studs - Part 1: Initial performance requirements
- NS-EN 1790 Road marking materials - preformed road markings
- NS-EN 471 High visibility warning clothing
- NS-EN13422 Vertical road signs - Portable deformable warning devices and delineators - Portable road traffic signs - Cones and cylinders
- Manual 018 Vegbygging. [Road building]
- Manual 048 Trafikksignalanlegg [Road traffic signal systems]
- Manual 049 Vegoppmerking [Road marking]
- Manual 050 Skiltnormalen. [The sign standard]
- Manual 051 Arbeidsvarsling [Warning of work carried out on and alongside roads]
- Manual 062 Trafikksikkerhetsutstyr – Tekniske krav (Road traffic safety equipment – Technical requirements) Parts 1, 3, 5 & 6
- Manual 231 Rekkverk [Guardrails]
- NCHRP Report 230: Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances (Washington DC 1981)
- NCHRP Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features (Washington DC 1993)

5 Safety support equipment

5.1 Safety support equipment - general

5.1.1 Introduction

The Norwegian Public Roads Authority has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce damages in any accidents that nonetheless occur. Head-on collisions and driving off the road are the predominant types of accidents where there are many fatalities. Action targeting these types of accidents in particular will therefore be very important. Safety support equipment will often have to be placed within the safety zone defined in Manual 231 "Railings". This part of Manual 062 therefore contains requirements relating to functions and materials in connection with the production and use of safety support equipment.

5.1.2 Terms and definitions

Safety support equipment is used for bearing traffic safety equipment. In this document, safety support equipment consists of signposts, sign columns, sign gantries, lighting columns, signal posts and posts for automatic traffic control (speed cameras), controller enclosures/switchboards etc. with associated foundations.

The table below contains common terms for safety support equipment with the technical definitions and designations used in Part 5 of Manual 062.

5.1.3 Status international requirements

CEN standards that deal with the area of safety support equipment and have been approved by NS – Norwegian Standards, and other relevant publications are given in the reference list at the back of the manual.

The most relevant standards for safety support equipment are NS-EN 12899-1, NS-EN 40-3-1 and NS-EN 12767. The most relevant requirements from these standards are included in this Part 5. The most relevant requirements from NS-EN 12899-1 are also included in part 1. When CE labelling of various products becomes a requirement, information will be provided.

5.1.4 Overview of approved lighting columns, sign columns and signal columns

Yielding (passively safe) road equipment shall be approved by the Directorate of Public Roads until further notice. The approval applies until an inspection body for railings has been established with legal basis in the Norwegian Act relating to technical inspection bodies. Since no formal approval system has yet been established, until further notice these approvals apply in Norway's case only to the Norwegian Public Roads Administration (national and county highways). Lists of the passively safe safety support equipment that is approved at any time can be found here: http://www.vegvesen.no/Fag/Publikasjoner/Vegnormaler/Rekkverk+og+master (Norwegian only).

5.2 Functional requirements

All safety support equipment must be viewed as a complete structure pursuant to NS 3473 "Prosjektering av betongkonstruksjoner, Beregnings- og konstruksjonsregler" (Design of concrete structures, design and detailing rules), where the foundation is also part of the structure. All safety support equipment shall have a minimum service life of 30 years.

5.2.1 Lighting columns

Lighting columns comprise columns and posts of steel, aluminium or timber for road and street lighting along public roads. The columns shall satisfy all public standards and requirements.

Sign column:	Post for bearing a traffic sign. Usually used for large sign surfaces and variable signs, consisting normally of steel or aluminium.
Signpost	Standard pipe for bearing a traffic sign. Usually used for small sign surfaces. Two to three posts are often used for road direction signs. Normally consists of steel or aluminium.
Half gantry:	Structure consisting of a column with a cross-bar for bearing traffic signs or light signals over the carriageway. Normally consists of steel or aluminium.
Full gantry:	Structure consisting of two legs, one on each side of the carriageway, with a cross-arm over the carriageway for bearing traffic signs or light signals. Normally consists of steel or aluminium.
Lighting column:	Post for bearing light fittings, normally consisting of wood, steel or aluminium.
Signal column:	Post for bearing light signals, normally consisting of steel or aluminium.
Yielding column:	The term "yielding column" or "passively safe column" is used for lighting columns, sign columns and signal columns etc. which are approved according to NS-EN 12767 Passive safety of support structures for road equipment - Requirements and test methods.

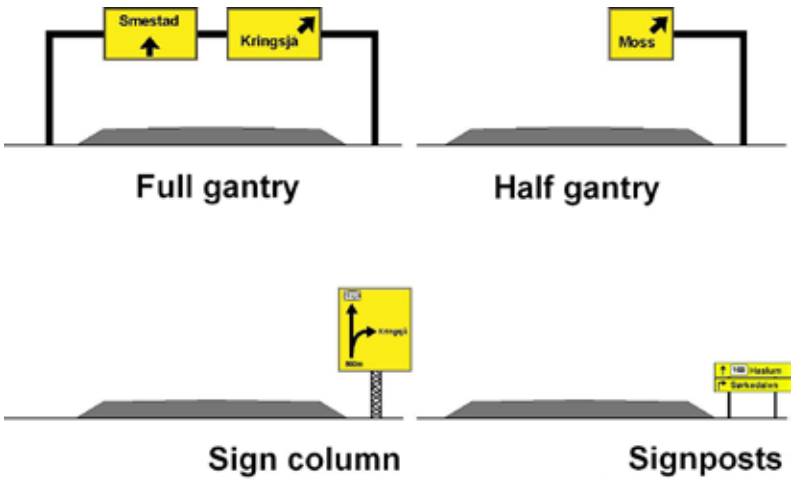


Figure 5.1. Sign gantries, sign columns and signposts.

Wind loads for lighting columns

In inquiries about and deliveries of lighting columns, the height over the terrain and the terrain category shall always be stated to ensure that the lighting columns are adequately dimensioned for the local wind loads.

No traffic signs larger than about 1 m^2 should be set up on lighting columns. If larger signs are wanted, the wind loads on the column must be calculated. Signs must not be set up on HE (high energy absorption) and LE (low energy absorption) columns (see section 5.2.4.4). Before traffic signs are mounted on lighting columns, permission must be obtained from the column owner.

In connection with the compiling of specifications for lighting columns for new roads, it is important to note that new Norwegian standards have been published for wind loads and engineering of lighting columns. These standards are now in line with European standards.

The new standard for Wind loads, NS 3491-4, replaces NS 3479 and the old wind graphs. Standard NS-EN 40-3-1, "Lighting columns – Specification of characteristic loads" specifies the factors and loads that are to be used in designing lighting columns.

A new concept, Reference wind velocity, Vref, has been introduced. Reference wind velocity is defined as the average wind velocity over 10 minutes, 10 m above a flat landscape with terrain category II. The reference wind velocity Vref is specified for all municipalities in Norway in NS 3491-4, Annex A.

NS-EN 40-3-1 is a special standard for calculating characteristic loads on lighting columns and supplemented by data from NS-3491-4 it provides a good way of calculating what can be regarded as static wind load. There is some correspondence between NS-3491-4 and NS-EN 40-3-1, but the designations are not identical and there are some differences in how to calculate wind forces on structures. It is therefore suggested that NS-EN 40-3-1 be used as far as possible. In this present manual we will largely use the designations in NS-EN 40-3-1. All units are SI units (metre, second, kilogram, Newton).

Calculation of forces and moments

It must be possible to document all calculations.

A column founded only in the ground is a statically determinate structure. A practical calculation method is to determine the reference wind velocity V_{REF} for the installation site and terrain category and then start the calculations at the top of the column. Use terrain category II unless otherwise specified. Determine the wind forces on the fittings and calculate the moments and torsion moments for fastening the fittings. Then determine the wind

forces on the brackets and determine the moments and torsion moments for fastening the bracket. Then divide up the column into a suitable number of sections and calculate the wind forces acting on the uppermost section (Section 1). Determine the moments acting on the lower edge of Section 1 by multiplying the wind forces on the sections above by their respective moment arms. Continue in a similar way with the next section, until you reach ground level. Separating lines should be placed between sections at all places where there may be a critical point such as sudden changes of diameter (reduction), joints, hatch openings and foot point or change of the cross-sectional shape or similar. The approach for steel and aluminium columns is described in NS-EN 40-3-3.

Characteristic wind loads

The starting point for a wind load calculation in NS-EN 40-3-1 is the reference wind velocity $V_{ref,0}$, which is identical to V_{REF} in NS 3491-4. This is specified in Annex A to NS 3491-4 as the 10 minute mean wind velocity 10 metres above the ground for every municipality in Norway for terrain category II. For a description of the different terrain categories, see NS 3491-4 Section 5.3.1.

There are two modifications that are relevant for reference wind velocity before we arrive at basic wind velocity V_b:

1. V_{REF} is specified as having a return period of 50 years. The usual calculating life for lighting columns is 30 years, so that V_{REF} is converted to a 30 year return period with the factor $C_s = C_{SAN} = V_{REF}$ (in NS 3491-4 this is called C_{SAN}).
2. V_{REF} is specified for terrain category II, i.e. ordinary flat, open cultural landscape for areas up to the tree line. For installations above the tree line V_{REF} can be calculated using the factor $C_{ALT} = C_{HOH}$ according to NS 3491-4 Annex A4.

The basic wind velocity is the starting point for a load calculation and is given as:

$$V_{ref} = V_b = C_s C_{ALT} V_{REF} \tag{0.1}$$

For column installations in most areas in Norway, the basic wind velocity and terrain category II will be sufficient and a conservative assumption for the wind load on a column. The exception is column installations right on the coast, on rises in the terrain or on ridges or hilltops with a typical height of more than 5 m above the general ground level. Then the wind profile up along the column can change considerably, and in this case it is not enough to change the basic wind velocity. In such cases the columns must be specially calculated with a wind profile that also depends on the topography of the rise (see Section 3.2.5 and Annex B of NS-EN 40-3-1). Alternatively, they can be calculated in accordance with Section 5.4 of NS 3491-4, but then the whole wind load calculation should be done in accordance with this standard. For columns that are covered by one of the standardised terrain categories below the tree line we thus have

$$V_{ref} = V_b = 1.0 \sqrt{0.92}\, V_{REF}$$

(0.2) For installations where one of the standardised terrain categories 0 – IV applies, the columns can be dimensioned once and for all by calculating the ratio between permitted effective fitting area for a given column and terrain category and the reference wind velocity V_{REF} as specified in NS 3491-4. In addition to the terrain category, the wind pressure on a column will also vary with height and with cross-sectional shape, surface and diameter of the column, since these contribute to determining the flow conditions around the column. In general, column profiles with edges and very rough surfaces will result in considerably larger wind loads than circular columns with smooth surfaces. In addition the dynamic behaviour of the column (with fittings mounted) must be taken into account. The wind pressure of the column at a height z above the ground is calculated as

$$q(z) = \delta\ \beta\ f\ C_e(z)\frac{\rho}{2}V_{ref}^2 \qquad (0.3)$$

Where:

$\delta = 1 - 0.01h$	Reduction factor due to reduced probability of a full wind load over the whole column at the same time. The height h of the column is inserted in [m].
$\beta = \beta(T)$	Dynamic gust factor depending on the natural period (T) of the column structure. The maximum fittings weight at the top shall be included in the structure mass. β an be determined from the figure in NS-EN 40-3-1.
$f = f(z)$	Topographic factor that depends on the topography of the installation site and varies with the height (*z*) over the ground. This is usually set at 1.0 when account is not taken of special topographical conditions other than standardised terrain categories.
$C_e(z)$	The distribution of the wind load pressure along the column as a function of height (*z*) above the ground. This depends on the terrain category. In the absence of specifications, use terrain category II.
$\rho = 1.25$ [kg/m³]	Air density.

The distribution of the wind load pressure is controlled by the roughness factor, C_r, which in turn is determined by the terrain category, and shall be calculated as

$$C_e(z) = C_r^{\,2}(z) + 7k_r C_r(z) \qquad (0.4)$$

Here $C_r(z) = c_r(z)$ where the latter is the designation used in NS 3491-4. This results in a logarithmic wind profile up the column and is given with the same formula with appurtenant parameters in both standards. For a given terrain category, for example II, the same value will be obtained at a given height above ground irrespective of the cross-sectional profile of the columns.

However, the wind forces on a column at a given height depend strongly on the cross-sectional shape, surface roughness and size (diameter) of the column. This is taken into account by using a shape factor *c* (drag coefficient or force factor = $= c_f$ in NS4991-4). This

is calculated using the Reynolds number defined as:

$$\mathrm{Re} = \frac{VD}{\nu} \tag{0.5}$$

Here D [m] is the diameter of the column at a height z above the ground. Air viscosity is set as $\upsilon = 15.1 \times 10^{-6}$ [m^2/s]. There is a considerable difference between NS-EN 40-3-1 and NS 3491-4 with respect to how the Reynolds number (dimensionless) is calculated and how the shape factor is determined. We keep to NS-EN 40-3-1 and here the velocity V is calculated on the basis of the wind pressure on the column:

$$V = \frac{1}{C_s}\sqrt{\frac{q(z)}{0.5\rho\delta\beta}} \tag{0.6}$$

The Reynolds number, and hence the shape factor, c, can vary substantially up the column. The shape factor is determined from the Reynolds number for a column cross section at a given height z from Figure 3 in NS-E 40-3-1. NS-40-3-1 applies only to columns with a circular or octagonal cross-sectional shape with smooth surfaces. For columns with a different surface or cross-sectional shape, specialist literature or NS 3491-4 must be used and adapted to the method of calculation in NS-EN 40-3-1. In order to calculate the wind force on the column, the column is divided up into sections (sub-areas) and the conditions within each section are regarded as constant with respect to wind loading. Horizontal wind force must be calculated individually for each section. Fittings and fastening brackets are regarded as separate sections where the shape factors and section areas have to be estimated separately. This also applies to signs and similar equiment that are fixed to the columns.

Horizontal wind force for a section at a height z on the column can now be calculated as:

$$F = Acq(z) \tag{0.7}$$

Where:

$A = A(z)$	is the projected area normal to the wind direction for a section. For a column, this will normally depend on how high up the column the wind force is calculated. Fittings are usually regarded as a separate section with known shape factor and projected area. Brackets are regarded either as separate sections in those cases where the shape factor is known for the bracket as a whole. If not they have to be divided up and estimated in the same way as the column.
$c = c(z)$	Formfaktoren for en seksjon i høyden z. Denne vil kunne variere betydelig fra seksjon til seksjon. For sirkulært eller oktogonalt tverrsnitt kan denne bestemmes fra figur 3 i NS-EN 40-3-1. For armaturer må denne oppgis fra leverandøren basert for eksempel på opplysninger fra vindtunnelforsøk.
$q(z)$	is the distribution of the wind load pressure as a function of height (z) above the ground. This depends on the terrain category. Use terrain category II when the terrain category has not been specified.
z	Height above the ground of the centre of gravity of a section.

The largest extent of a section is 2 metres in a vertical direction. This means that a 12 m column must be divided up for calculation purposes into at least 6 sections + fittings section(s) and bracket section(s). It is often desirable to divide the column up into smaller sections for greater accuracy and in order to be able to determine the moments in all critical parts.

The location and design of the fittings and brackets can often give rise to strong vertical wind forces and/or moments (lifting forces) if the wind comes from straight ahead or at an angle. Wind on combinations of fittings and brackets in different directions should be assessed as separate load cases.

Calculating in the failure limit state

Calculating in the failure limit state shall provide a safeguard against failure or major deformations that can be compared with failure.

In dimensioning, the wind loads must be combined with the self loads of column, fittings and brackets. Special rules for calculating moments and torsion moments from self loads and wind loads from brackets and fittings are given in NS-40-3-1 and NS-EN 40-3-3, depending on the material used in the columns. The self loads of straight, high, slender columns without cantilever beams will normally be small compared with the wind loads.

The loads calculated according to NS-EN 40-3-1 (or NS 3491-4) are characteristic loads and must be multiplied by load factors and combined in order to give design load combinations. Failure safety is evaluated with the aid of calculations in the failure limit state. The following load factors must be used for columns in Norway when calculating design forces in the failure limit state:

$\gamma_G = 1.2$	Partial factor for self load in the failure limit state
$\gamma_Q = 1.4$	Partial factor for wind load in the failure limit state

This corresponds to Class A in NS-EN 40-3-3, for example, and approximately one structure in reliability class 1 in NS 3490 if a column is regarded as an ordinary structure.

Partial factors γ_{Mj} shall also be used when calculating design resistance. These are material-specific, and as a general rule will be given in the design standards for a specific material. Separate material-specific standards have been prepared for some structural materials for columns, such as NS-EN 40-3-1 for steel columns and NS-EN 40-3-3 for aluminium columns, and γ_{Mj} is specified in these.

Calculating in the serviceability limit state

In addition to the safety requirements against failure, functional requirements may be associated with the columns, and these are calculated in the serviceability limit state for smaller loads than those in the failure limit state. The most relevant functional requirement is normally deformations at the top or by the fittings. The same characteristic loads are used as in the failure limit state. When deformations in the serviceability limit state are calculated, all partial factors of safety are normally set at 1.0, i.e.:

$\gamma_G = 1.0$	Partial factor for self load in the serviceability limit state
$\gamma_Q = 1.0$	Partial factor for wind load in the serviceability limit state
$\gamma_{Mi} = 1.0$	Partial factor for materials in the serviceability limit state

The functional requirements regarding deformation (outwards and/or downwards) are normally associated with the location of the fittings (see e.g. NS-EN 40-3-3 for steel and aluminium columns, where outward deformations are classified (4, 6 and 10% of the total column length to the fitting).

It is possible to mount large fittings on one and the same column in areas with a low wind speed, or small fittings in areas with a greater wind load. The deformations will not be the same size in the two cases, and one and the same column may well fall into two function classes at the same time, depending on the size of the fitting and the maximum wind load.

The following shall therefore be used for calculating deformations:

- Reference wind velocity $V_{REF} = 26$ m/s
- Maximum fitting surface calculated on the basis of the column's capacity (failure limit state) at $V_{REF} = 26$ m/s.

When calculating deformations, account should be taken of the fact that most of the deformation at the top of a column may be due to the column not having perfect restraint at the foot point. Only very small rotations are necessary at the foot or the foundation for this to result in larger deformations at the top than the deformation in the column structure.

The serviceability limit state is also used in fatigue calculations.

Dynamic snow loads for lighting columns

In choosing lighting columns, account is not taken of dynamic snow loads (it is not required that the column strength be increased to take account of them). In places where there are large quantities of snow, this is taken into account in the siting of the column, however.

Calculating supplementary loads for steel columns with an aerial network

Account must be taken of the column strength when mounting aerial networks on steel columns. Load calculation and column strength design must be performed for the individual case.

The columns must be end-guyed. In cases of tension deviations of > 15° from the horizontal, guys or stays should be mounted. If there is any doubt, the stresses relating to column strength must be calculated. Requirements pursuant to FEA-F "Forskrifter for elektriske forsyningsanlegg" (Regulations for electrical supply facilities) must be complied with.

5.2.2 Gantries

Gantries consist of full or half-gantries along public roads that carry public traffic signs and/or traffic signals.

Wind loads for gantries

NS 3491-4 "Prosjektering av konstruksjoner. Dimensjonerende laster – Del 4: Vindlaster" (Design of structures. Design loads – Part 4: Wind loads) shall form the basis for the calculation of horizontal wind loads on gantries for traffic signs and signals.

Suppliers of approved sign columns shall be able to document the moment, torsion and bending capacity of the columns (either through calculations or through full-scale tests). This documentation must be in accordance with NS-EN 12899-1: "Fixed vertical road traffic signs / Part 1: Fixed signs", which includes a description of wind load categories.

The gantries should be marked with a sign that specifies the maximum permitted sign area and associated wind load category, i.e. maximum sign area for which the gantry is designed.

Dynamic snow loads for gantries

Dynamic snow loads for gantry legs are regarded as insignificant compared with the loads that are transferred to the gantry leg by wind loads on the signs mounted on the arm/crossbar of the half gantries and full gantries. As a result, only wind loads and snow loads are used on signs and gantry arms/cross-bars as a design basis for calculating loads on gantries.

Snow loads on gantries

1 kN/m^2 is used as a design vertical static snow load on full gantries and half gantries.

5.2.3 Posts and columns for signs and signals

Posts and columns for signs and signals consist of posts and columns along public roads upon which public traffic signs and/or traffic signals are mounted.

General

Sealed sign and signal columns with cables passing through shall be supplied with ventilation openings. These shall be designed to satisfy the requirements in NEK 400-2. These columns must have an enclosure rating corresponding to IP 44 when they are installed and operating.

Internal signal/ring cables must not be spliced in the column. Connections to external cables shall take place in a connection hatch or at the top of the column. Connection hatches must not face the road.

Posts in signal facilities must be earthed. The connection in the posts must be designed to provide protection against condensation, and must be able to tolerate the aggressive stresses to which the material may be subjected.

Wind loads on sign and signal columns

In calculating characteristic loads for sign and signal columns, the ordinary rules for designing structures should be used as a general rule. The following loads shall be included for sign columns:

- Wind loads pursuant to NS 3491-4 or EN 1991-1-4.
- Self loads
- Dynamic snow loads as specified in NS-EN 12899-1

A distinction must be made between calculations in the failure limit state, intended to safeguard against failure or deformations that can be compared with failure, and purely functional requirements that are covered by the serviceability limit state. Unless otherwise specified, the assumed service life of signs and sign structures is set at 25 years.

Characteristic wind loads

Calculation of wind loads will only be discussed here in relation to NS 3491-4, but this is very similar to the European regulations EN 1991-1-4. Wind loads are to be regarded as static wind loads. All units are SI units (metre, second, kilogram, Newton).

The starting point for calculating wind loads is the reference wind velocity, V_{REF}. This is specified in Annex A to NS 3491-4 as the 10-minute mean wind velocity 10 metres over the ground for every municipality in Norway for terrain category II. For a description of the different terrain categories, see NS 3491-4 Section 5.3.1.
There are two modifications of reference wind velocity that are relevant before we arrive at basic wind velocity V_b::

2. V_{REF} is specified with a recurrence interval of 50 years. The usual calculated service life of sign column structures is 30 years, so that V_{REF} is converted to correspond to a 30 year recurrence interval using the factor $C_{SAN} = \sqrt{0.92}$.

2. V_{REF} is specified for terrain category II, i.e. ordinary flat, open cultural landscape for areas up to the tree line. For installations above the tree line VREF can be calculated using the factor CHOH according to NS 3491-4 Annex A4.

The basic wind velocity for a load calculation is then given as:

$$V_b = C_{SAN} C_{HOH} V_{REF} \tag{0.8}$$

For column installations in most areas of Norway, the basic wind velocity and terrain category II will apply and a conservative assumption for the wind load on a sign column. The exception is column installations right on the coast, on rises in the terrain or on ridges or hilltops with a typical height of more than 5 m above the general ground level. Then the wind profile up along the column can change considerably, and in this case changing the basic wind velocity is not sufficient. In such cases, special calculations must be made for the sign column, with a wind profile that also depends on the topography of the rise. This is calculated according to Section 5.4 in NS 3481-4 with information about the topography of the installation site. For installations where one of the standardised terrain categories 0 – IV applies, the columns can be dimensioned once and for all by calculating the ratio between permitted effective fitting area and basic wind velocity V_b for a given column and terrain category.

For sign structures that are covered by one of the standardised terrain categories below the tree line we thus have $V_b = 1.0\sqrt{0.92}\, V_{REF}$ (0.9)

As a general rule, account is taken of the terrain category and effect of local topography by calculating the local wind velocity. This depends on the height above the ground, and is calculated by introducing the terrain roughness factor $C_r(z)$ and topology factor $C_t(z)$ as follows:

$$V_s = C_r(z) C_t(z) V_b \tag{0.10}$$

The terrain roughness factor $C_r(z)$ expresses the variation of the local wind velocity with height depending on the terrain category. The topology factor $C_t(z)$ introduces a correction of the local wind velocity on the basis of the fact that hills and rises in the terrain normally cause the wind velocity to be higher close to the ground. For calculation of the terrain roughness factor $C_r(z)$ and the topology factor $C_t(z)$, see NS 3491-4, Section 5. In cases where account is not taken of local topography, the topology factor is set as $C_t(z) = 1.0$ and the local wind is given only by terrain category and the reference wind V_{REF} for the municipality. Unless otherwise specified, $C_t(z) = 1.0$ is used.

The wind pressure from a wind gust on a surface normal to the wind direction will vary with the terrain category, the height above the ground and also the geometrical shape of

the sign and bearing structure. The wind pressure on a surface at a height z above ground level is calculated according to NS 3491-4.

$$q_{kast}(z) = \frac{\rho}{2} V_s^2(z)[1 + 2k_p I_v(z)] \tag{0.11}$$

Where the air density $\rho = 1.25$ [kg/m3] and the contents of the square parentheses also include the effect of turbulence. Against the background of calculated wind pressure $q_{kast}(z)$ at a height equal to the centre of gravity of the sign area, the wind pressure category is determined from the following table:

Wind pressure category	Characteristic wind pressure [N/m²]	Typical wind velocities [m/s]
WL0	No requirements specified	0
WL1	400	25,6
WL2	600	31,3
WL3	800	36,1
WL4	900	
WL5	1000	40,4
WL6	1200	44,3
WL7	1400	47,8
WL8	1500	
WL9	1600	51,1

Figure 5.2 Wind pressure categories traffic signs.

If, for example, the calculated wind pressure for an installation site is $q_{kast}(z) = 1042$ [N/m²] , this indicates that the necessary wind pressure category is WL6, and further on in the calculations $q_{kast}(z) = 1200$ [N/m²] is used, or the calculated wind pressure, for example 1042 [N/m²], as the characteristic wind pressure for all parts of the sign structure. If there is more than one sign on the sign structure, $q_{kast}(z)$ is used with z equal to the distance above the ground to the centre of the surface of the sign that is farthest from the ground, and the wind pressure category WLn is determined.

Wind force

In order to calculate the wind force on the sign structure, the structure is divided up into sections (sub-areas) and the conditions within each section are regarded as constant with respect to wind loading. Each sign is regarded as a separate section. The column structure is regarded as an ordinary column, but with constant wind pressure over the whole column structure. Horizontal wind force is calculated individually for each section.

Horizontal wind force for a section (sub-area with its centre at a height z_e) of the column can now be calculated as: $F_w = A_{ref} c_d c_f \, WLn$ (0.12)

Where:

$A_{ref} = A_{ref}(z_e)$	is the projected area normal to the wind direction for a section. For a sign, this is normally the whole sign area. Any light fittings are usually regarded as a separate section with known shape factor and projected area.
c_d	Structural factor that takes account of dynamics. For fixed signs this is set as 1.0.
$c_f = c_f(z_e)$	Force factor for the sub-area A_{ref} which includes both pressure and suction forces on A_{ref} . For signs, this is determined according to Section 10.4.4 in NS 3491-4. For the column structure this is determined according to Section 10 in NS 3491-4, depending on the structure type. In cases where the shape factor depends on wind velocity, local wind velocity $v_s(z_e)$ is used for a section with height up to the centre of the surface. In the case of fittings, the shape factor must be specified by the supplier on the basis, for example, of wind tunnel tests.
WLn	Wind load pressure on the column structure determined by necessary wind load category n. The wind load pressure is regarded as constant over the whole column structure.
z_e	Height above the ground usually to the centre of gravity (surface centre) of a section (sub-area A_{ref}).

Calculations in the failure limit state

A distinction is made between sign structures where collapse could entail a substantial risk of major damage and loss of human lives, and sign structures where collapse would have insignificant consequences. Sign structures whose collapse could prevent free passage on roads with high traffic speeds and density, and which entail risk of collision or penetration of vehicles, should be treated as a Safety Level 2 structure according to NS 3490. Sign structures whose collapse would not come into conflict with traffic can be treated as a Safety Level 1 structure. One of the following two sets of load factors is therefore used in the failure limit state:

Safety Category	Self weight γ_G	Wind load γ_Q
1	1.2 (1.0)	1.35
2	1.35 (1.0)	1.5

The loads calculated according to NS-EN 40-3-1 (or NS 3491-4) are *characteristic loads* and must be multiplied by load factors and combined in order to give d*imensioning load combinations*. In the engineering, the *wind loads* must be combined with the *self loads* of sign, column, fittings and brackets. The load factor (1.0) in parentheses in the table above applies if 1.0 is less favourable than the specified value. Only the load effect of wind and self load is calculated in the failure limit state.

The design resistance to failure is calculated, depending on the material, using the following values for the material factor γ_M

Material	γ_M
Steel	1.15
Aluminium	1.15
Wood	1.35
Fibre-reinforced polymer composite	1.50
Plastic	1.80

For detail designs and similar, some design standards prescribe special values of γ_M and these must then be used rather than the values in the table above.

Calculations in the serviceability limit state

There are normally functional requirements associated with the columns, and these are calculated in the serviceability limit state for smaller loads than in the failure limit state. The most relevant functional requirement is normally deformations at the top or by the fittings. Design resistance and deformations are calculated according to the elasticity theory for calculations in the serviceability limit state.

Relevant loads are wind load, dynamic snow load and a single point load specified in EN 12899-1.

The following load factors are used to calculate deformations in the serviceability limit state:

$\gamma_G = 1.0$	Partial factor for self load in the serviceability limit state
$\gamma_Q = 1.0$	Partial factor for wind load in the serviceability limit state
$\gamma_M = 1.0$	Partial factor for material

Calculation of forces and moments

The resultant force $_{c_f = c_f(z_s)}$ at right angles to a sign must act at a point at the height of the surface centre and with a horizontal eccentricity (NS 3491-4, 10.4.4):

$$e = \pm 0.25b \tag{0.13}$$

Where b is the horizontal extent of the reference area, normally the width of the sign. This can have a major effect on the distribution of forces and moments in the column structure.

A column structure restrained only in the ground is usually statically determinate in the wind direction. A practical calculation method is to determine the reference wind velocity V_{REF} for the installation site and terrain category and then determine the wind pressure category WLn. Use terrain category II unless otherwise specified.

Then determine the wind forces of all the sub-areas and calculate moments and torsion moments. Controls should be included at all places where there may be a critical point such as sudden changes of diameter (reduction), joints, hatch openings and foot points or change of cross sectional shape or similar.

Documentation

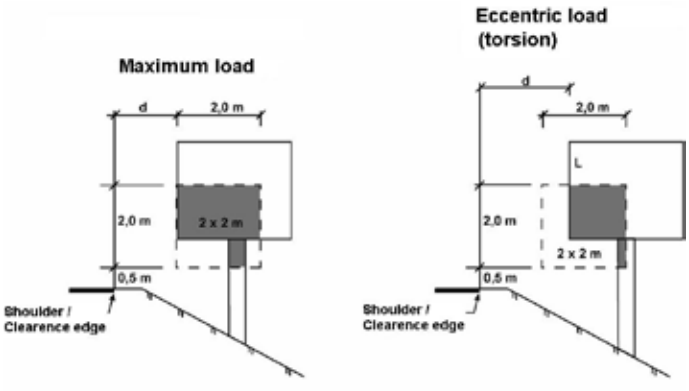
Suppliers of approved sign columns must be able to document the moment, torsion and bending capacity of the columns (either through calculations or through full-scale tests). This documentation must be in compliance with NS-EN 12899 Part 1: "Fixed traffic signs". Sign columns should be marked with a sign that specifies the maximum permitted sign area, i.e. maximum sign area for which the column is designed.

Dynamic snow loads for sign and signal columns

NS-EN 12899-1 forms the basis for calculating dynamic snow loads for traffic signs and signals mounted on posts and columns. The table below indicates the classes that are used. The choice of class depends on the following:

- Siting in the form of distance from asphalted shoulder/clearing edge to the nearest sign edge (d)
- Area of sign/signal and post/column within a surface of 2 x 2 m measured 0.5 m above the carriageway surface
- Plough speed greater or less than 60 km/h (N.B. does not apply to the speed limit on the road). The speed of ploughs on most roads is 60 km/h.

The calculation of the dynamic snow load applies to the whole unit, i.e. both sign and column.Deflection in relation to snow load shall not be calculated.



Distance, d	Plough velocity > 60 km/h	Plough velocity < 60 km/h
< 3,5	4 kN/m² = DSL 4	2,5 kN/m² = DSL 2
> 3,5 < 5	3 kN/m² = DSL 3	1,5 kN/m² = DSL 1
> 5 < 6	2,5 kN/m² = DSL 2	0 kN/m²
> 6 < 7	1,5 kN/m² = DSL 1	0 kN/m²

Figure 5.3 Calculation of dynamic dynamic snow load.

The figure on the left applies to the maximum load on sign and column, while the figure to the right applies to torsion. The table applies to maximum load.

Point loads for sign and signal columns

Point loads are used for the design of signs located in places that are particularly subject to vandalism (e.g. hanging on, pushing, pulling at the sign). Places of this kind are near schools, football stadiums, pubs etc. There should not be a general requirement to engineer for point loads everywhere.

If there is a need to engineer for point loads, for example in connection with the possibility of vandalism, it should be defined by the local road owner and calculated according to NS-EN 12899 Part 1.

5.2.4 Yielding columns (passively safe columns)

Definition

The term "yielding column" or "passively safe column" is used for lighting columns, sign columns and signal columns etc. which are approved according to NS-EN 12767 "Passive safety of support structures for road equipment - Requirements and test methods". Products that are not approved pursuant to NS-EN 12767 cannot be designated yielding, apart from products that are so weak and/or of such a light design/dimensions that they yield naturally for that reason.

Other designations such as impact-friendly, safe in traffic, safety columns etc. are unofficial designations not based on any formal approval.

Requirements relating to the use of yielding lighting columns are set out in Manual 264 "Teknisk planlegging av veg- og gatelys" [Technical planning of road and street lighting].

The choice of column type and siting shall take into account that in the event of a collision they shall not be a hazard to "vulnerable road users".

Approval requirements

Yielding columns shall be tested and approved in accordance with NS-EN 12767.

Yielding posts and columns must be approved as being in compliance by a body that the Notified Body has appointed to carry out this approval of compliance. Until this body is in place, the Directorate of Public Roads approves yielding posts and columns. Lists of approved posts and columns have been published on the NPRA's website under the road standards. The Notified Body is a body with legal base in the EU system and will be responsible for verifying that products are in compliance with the appropriate product standards.

An approved post or column does not automatically give the supplier the right to require that the post or column must be used on public roads. The Directorate has the right to make functional requirements founded in factors such as aesthetics, environment, and service life, maintenance and other special considerations.

The products delivered are required to be of the same design and quality as the drawings and data for the approved product.

Classification of yielding columns

Yielding columns are described by means of type designations. The type designations are expressed by means of three function parameters. These are velocity classes, function categories (energy absorption capacity) and safety categories (safety levels) as described below.

Type designation	Alternative function parameters
Velocity class	50, 70 or 100
Function (energy absorption) category	HE, LE or NE
Safety level	1, 2, 3, or 4

Figure 5.4 Classification of yielding posts and columns pursuant to NS-EN 12767.

For example, a column approved for an impact velocity of 100 km/h with function class NE and safety class 3 will have the following type designation: 100, NE, 3.

Velocity classes

Yielding columns must be tested at a low and a high impact velocity. The low impact velocity must always be 35 km/h. The high impact velocity may be 50 km/h, 70 km/h or 100 km/h. The high impact velocity indicates the velocity class of the column (see Figure 5.5).

Velocity class	Impact velocities
50	35 and 50 km/h
70	35 and 70 km/h
100	35 and 100 km/h

Figure 5.5 Classification by velocity class.

Function classes – energy absorption capacity

Yielding columns are designed so that they substantially reduce the danger of injuries as a result of collision with the column. Pursuant to NS-EN 12767, yielding columns are classified into 3 types according to their energy absorption capacity as indicated below and shown in the figure below. The exit velocity after the impact determines which function class the columns end up in.

HE: High energy absorption
LE: Low energy absorption
NE: Non-energy absorbing.

HE columns shall be capable of stopping the vehicle with a brief, but gentle retardation. The column is deformed by the impact. As a rule the vehicle will be virtually brought to a halt, or have its velocity very substantially reduced.

LE columns shall also to a certain extent be capable of stopping the vehicle on impact and being somewhat deformed, but the column normally breaks off at the foundation during the collision, so that the vehicle will continue, but with substantially reduced velocity.

NE columns break easily on impact, so that the vehicle continues, but with somewhat reduced velocity. The damage to the vehicle is normally limited, but secondary accidents may occur during its continued passage off the road. NE columns normally have either a weakened structure or a specially designed breakaway joint at the bottom of the column.

A more detailed description of energy absorption categories and safety levels is given in NS-EN 12767.

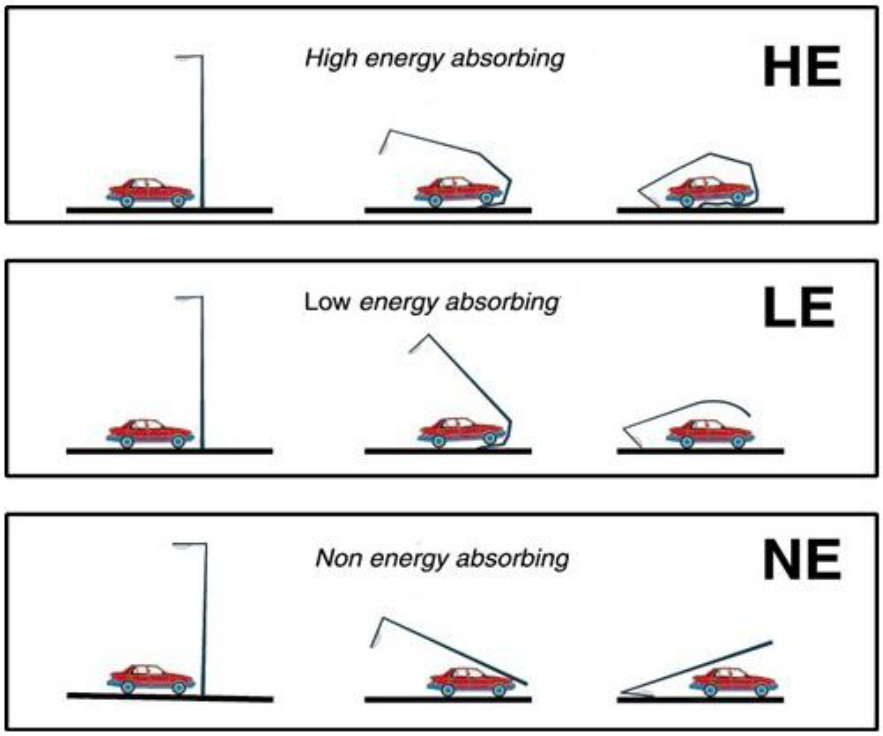


Figure 5.6 Energy Absorption capacities.

The classification of the column is based on a collision with a passenger car at high impact velocity. The exit velocity (ve) shows the column's energy absorption capacity and is used to express the energy absorption capacity of the column. The table below shows the classification of the yielding posts and columns as HE, LE or NE according to exit speed.

Function (energy absorption) category	Impact velocity		
	50 km/h	70 km/h	100 km/h
	Exit velocity v_e		
HE	$V_u = 0$	$0 \leq v_u \leq 5$	$0 \leq v_u \leq 50$
LE	$0 \leq v_u \leq 5$	$5 \leq v_u \leq 30$	$50 \leq v_u \leq 70$
NE	$0 \leq v_u \leq 50$	$30 \leq v_u \leq 70$	$70 \leq v_u \leq 100$

Figure 5.7 Classification in energy absorption category on the basis of exit velocity V_e.

The capacity of a yielding post or column to reduce the risk of serious personal injuries in a collision is expressed by means of the parameters THIV (Theoretical Head Impact Velocity) or ASI (Acceleration Severity Index). The lower the THIV and ASI values, the safer the column.

Yielding posts and columns are divided into safety levels or safety classes according to their THIV and ASI values on impact.

The table below shows the division of ASI and THIV values into safety levels. There are four safety levels. In order to be placed in a safety level, the test results must be lower than the values in the table for that safety level. The higher the safety level and lower the ASI and THIV values, the lower the risk of injury.

Function class (energy absorption capacity)	Safety class (safety level)	Low impact velocity – mandatory speed (35 km/h)		High impact velocity – classification velocity (50, 70 or 100 km/h)	
		ASI	THIV km/h	ASI	THIV km/h
HE	1	1,0	27	1,4	44
HE	2	1,0	27	1,2	33
HE	3	1,0	27	1,0	27
LE	1	1,0	27	1,4	44
LE	2	1,0	27	1,2	33
LE	3	1,0	27	1,0	27
NE	1	1,0	27	1,2	33
NE	2	1,0	27	1,0	27
NE	3	0,6	11	0,6	11
NE	4	requirement	requirement	requirement	3

Figure 5.7 Classification according to safety level based on ASI and THIV.

Mounting of traffic signs on energy-absorbing lighting columns

Energy absorbing lighting columns (HE or LE) will not function according to intention if signs are mounted on them. The column will only be deformed up to where the sign is mounted because the sign clamps lock the column against further deformation. Energy absorbing light columns must therefore not have traffic signs mounted on them. It is very important that sign installers be made aware of this.

Special safety requirements for gantries

For half gantries and full gantries, there is a requirement additional to those in Section 5.2.2, that no part of the gantry cross-bar or signs mounted on it should have sunk to a height of less than 4 m over the carriageway within 15 minutes of the collision.

Standard signposts

The requirement of passively safe sign columns does not apply to signposts with a diameter equal to or less than 90 mm and a material thickness equal to or less than 3.2 mm (3″ posts) which are placed alone or, for two similar signposts, more than 1.5 m apart.

Columns with a breakaway joint

There are different types of columns with breakaway features. These are specified won NPRA's website under 'Vegnormaler' [Road standards].

For columns with a breakaway joint, the breakaway joint shall be installed a maximum of 10 cm above ground level, measured to the shim. It is important for the vehicle not to hit the column below the breakaway joint. If the breakaway joint is equipped with a tilt plate, this must be mounted parallel with the road, according to the supplier's instructions.

Columns with breakaway joints are not easy to release if the vehicle hits the column too high up. This may be a particular problem on embankments/sloping terrain where the column is placed too far down on the slope. On slopes steeper than 1:4, a vehicle that drives off the road may leave the road at a wide angle to the driving direction. In such cases columns with a breakaway joint should preferably be placed as high up on the embankment as is prudent with respect to road maintenance, so that the vehicle does not strike the column too high up. Alternatively, another yielding structure can be chosen that is not sensitive to the impact height.

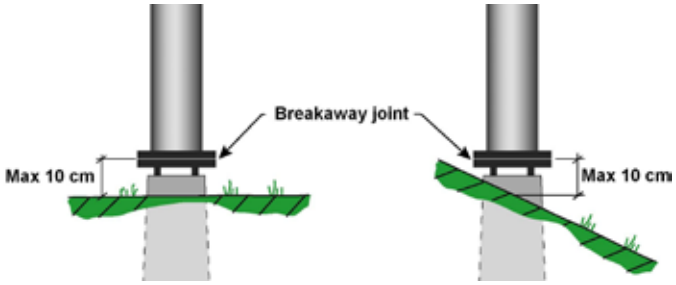


Figure 5.9 Installation of breakaway joint

Irrespective of the slope angle, the breakaway joint must be mounted a maximum of 10 cm above the terrain. The breakaway joint must not be covered by masses as this will prevent it being released in the event of a collision.

It is recommended that the breakaway joint be installed at the factory. This will reduce the risk of tightening the bolts incorrectly. In those cases where the breakaway joint is installed on site, the supplier shall prescribe the tightening moment to be used on the bolts of the breakaway joint. This must be clearly shown on the installation instructions in those cases where the breakaway joint is installed on site. In addition, the invitation for tenders should request that the supplier specify this.

The installation of the breakaway joint shall be carried out so that the bolts are tightened to t he fully prescribed moment. After a short time (usually about 24 hours), the bolts are loosened again and then tightened to the correct moment in accordance with the supplier's instructions. Columns with a breakaway joint that is not installed at the factory should be followed up with a post-check of the tightening moment before takeover of the road/lightning installation. Before takeover of the lighting installation, an inspection should first be made to ensure that the breakaway joint is correctly installed, particularly with respect to height above the terrain and the angle of the tilt plate (if there is one) in relation to the driving direction.

It is also recommended that routine post-testing be carried out of selected existing columns with breakaway joints to check the tightening moment of the breakaway joint.

Two or more sign columns for the same sign

For situations where there are two or more sign columns attached to the same sign, these must be tested and approved as follows:

- Sign columns mounted 1.5 m apart or more must be approved after a test involving impact of the centre of the vehicle on the one sign column.
- Sign columns less than 1.5 m must be approved after a test with impact of the vehicle midway between two of the columns.

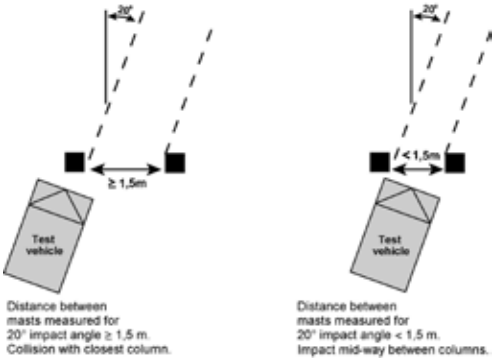


Figure 5.10 Requirements regarding inter-column distance.

Modification of steel and wooden columns to make them passively safe

Various methods have been developed for modifying steel and wooden columns to make them passively safe. Before they can be designated passively safe, columns modified by these methods must have been tested according to NS-EN 12767 and approved as yielding.

The strength of the columns must satisfy the FEA-F requirements ("Forskrifter for elektriske anlegg- Forsyningsanlegg" [Regulations for electrical facilities – electricity supply facilities]), FEL ("Forskrifter for lavspenningsanlegg" [Regulations for low voltage facilities]) and safety requirements.

5.2.5 Footings

Special foundations are usually used for passively safe lighting, signal and sign columns. The foundation is regarded as part of the column structure, and must be delivered and assembled in accordance with the column supplier's specifications and instructions. Footings are discussed in more detail in Section 5.3.6.

5.3 Material requirements

5.3.1 Requirements relating to materials for lighting columns

All columns must be numbered and addressed in relation to a defined object number. There must be site documentation for the lighting point referred to in the object number. Cables must be measured in a mapping format that can be read by NPRA's map databases.

The documentation on handover must be structured in the same way as the process in the tender. It must be possible to recognise the specified main processes and subordinate processes. This will ensure that details are also included as built.

Lighting columns comprise columns and posts of steel, aluminium or wood for road and street lighting along public roads.

Steel

Steel lighting columns shall be designed pursuant to NS-EN 40-5.

Lighting columns are slender structures that easily begin to oscillate in strong wind, and are therefore vulnerable to fatigue in welds and hatch openings. Almost all failure starts as fatigue failure, and when the cross-section is substantially reduced, there will be residual plastic failure. Lighting column calculations are static, but the impact factor increases the pipe dimensions and compensates for the dynamic oscillations.

The fatigue properties of steel are independent of steel quality. Welded low-alloy steel pipes with a quality poorer than S235JRG2 (formerly RSt37-2) must not be used.

It is important that the welds be done correctly. Requirements are therefore made of welding procedure and a welding certificate is required to assure the quality of the welds.

Steel columns for earth cables are described in REF publication no. 12 1/94, which also contains a description of column design and foundations. Experience shows that columns with a pipe diameter of 70 mm at the lamp casing should be chosen. This is particularly important for bridges.

Aluminium

The same requirements as for steel columns are made for resistance to wind loads and stresses with respect to fittings and suspension equipment.

The minimum requirements for aluminium quality must be A1 6060 T or better. Material requirements for extruded pipes and profiles are specified in EN AW 6060 and EN AW 6063. Cast parts, base plates, bases and aprons should be made of quality AlSi12 as a minimum. Insulation boarding should be used between the foundation and the base plate and plastic casing for bolts to prevent galvanic currents.

Aluminium columns shall be designed according to NS-EN 40-6, with the addition of wind load requirements as for steel columns.

Tre

Road lighting installations mounted on wooden columns with airborne lines shall be assembled and dimensioned in accordance with FEA-F "Forskrifter for elektriske anlegg – forsyningsanlegg" [Regulations on electrical supply installations]. Wooden columns are not normally yielding, and must therefore be treated as not yielding. However, methods have been developed for modifying wooden columns into yielding structures. See Section 5.2.5.9 and Manual 231 "Rekkverk" [Railings].

Wooden lighting columns are divided into categories. There are largely 2 categories in use.

Category no	Post length	Top diameter
Category 1	7 and 8 metres	3 to 14.9 cm
Category 2	8–9 and 10 m	15 to 16.9 cm

Figure 5.11 Categories of wooden columns.

Requirements for selection/delivery, installation and support of wooden columns are stipulated in REF publication no. 3. Requirements relating to work on impregnated wooden columns are regulated in orders from the Norwegian Labour Inspectorate. Since 1 July 2003 it has only been permitted to sell creosote and pressure-impregnated materials for industrial and public sector activities. See "Forskrift om forbud mot CCA-impregnert trevirke" [Regulations relating to the prohibition of CCA-impregnated wooden materials], dated 10 September 2002.

5.3.2 Requirements regarding gantry materials

Gantries consist of full or half gantries along public roads that carry public traffic signs and/or traffic signals. The foundation is regarded as a natural part of the structure, and must therefore be included as a natural part of the strength calculations for the gantry.

Steel

Sign gantries are normally rigid structures and fatigue failure will not normally occur. It may therefore pay to go up in steel quality to S355J2G3 (formerly St52-3R) if the calculations require greater strength.

Aluminium

Aluminium must be able to tolerate the same forces due to wind loads and snow clearing as corresponding steel columns. In coastal areas, corrosion property requirements dictate that materials must tolerate sea water.

The minimum requirement for aluminium quality must be A1 6060 T or better.

5.3.3 Requirements regarding materials for sign and signal columns

Sign and signal columns consist of columns along public roads that carry public traffic signs and/or traffic signals. If standard round tubular posts are used for traffic signals, they must have an external diameter of 114 mm.

Steel

The material must be of quality S235JRH pursuant to NS-EN 10210-1 with a material thickness of 3.5–45 mm, or a reinforced aluminium profile with a material thickness of at least 3 mm.

Aluminium

Aluminium posts must satisfy the requirements in NS-EN 754-2 "Aluminium and aluminium alloys – Cold drawn rods/bars and tubes - Part 2: Mechanical properties". The posts must be anodized and treated with poly(acrylic acid) electrostatically before painting.

The minimum requirement for aluminium quality must be A1 6060 T or better.

5.3.4 Requirements regarding materials for traffic signs

Posts consist of posts along public roads that carry public traffic signs and/or traffic signals.

Steel

Standard posts for steel traffic signs shall have one of the following two sets of dimensions:
External diameter 60.3 mm and material thickness 2.9 mm (designated 2")
External diameter 88.9 mm and material thickness 3.2 mm (designated 3")

The material shall be of quality S235JRH pursuant to NS-EN 10219-1 and NS-EN 10210-1 (see reference list).

Aluminium

Aluminium posts must satisfy the requirements in NS-EN 754-2, "Aluminium and aluminium alloys – Cold drawn rods/bars and tubes - Part 2: Mechanical properties". The posts must be anodized and treated with poly(acrylic acid) electrostatically before painting.

The minimum requirement for aluminium quality must be A1 6060 T or better.

5.3.5 Surface treatment

Steel

Lighting columns, sign gantries and signposts of steel shall be hot dip galvanized pursuant to NS-EN ISO 1461 ""Varmforsinkede belegg på fabrikerte jern- og stålprodukter. Spesifikasjoner og prøvingsmetoder" [Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods] (replaces NS 1978). The minimum zinc thickness shall be 55 mm for a material thickness of between 3 and 6 mm. If other material thicknesses are used, the requirements in NS-EN ISO 1461 shall apply.

Steel columns for traffic signals and steel posts for traffic signs shall be hot dip galvanized pursuant to NS-EN 10240, "Innvendig og/eller utvendig beskyttende belegg for stålrør – Spesifikasjon for varmforsinkede belegg påført i automatiske anlegg" [Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants].

Steel columns for traffic signals shall additionally be treated with primer and paint of an approved quality (cf. Section 5.3.5.4 and Section 5.3.5.5). Posts in signal installations shall normally be yellow, but other colours can be used if desired for aesthetic reasons. See Manual 048 "Trafikksignalanlegg" [Traffic signal installations] for recommended colours.

For requirements regarding attachment bolts embedded in concrete, see Section 5.3.6.2.

Aluminium

Steel columns for traffic signals shall if desired be treated with primer and paint of an approved quality (cf. Section 5.3.5.4 and Section 5.3.5.5).

Posts in signal installations shall normally be yellow, but other colours can be used if desired for aesthetic reasons. See Manual 048 "Trafikksignalanlegg" [Traffic signal installations] for recommended colours.

Wood

For use of CCA-impregnated timber, see ""Forskift om forbud mot CCA impregnert trevirke" [Regulations relating to the prohibition of CCA-impregnated wooden materials], dated 10 September 2002.

(Powder) coating

Lighting columns, sign columns and steel or aluminium posts may if desired have their surface powder-coated. In the case of steel columns, this is additional to hot dip galvanizing. The thickness of polyester powder coating shall be 90 – 130 mm. There are requirements relating to the pre-treatment, degreasing and chromatization processes.

A new standard, NS-EN ISO 13438 "Geotextiles and geotextile-related products - Screening test method for determining the resistance to oxidation". It specifies a coating thickness of min. 60 mm, but the coating thickness should normally be between 60 and 140 mm. The most important things are to ensure that the powder coating has good adhesion and quality, and that the pre-treatment before the coating is correct for hot dip galvanized steel. Polyester coating must be used for lighting columns that are exposed to sunlight, to avoid chalking/breakdown.

If the columns cannot be powder coated, it should be required that the paint have a durability and quality equivalent to powder coating. Therefore a two-component paint of the type epoxy or polyurethane should be used for columns that are painted.

The colour standards RAL and NCS can both be used to describe the colour of the posts. The NCS standard is more nuanced, and has an almost unlimited number of colours. The degree of gloss of the surface treatment is specified as a percentage and is independent of the colour standard. In urban areas, dark colours can create problems for the partially sighted, and the posts should therefore be marked with at least one white or luminous sleeve with a breadth of 10 cm at a height of 150 cm above ground level.

Service life

The requirements relating to surface treatment are based on the product having a service life of at least 30 years. If necessary, the NPRA can require that the supplier/manufacturer substantiate this assumption.

5.3.6 Footings

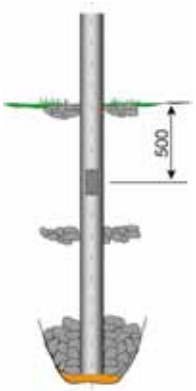
Footing types

Normally foundations of concrete or steel are used. Steel spearheads can be used in some cases as an alternative to standard foundations for traffic signs. The foundations are normally delivered either as earth-stick foundations (the column is given a foundation), down-stick foundations or baseplate foundations.

Below are examples of the different types of foundations for lighting columns and sign columns/posts.

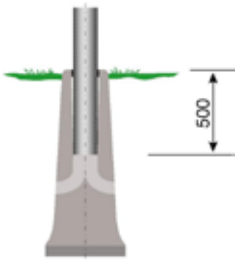
Footings for lighting columns

Earth-stick foundations
Earth-stick foundations are of steel. There is a very high level of risk of corrosion at the groundwater level and at ground level. It is difficult to establish good ventilation and stability is poor without special preliminary measures. This type of foundation should not be used on roads that are salted.



Earth-stick foundation

Down-stick foundations
Down-stick foundations are made of concrete. The disadvantages of this type of foundation are a considerable risk of corrosion in the area around the retaining ring and it is difficult and costly to adjust the column later on, which means relatively high maintenance costs and a limited service life. It is recommended that the part around the locking ring receive special additional protection to prevent moisture accumulating between hot dip galvanized material and the retaining ring. Footing with down-stick of the column, where the column is surrounded by rubber or plastic packaging, should not be used in urban areas, areas with many dogs or areas where roads are salted. Experience has shown that there will be corrosion because of moisture at the transition between the protective covering and the column.



Down-stick foundation

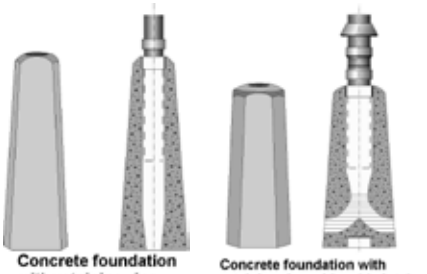
Baseplate foundations
Baseplate foundations are made of steel or concrete. The advantage of baseplate foundations is simple installation and later adjustment of the column. There is minimal risk of corrosion, good ventilation in the column and high stability. The disadvantages are that the concrete foundations are so heavy that they make mechanical handling necessary. In order to achieve good ventilation, it is important that the baseplate be installed 5 cm above the finished terrain level, and that the adjustment nut under the baseplate be used. When the height above the terrain is to be determined in sloping terrain, the starting point is the outer edge.

Steel baseplate foundation

Footings for signposts and sign columns

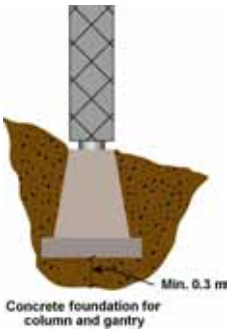
Concrete foundations with retention ring without cable entry

The drawing shows standard foundations for 60 mm or 89 mm standard signposts. Usually used for signposting with standardised traffic signs where the sign area is limited. The foundations are buried so as little as possible of the foundation is above ground. There are also foundations with baseplates for standard signposts. The baseplate can be adjusted to the horizontal if difficult ground conditions bring the posts out of the vertical.



Concrete foundations for columns and gantries

The suppliers deliver foundations geared to different column and gantry types, with different dimensions. It is important that the assembly be carried out according to the supplier's instructions. In general it will be advantageous to the stability of the foundation that it has a conical design, and possibly also a collar at the bottom, as shown in the drawing. It is important that the foundation be installed so that as little as possible is above ground, and that it is packed with frost-free masses that result in the prescribed compression. (If a breakaway joint is used, this must be a maximum of 10 cm above the terrain, and not be covered by masses, cf. 5.2.4.7).



Wing foundations

Wing foundations are used in connection with the installation of posts and columns for traffic signs. The foundation is pressed down into the ground by pile-driving or hydraulic tools. It is important to ensure that the foundation does not impact against solid rock and suffer damage. They are also unsuitable in areas with masses where there is a lot of frost.

Requirements regarding concrete foundations

The quality of the concrete in concrete foundations is specified in NS-EN 206-1. The minimum requirement for the quality of the concrete cast in situ and prefabricated concrete foundations, including those that are integrated into the structure of bridges, support walls etc., is C 45 MA (MA means that it must tolerate an aggressive environment).

Requirements regarding design safety and reliability are specified in NS-EN 3490. Design requirements (wind forces and loads) are specified in NS-EN 3491 Parts 1 and 4. NS-EN 3473 stipulates requirements regarding the engineering standard, i.e. that the correspondence in the design between the aforementioned standards is included. The overall design shall satisfy the requirements in NS 3473.

Embedded fastener bolts in the concrete foundation for the columns' baseplates shall be rust-resistant and treated so that no undesirable reactions occur between concrete and steel. The bolts must first be hot dip galvanized pursuant to NS EN ISO 1461, then chromatized where the process is described as: ZnEl-Cr. Alternatively, bolts of acid-resistant threaded steel can be used.

Requirements regarding steel foundations

Footings for road lighting columns and signal columns must be geared to the columns in accordance with the requirements in REF publication no. 12 1/94.

The foundation must be stable and easy to assemble. It must be easy to thread cables through the foundation to the column.

The quality of the steel in the foundations must be either S235JG2 or S355J2G3. It must be hot dip galvanized according to NS-EN ISO 1461 (average galvanizing thickness 70m with minimum permitted value for individual measurements 50 m). To further improve the corrosion properties, the foundations should be additionally protected with powder coating or paint with equivalent durability before assembly. It must be possible to document the treatment and it should be guaranteed for the service life of the structure.

Installation requirements

As a general rule, foundations, posts and cable enclosures may not be installed on roads unless they have been included in the plan during the project phase, or permission has been given by the road owner subsequently as a completion or a re-investment project.

Enclosures and foundations shall be located in such a way that they are not an impediment or hazard to road users (see Manual 231 "Rekkverk" [Guardrails]).

The installation height of the top of the foundation should be specified in the plans for each individual foundation. It may be practical to define the height of the individual foundation on the basis of a defined contour.

Footings must be installed vertically, at the correct height in relation to the completed terrain, and not closer to the side of the road than permitted by the NPRA's operations and

maintenance requirements, and traffic safety. Deviations from this requirement are aesthetically unpleasing, and the stability of the columns is lessened. A point should therefore be included in project descriptions specifying who is responsible for ensuring that the foundation is installed at the correct height.

Existing masses must be removed when a foundation is installed. The foundation shall be set in and filled up to the cable hatch with crushed rock < 10 mm and after the cable has been laid the fill around the foundations shall be crushed rock. This also applies to foundations that are cast in situ and prefabricated concrete foundations with a length of < 100 cm.

Special foundations for yielding columns shall be installed in accordance with the supplier's installation instructions. It is very important that the columns function according to intention.

Requirements regarding switchboards

Switchboards/igniter cabinets shall be visually harmonised with other traffic safety equipment for roads. The switchboards shall be easily accessible for operations and should not be in a vulnerable position with respect to snow clearing. Where possible, the switchboards/igniter cabinets should be located in connection with a board facility or integrated into the low-voltage board at substations.

In order to reduce the risk of collision, igniter cabinets should be placed as far as possible away from the road.

Footings for switchboards/igniter cabinets shall be in accordance with statistical calculations of forces due to external conditions at the site and the weight of the cabinet and equipment.

5.4 References

- NS-EN 12899-1 “Fixed, vertical road traffic signs - Part 1: Signs.”
- NS-EN 12767 “Passive safety of support structures for road equipment - Requirements and test methods”.
- Nordisk samordning av testing og godkjenning av ettergivende columner i samsvar med EN 12767, Vejdirektoratet i Danmark, Vägverket i Finland, Vegdirektoratet i Norge, Vägverket i Sverige, juni 2000.
- NS-EN 40-3-1 ”Lighting columns - Part 3-1: Design and verification - Specification for characteristic loads”
- NS-EN 40-3-3 “Lighting columns - Part 3-3: Design and verification – Verification of calculations”
- NS-EN 40-5 ”Lighting columns - Part 5: Requirements for steel lighting columns”.
- NS-EN 40-6 ”Lighting columns - Part 6: Requirements for aluminium lighting columns”.
- NS-EN 10240, “Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants”.
- NS-EN ISO 1461 ”Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods (ISO 1461: 1999)” (replaces NS 1978).
- PrEN 13438 “Powder Organic Coatings for Galvanized Steel Products for Construction Purposes”.
- NS-EN ISO 13438 “Geotekstiler og geotekstilrelaterte produkter – Utsilingsprøving for bestemmelse av motstand mot oksidasjon” (Geotextiles and geotextile-related products - screening test method for determining resistance to oxidation).
- NS-EN 754-2 “Aluminium and aluminium alloys – Cold drawn rods/bars and tubes - Part 2: Mechanical properties”.
- NS-EN 10210-1 “Hot finished structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions”.
- NS-EN 10219-1 “Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions”.
- NS-EN 206-1 “Concrete, Part 1: Specification performance, production and conformity”.
- NS 3473 “Concrete structures - design rules”
- NS 3476 “Design of composite steel and concrete structures – Calculating and dimensioning”
- NS 3490 “Design of structures. Reliability requirements”.
- NS 3491 “Design of structures. Design loads – Part 1: Self-weights and imposed loads (including correction sheet A:99)”.
- NS 3491-4 “Design of structures. Design loads – Part 4: Wind loads”.
- FOR 1998-11-06 nr 1060: “Forskrift om elektriske lavspenningsanlegg” [Regulations concerning electric low-voltage systems].
- “Street lighting columns” [Gatelysmaster]– REF specifications, REF-publication no. 12 1/94, Energiforsyningens Fellesorganisasjon.

- Manual 017 “Road and street design” [Veg- og gateutforming], NPRA 2005
- Manual 231 “Guardrails” [Rekkverk], NPRA 2003
- Manual 211 “Waste treatment” [Avfallshåndtering], NPRA, oktober 1998.
- Manual 214 “Health, environment and safety” [Helse, miljø og sikkerhet], NPRA, mars 1999.
- Manual 264 “ Technical planning of road and street lighting” [Teknisk planlegging av veg- og gatelys], NPRA 2005
- “Forskrift om forbud mot CCA-impregnert trevirke” [Regulations relating to the prohibition of CCA-impregnated wooden materials], 10 September 2002.

6 Road markings

6.1 General

6.1.1 Introduction

The Norwegian Public Roads Administration has adopted a "Vision Zero". Vision Zero means that we shall work both to prevent serious accidents and to reduce injuries in any accidents that nonetheless occur. Head-on collisions and driving off the road are the predominant types of accidents in which many people are killed and injured. Measures directed especially towards these types of accidents will therefore be very important. Road markings are part of providing a linear visual guidance to the road and some types of road markings give warning when they are driven over. Both these characteristics are measures that help to prevent such accidents from occurring. It is important that road markings at all times meet the technical requirements that are made of them. Part 6 contains technical requirements for laying out road markings and performance requirements for the road markings that are laid out. If the requirements in this document and/or in the maintenance standard are not met, measures shall be initiated in the form of repairs or the laying of new lines. Requirements linked to carrying out repairs are given in section 6.3.4.

6.1.2 Validity

The requirements in Part 6 apply to all road markings that are laid out on new and existing roads. The requirements apply within the product guarantee period, which for road markings is usually 2 years (until the expiration of the season concerned 2 years after it is laid out). For technical requirements beyond the guarantee period, reference is made to Manual 111 Drift og Vedlikehold [Operation and maintenance] and any contracts that have been entered into.

6.1.3 International requirements

Where European standards require that product types be CE marked to have commercial access to the market, this will also apply to Norway.

6.1.4 Definitions and concepts

General definitions

Road markings are an important means of ensuring efficient, safe traffic flow. The road markings shall serve several purposes:

1. Guide traffic (visual guidance)
2. Warn road users about special conditions regarding the road's geometry and hazards.
3. Regulate traffic
4. Supplement and augment information given by traffic signs

For the road markings to function as desired, they must function satisfactorily with respect to the following characteristics:

- visibility in daylight
- visibility at night
- colour
- friction

Different road marking methods can have different characteristics. There are special challenges in Norway and the Nordic countries in relation to the rest of Europe. This is mainly due to special:

- climatic conditions
- winter maintenance
- use of studded tyres

Longitudinal road markings (markings along the road): Comprises mid-lines, delineator lane lines, guiding lines, edge lines and delineator lines for areas that are blocked off.

Transverse road markings: Road markings that lie in the carriageway/driving lane. Transverse road markings comprise stop lines, give-way lines, pedestrian crossings, diagonal lines in areas that are blocked off, cycle crossings and parking places.

Symbols and texts: This category is a sub-category of transverse road markings. Symbols and texts comprise arrows, yield right of way symbol, pedestrian and bicycle symbols, parking symbols, symbols for the physically disabled and texts (e.g. BUS).

New laying: The first markings on newly laid road surfaces.

Repairs: Repairs to existing road markings.

New state: By new state is meant the period from 14 days after laying and for the remainder of the marking season the lines were laid out.

Plane line: road marking that is laid out in an evenly extruded or sprayed film, where the purpose it to produce a line with a level (smooth) surface. A plane line can nonetheless take on the structure of the base.

Profiled line: road marking that is laid out as a broken line, or a line with an uneven or structured surface. Profiled lines are laid out to achieve special lighting or acoustic effects. The uneven surface can be characterised by a special structure, pattern, profile or a random structure.

Visibility in daylight and darkness

There are several different factors that affect the visibility of road markings.

Visibility in daylight and under street lights is dependent on:

- the road marking's luminance coefficient (Qd)
- the colour of the road marking
- the size of the surfaces with road markings
- contrast with the road surface's colour

Visibility in darkness is dependent on:

- The road marking's retroreflection coefficient (RL) (i.e. the ability to reflect light back from vehicle headlights to the driver).
- as above, colour, surfaces and contrast

Luminance coefficient Qd is a measure of the road marking's ability to reflect diffuse light (cloudy daylight or road lighting). The unit of measurement for the luminance coefficient is mcd/lx/m^2. Typical measurement values for white, dry road markings are 150–200 mcd/lx/m^2. Measuring the luminance coefficient is done on dry road markings.

Retroreflection coefficient RL is a measurement of the road marking's ability to reflect light from vehicle lights back to the driver. The unit of measurement for the retroreflection coefficient RL is mcd/lx/m^2. Typical measurement values for white road markings lie between 100-400 mcd/lx/m^2. Measuring the retroreflection coefficient can be done in both dry and wet conditions. Plane lines traditionally have poor visibility in darkness when they become wet, because the reflective media (often glass beads) are covered by water. Methods to improve visibility on wet roads have been developed. What is often spoken of as profiled lines can have two different performance characteristics, better visibility in the wet state and/or a noise and vibration effect. It is important to be aware of this when selecting line type.

Friction

Friction is given by means of a SRT value (using a British Skid Resistance Tester). The road marking's friction characteristics are significant for safety, especially for two-wheeled vehicles and vulnerable road users. Typical SRT values are 40-70

Colour coordinates

The road marking's colour is indicated as chromatic colour coordinates x, y in the CIE colour system. With the Norwegian two-colour system, it is important to have a distinction between the specifications of white and yellow colours. In order that the yellow mid-line is perceived as yellow in both daylight and as reflected by vehicle lights in the dark, there are requirements for 2 sets of colour coordinates, which must both be met.

6.2 Performance requirements

6.2.1 General

The performance requirements are specified in NS-EN 1436 Vegmerkingsmaterialer: Funksjonskrav til vegmerking. [Road marking materials: Performance requirements for road markings. Measurements of different functions shall be carried out pursuant to this standard.

Performance requirements are made for the following parameters for markings on the road:

- Retroreflection coefficient RL
- Luminance coefficient Qd
- Colour coordinates x, y
- Friction, SRT

The given performance requirements are minimum requirements. The road authorities can set higher requirements for functions by specifying a higher class in the tender documents. Higher classes are described in NS-EN 1436. The NS-EN class is given in parentheses.

6.2.2 Retroreflection coefficient RL

Retroreflection coefficient RL is a measured value of the visibility of the road marking in the dark. There are two sets of performance requirements: one for traditional road markings and one for road markings that are specified to have good visibility in a wet condition (for example profiled lines). All edge lines on national roads with AADT > 2000 shall have requirements with respect to wet performance. The requirement for wet performance does not apply to road stretches with road lighting. In addition, with the use of profiled lines, consideration must be given to noise levels for populated areas in the vicinity according to usual rules. Both sets of requirements shall have specified required values for RL in a new state and throughout the rest of the guarantee period.

$R_{L\,dry}$ in new state:

Type	White mcd/lx/m²	Yellow mcd/lx/m²
R_L, Longitudinal markings	≥ 200 (R4)	≥ 150 (R3)
R_L, Transverse markings	≥100 (R2)	≥ 100 (R2)

Figure 6.1 Minimum requirements for retroreflection coefficient in a new stat.

$R_{L\,dry}$ during the guarantee period:

Type	White mcd/lx/m²	Yellow mcd/lx/m²
R_L, Longitudinal road markings	≥ 150 (R3)	≥ 100 (R2)
R_L, Transverse road markings	≥100 (R2)	≥ 100 (R2)

Figure 6.2 Minimum requirements for retroreflection coefficient during the guarantee period.

R_L in wet condition:

Type	White mcd/lx/m²	Yellow mcd/lx/m²
R_L, wet	≥ 35 (RW2)	

Figure 6.3 Minimum requirements for lines with a wet function.

6.2.3 Luminance coefficient Qd

The value of the luminance coefficient says something about road marking visibility in cloudy daylight and in road lighting. The requirement applies to wet road markings.

Colour	Minimum luminance coefficient Qd mcd/lx/m²
White	Qd ≥ 130 (Q3)
Yellow	Qd ≥ 100 (Q2)

Figure 6.4 Requirements for luminance coefficient.

6.2.4 Colour coordinates x, y

Limit values for the material's colour coordinates are given in the tables below. The requirement applies to dry road markings.

Requirements for colour coordinates in the dark are guidelines, initially for a transitional period of 2 years. From 2013, the requirements are to be seen as absolute, unless experience from the transitional period leads to another decision.

Colour		1	2	3	4
White	x y	0,355 0,355	0,305 0,305	0,285 0,325	0,335 0,375
Yellow (Y1)	x y	0,443 0,399	0,545 0,455	0,465 0,535	0,389 0,431

Figure 6.5 Requirements to colour coordinates in daylight (diffuse lighting)

Colour		1	2	3	4
White	x y	0,480 0,410	0,430 0,380	0,405 0,405	0,455 0,435
Yellow (Y1)	x y	0,575 0,425	0,508 0,415	0,473 0,453	0,510 0,490

Figure 6.6 Requirements for colour coordinates in the dark (vehicle lights)

6.2.5 Friction, SRT

The friction for plane lines is determined by measuring the road marking's SRT value.The SRT value is determined by measurement using a British pendulum apparatus (NS-EN 1436). The British pendulum apparatus is suitable only for measurement of plane lines. Profiled road markings are always assumed to satisfy friction requirements, and friction measurement of such lines is therefore not obligatory.

Alternative methods of measurement can be used if good correlation to the British pendulum can be documented. The pavement friction tester (PFT) apparatus is an example of an approved alternative method.

Product	Requirement for SRT (NS-EN class)
Longitudinal road markings	SRT ≥ 45 (S1)
Transverse road markings, text and symbols	SRT ≥ 55 (S3)

Figure 6.7 Friction requirements .

6.3 Requirements related to laying out road markings

6.3.1 In general on laying out

Laying out road markings must satisfy standard aesthetic requirements including:

- Good line stroke
- Well-aligned with preliminary markings
- Satisfactory stroke quality with respect to how it looks (sharp contours/edges)

Road markings are laid out when adequate adhesion can be achieved, i.e. when the carriageway is clean and dry. Road marking materials shall be handled in accordance with the material manufacturer's guidelines. Drop-on glass for machine laid lines shall be evenly distributed over the width of the line. In the case of repair work, the road markings shall, as far as possible, be laid on the remains of previous road markings where these exist, if no changes are indicated by the preliminary markings.

6.3.2 Preliminary markings

Preliminary markings are usually a task for the authorities. If the authorities ask for preliminary markings, these shall be done according to the requisitioner's directions.

6.3.3 Tolerance requirements

Tolerance requirements are set up to ensure excellent, uniform quality of road markings with respect to looks and exactitude. It is very important that repairs to the original road markings are carried out as exactly as possible.

Longitudinal road markings

The tolerance requirements below apply to all longitudinal road markings.

Tolerance requirements for different line lengths and line openings

The requirements apply to lines on a straight stretch of road.

Line lengths/openings	New laying:	Repairs:
1 m	± 5 cm	± 20 cm
2 m	± 5 cm	± 20 cm
3 m	± 10 cm	± 20 cm
9 m	± 10 cm	± 20 cm

Figure 6.8 Tolerance requirements for different line lengths and line openings.

Cycles of 12 m or less may deviate by ± 5 cm. Otherwise the table above applies. For example: if a warning line is 8.90 m, the following opening must be minimum 3.03 m and maximum 3.15 m, cf. the requirement that a cycle shall be 12.0 m ± 5 cm.

Tolerance requirements for line distance when using combination lines

This requirement specifies the largest deviation in line spacing in a line combination.

Surface	Requirement
Newly laid and smooth asphalt	± 1,0 cm
Rutted asphalt within max. 2.5 cm asphalt groove	± 2,0 cm

Figure 6.9 Tolerance requirements for line spacing, combination lines

Tolerance requirements for line widths are given in the table below.

Line width	Newly laid and smooth asphalt	Old and rutted asphalt up to 2.5 cm rutting	
		Combination lines	Single lines
10 cm line	± 0,50 cm	±1,0 cm	± 1,0 cm
15 cm line	± 0,75 cm	± 1,5 cm	± 1,0 cm
20 cm line	± 1,00 cm		± 1,0 cm
30 cm line	± 1,50 cm		± 1,0 cm

Figure 6.10 Tolerance requirements for line widths.

Tolerance requirement for lateral accuracy on lines being repaired

For repair of existing road markings, a lateral deviation of ± 3.0 cm may be permitted over a distance of 4 cycles (48 cm) in a longitudinal direction from the starting point.

Road markings milled into the road surface

Road markings may be placed in milled grooves in the road surface to reduce wear and tear,

and achieve better traffic safety effects. An effort should be made to give the milled groove a diagonal edge on both sides, so that the danger of tracking is reduced. The design of milled grooves is still under development and no absolute dimension is set in this version of Manual 062.

Transverse road markings, text and symbols

General

As for longitudinal road markings, minor deviations from the measurements given in the road marking standard (Manual 049) are permitted. The tolerance limit that is given applies to new laying and repairs. Tolerance requirements have not been set for all types of transverse road markings. Where no requirement has been given, other requirements in this section may be used as guidelines for tolerance requirements. Transverse road markings, text and symbols shall be made in a good, workmanlike manner with an emphasis on meeting the aesthetic requirements such as sharp edges and even surfaces.

Give-way lines

1. Give-way lines consist of triangles with the tip pointed against the traffic direction (inverted triangles) standing at right angles to the traffic direction unless the marking schedule or other work conditions dictate otherwise.
2. The give-way triangle's individual distance and measurements shall not deviate more than 2 cm.
3. A deviation/curve of the give way triangle sidelines of 2 cm is permitted.
4. The give-way triangle's deviation in relation to the laying out line shall not exceed 2 cm.

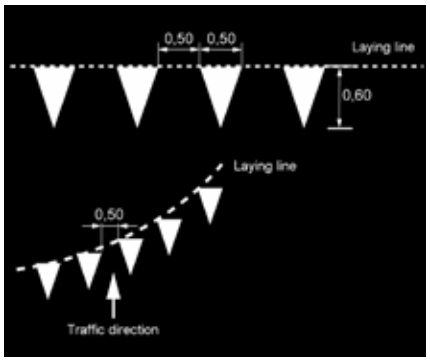


Figure 6.11 Illustration of give-way lines.

Give-way symbol

1. The give-way symbol shall be laid on the centre of the traffic lane's midline, or according to the schedule map or other work description. Deviation with respect to the centreline must not exceed ± 2 cm.
2. The give-way symbol's measurements shall not deviate more than ± 2 cm.
3. A deviation/curve of the give-way symbol sidelines of 2 cm is permitted.

Note: Corresponding requirements can be applied to other symbols, for example the bicycle symbol.

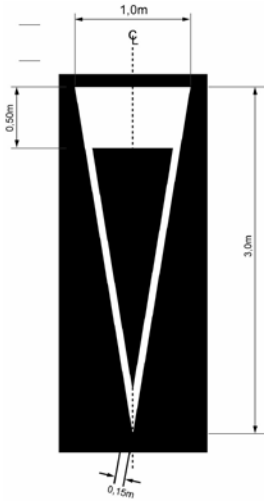


Figure 6.12 Illustration of give-way symbol.

Arrows

1. Arrows shall be laid in accordance with the description in Manual 049, with a permitted deviation of ± 2 cm in relation to the traffic lane's centreline.
2. The arrows' measurements are permitted a deviation of ± 2 cm, with the exception of the arrow's length where a deviation of ± 5 cm is allowed.
3. A deviation/curve of the arrow head's lines of 2 cm is permitted.
4. A spacing deviation between consecutive arrows of 0.50 m is permitted in relation to the distance given in Manual 049, marking schedule or other work conditions.

Note: Corresponding requirements can be applied for text markings in the traffic lane.

Note: The illustrations below (Figures 6.12 and 6.13) are examples of arrow shapes. For other symbols, refer to Manual 049.

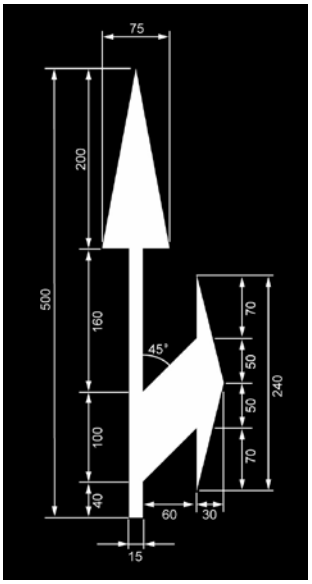


Figure 6.13 Illustration of arrows.

Pedestrian crossing

1. Deviations between the actual placement and the marking schedule shall not be greater than ± 5 cm.
2. The distance between the stripes and the width between stripes shall not deviate more than ± 2 cm. Only whole stripes with a width of 0.5 m shall be laid unless the schedule map or other work conditions dictate otherwise.

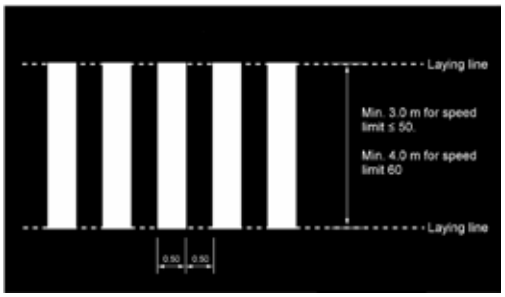


Figure 6.14 Illustration of a pedestrian crossing.

3. The beginning and end of the pedestrian crossing field shall lie in a straight line with deviations of no more than ± 2 cm.
4. The pedestrian crossing bands shall lie parallel with the traffic lane's longitudinal axis. Deviations in the form of lack of parallelism and/or curves shall not exceed 2 cm.
5. The length of pedestrian crossing bands shall not deviate more than ± 3 cm in relation to what is given in Manual 049 or in the marking schedule.

Note: Corresponding requirements can be applied for bicycle crossing lanes

Hatchin

1. The distance between the delineating lines (machine laid) and hatching lines/chevrons shall be 15 cm with a permitted deviation of ± 2 cm.

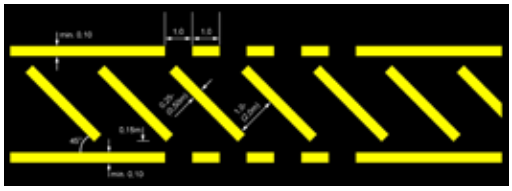


Figure 6.15 Illustration of hatching.

2. Deviations with respect to individual measurements for hatching given in Manual 049, the marking schedule or other work conditions, shall not exceed ± 3 cm.
3. Hatch lines placed longitudinally along the road shall not deviate more than 20 cm in relation to the original marking.

6.3.4 Requirements regarding repairs to existing road markings

General requirements for repair of road markings

These requirements apply generally to repair of existing road markings on shorter or longer stretches of road. Additionally, special requirements also apply to the repair of special types of lines.

There are several important condition to consider when repairing existing road markings, and efforts shall be made to achieve the most unified standard possible for road markings over longer stretches of road.

When repairing lines, the total thickness of the line on application of a new material may rapidly become too thick.

The total thickness after repairs should not exceed 5 mm.

To solve this, road markings may be repaired using thinner lines or possibly other methods.

If the total thickness after repairs will be more than 5 mm, the old road markings must be removed or made thinner before laying new lines.

Special requirements

Curves (horizontal, vertical)

Horizontal curves

If repairs are made to short parts or only a small part of a curve, this can create misunderstandings and incorrect visual guidance by the curve in the dark. Repairs of road markings through a curve shall be carried out so that there can be no misunderstanding of the visual guidance.

Vertical curves

When repairing lines over crests, it may be appropriate to draw these lines over the entire crest to avoid incorrect visual guidance in the dark.

Barrier line requirements

In the case of repairs made to short parts of a barrier line, there will be a considerable danger

of misunderstanding or misinterpretation in the dark because the short 'parts' may be perceived as warning or lane lines.

In the case of double barrier lines, and barriers in combination with other lines, both lines shall therefore always be repaired.

In general the entire barrier line should be repaired to ensure uniform visibility in the dark. If the lines, where they are not worn away, satisfy performance requirements, shorter stretches may be repaired.

New laying in the case of sectional asphalting
Where there are many short sections of lapped asphalt along the whole of a stretch, new road markings should be laid over the entire stretch.

6.3.5 Temporary road markings

Temporary road markings are used in the case of temporary changes in the traffic pattern for road work or other measures. When using temporary road markings, the original road markings shall always either be removed or covered so that misunderstandings will not arise in the visual guidance of the traffic.

Temporary road markings shall be removable after use without causing damage to the road surface by their use.

Requirements for temporary road markings
Temporary road markings shall satisfy the same requirements as permanent road markings.

Temporary road markings that are used on newly laid surfaces while waiting for permanent road markings shall be placed on the unpainted centreline of the carriageway, with a lateral deviation tolerance of ± 3 cm.

Methods for removal or covering of permanent road markings

Removal
Equipment that removes road markings shall remove almost all of the road markings so that the remains of the road marking or traces after removal cannot under any light conditions be perceived as a marked line. This is especially important in the period before any new road markings are laid out.

Covering
If tape or alternate methods are used to temporarily cover existing road markings in connection with road work, almost all previous road markings shall be invisible when covered.

Outside of the season for studded tyres, such tape shall be able to last 1 month before it loosens, if the manufacturer's conditions for laying it out are followed.

Temporary coverage must be able to be removed without destroying the original road markings.

For pre-fabricated road marking materials, i.e. road marking tape, the requirements of NS-EN 1790 Prefabricated road marking materials apply.

Temporary retroreflective road studs
In connection with roadwork, the following types of carriageway reflectors are usually used, cf. NS-EN 1463-1 Road marking materials. Retroreflecting road studs. Part 1: Initial performance requirements

Type A: non-deformable, glued or nailed to the surface
Type B: deformable, glued to the surface

If type A is used, certain performance requirements in accordance with NS-EN 1463-1 shall be satisfied.

If type B is used, for example during the period between laying the surface and when permanent road marking is applied, retroreflective road studs that do not satisfy NS-EN 1463-1 may be used. Measures using type B retroreflective road studs shall in any case have a duration of minimum 2 weeks.

For both types, the following applies:
To replace or supplement road markings, retroreflective road studs that in the dark reflect light corresponding to the colour of the line they replace or supplement shall be used.

Removal of temporary retroreflective road studs shall be possible without damaging the road surface.

6.4 Inspection and quality followup of laid road markings

6.4.1 Checking the road markings' performance

The instruments that shall be used to measure the various parameters must be in accordance with the specifications given in NS-EN 1436.

Control measurements of road markings shall be carried out to ensure that the performance requirements made and technical provisions are complied with. In this way, the road users are ensured adequate visual guidance and friction, so that traffic flow can proceed as safely and comfortably as possible.

Control measurements are carried out either with portable instruments or dynamically with instruments mounted on vehicles in accordance with appropriate methodologies.

Only control measurements carried out in accordance with current rules and methodologies can trigger demands for economic compensation or error-correcting measures if the contractor has not met the contract performance level requirements. Economic compensation or error-correction can be triggered by simpler control methods if both the Owner and the Contractor agree to this.

Control measurements that are carried out in connection with follow up of a contract shall always be carried out by a neutral, third party body, which has neither direct nor indirect connections to the Project Owner or the Contractor.

If, after an inspection, new road markings result in a status of "not approved", the Contractor shall see to new road markings in the entire section at no cost to the Project Owner. Alternatively, a deduction in payment shall be made according to separate rules. Only the Project Owner can decide whether the road markings shall be re-laid if they are not approved, or whether a financial deduction shall be made. This assessment shall be based on the importance of the non-conformity.

6.4.2 Handheld measurement with portable instruments

Control measurements shall be carried out in accordance with NA circular 2006/11.

The Contractor is required to document the laid out road markings functional level as newly laid (delivery control). The measurements shall be carried out at the earliest 14 days after the day they were laid out. Additionally, the road markings' performance shall be documented each year throughout the guarantee period (guarantee control, as a rule over two years). All control measurements shall be carried out in accordance with the current regulations and descriptions of methodology.

The requirement for delivery control covers only newly laid road markings on new surface sections.

All parameters shall meet the specified performance requirements if the object is to be approved.

The methodology description for performance tests of road markings is built on the European standard, ENV 13459-3, Road marking materials - Quality control : Part 3 : Performance in use. The Nordic road authorities have together compiled an adaptation of the voluntary European standard in Nordisk veiledning for funksjonskontroll av vegoppmerking [Nordic guidelines for performance control of road markings], dated 17 February 1997.

This shall be the basis for test measurements carried out with portable instruments.
For a description of the selection of measurement locations and carrying out the control itself, reference is made to the methodology.
For the sections that are selected for testing, it can be required that both transverse and longitudinal road markings are controlled.

6.4.3 Dynamic measurement with vehicle-mounted measuring equipment

Control measurement using vehicle-mounted instruments is considered equivalent to controls by means of portable measuring instruments. The same rules apply for measurement using vehicle-mounted equipment as for measurement using portable instruments.

Measurements and documentation shall take place in accordance with a separate method description.

6.5 Material requirements

6.5.1 General

Procurement of road markings can take place in three ways:

1. Pure performance contracts
2. Purchase of road markings at unit prices with specification of product (materials and characteristics)
3. Unit price – performance requirements

The producer shall be given an opportunity to formulate the material in accordance with own specifications under the condition that the material satisfies all requirements set in

Manual 062, unless otherwise agreed. The requirements are related to the properties of the materials as shown in laboratory tests. Tests that are used as a basis for assessment shall be carried out at laboratories that are approved by the Directorate of Public Roads. No test results may be older than 2 years.

After the requirement for CE marking of road marking materials comes into force, only materials with such certificates will be allowed to be used on the public road network. It is the material manufacturer's responsibility to ensure CE marking of its materials. To achieve CE certification, requirements are made for documentation of the material's durability. Test fields for documentation of such durability will be arranged in a Nordic climate zone.

6.5.2 Health, safety and the environment

Road marking materials shall be manufactured and documented such that the requirements of health, safety and environmental legislation are satisfied. Road marking materials shall not contain heavy metals, carcinogenic substances or other compounds that will make the material classifiable as "Very toxic" or "Toxic" The manufacturer shall make use of raw materials that contribute to a product that results in the least possible burden to the working environment in production and use. Road markings shall contain maximum 2% by weight of VOC (Volatile Organic Compounds).

For glass beads that are to be used in road marking materials or for drop-on, any arsenic content shall not exceed 200 mg/kg (dry weight) (200 ppm).

6.5.3 Special requirements for water-based paint

When selecting paint products for road markings, it is important to consider product characteristics that meet satisfactory drying times, including usage under conditions of low temperatures. The supplier shall state drying times and describe how these are documented.

6.6 References

- Manual 049 Vegoppmerking [Road markings],
  the Directorate of Public Roads, April 2001
- Manual 111 Drift og vedlikehold [Operations and maintenance],
  the Directorate of Public Roads, 1999
- Temahefte til Håndbok 111, [Booklet for Manual 111],
  the Directorate of Public Roads, 2002
- NS-EN ISO 4892 Methods of exposure to laboratory light sources
  Del 1: General guidance
  Del 2: Xenon-arc lamps
  Del 3: Fluorescent UV lamps
- VVMB 502 Vägverkets metodbeskrivning - Termoplastisk vägmarkeringsmassa
  – Bestämning av vidhäftning [the Swedish Road Administration's method description
  – thermoplastic road marking materials, determination of adhesive qualities]
- NS-EN 1423 first version, 1997 Road marking materials - Drop on materials
  - Glass beads, antiskid aggregates and a mixture of the two
- NS-EN 1424 first version, Road marking materials - Premix glass beads
- NS-EN 1436, 2007 Road marking materials - Road marking performance for road users
- NS-EN 1463-1 first edition, 1997 Road marking materials - Retroreflecting road studs -
  Part 1: Initial performance requirements
- NS-EN 1463-2 first edition, Road marking materials - Retroreflecting road studs
  - Part 2: Road test performance specifications
- NS-EN 1790 first edition, 1998 Road marking materials - Preformed road markings
- NS-EN 1824 first edition, 1998 Road marking materials - Road trials
- NS-EN 1871 first edition, 2000 Road marking materials - Physical properties
- NS-EN 12802 first edition, 2000 Road marking materials
  - Laboratory methods for identification
- NS-EN 13197 first edition, 2001 Road marking materials - Wear simulators
- NA circular 2006/11

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