RetroSign GRX
– Description and applications

RetroSign GRX is a handheld instrument that measures the retroreflection of surfaces at angular combinations described in standards or regulations for the purpose of testing compliance.

The retroreflection is described by the coefficient of retroreflection R_A with the unit of $cd \cdot lx^{-1} \cdot m^{-2}$. Additionally, the coefficient of luminous intensity R_I with the unit of $cd \cdot lx^{-1}$ is used for retroreflectors of small surface areas.

The GRX can cope with a large range of cases described by:

a) the observation angle α, which is the angle between the illumination and observation axes,
b) the entrance angle β, which is the angle between the illumination axis and the retroreflector axis.

The entrance angle β has two components β_1 or β_2. In all relevant cases either β_1 or β_2 is 0°. This leads to the two main types of geometries shown in Annex C.

NOTE: The GRX is assumed to be held upright so that a rotation angle ε, need not be considered.

The geometries are handled by means of:

a) Simultaneous R_A results for α values of 0,20°; 0,33°; 0,50°; 0,70°; 1,00°; 1,50° and 2,00°,
b) Use of three “calibrators” called “CEN”, “ASTM” and “ECE 104” each of which allows the use of one or more sets of adapters, that define the geometries.

The calibrators “CEN” and “ASTM” come in versions “CEN Ø10” and “ASTM Ø10” with reduced measuring fields for the purpose of measuring thin lines.

The calibrators are calibrated in the laboratory at DELTA with accreditation through DANAK. A calibrator is shown in figure 1.

Figure 1: A calibrator.

However, a user of the GRX may need only one value of α, one calibrator and a couple of adapters.

This applies for instance when measuring R_A values of installed road signs in accordance with either EN 12899-1 or ASTM standards. In the case of EN 12899-2, the equipment needed is a GRX-1 with a single value α of 0,33° (GRX-1 allows one selected value of α), a “CEN” calibrator and adapters for β_1 of 5° and 30° with β_2 = 0° (EN12899+5 and EN12899+30).

In case more options are needed at a later point in time, the GRX-1 can be upgraded to a GRX-3 (GRX-3 allows for three selected values of α) or a GRX-7 (allows for all the above-mentioned α values). Further, additional calibrators and adapters can be requested.

With a few of several adapters, there is the safeguard against mistakes that an adapter cannot be used unless the GRX is first calibrated with the calibrator to which the adapter is made.

A table of relevant standards/regulations with the corresponding GRX equipment is given in annex A.

As the annex A is not exhaustive regarding calibrators and adapters, a complete list is given in Annex B.

The two main types of geometries are shown in Annex C. Finally, the nature of retroreflection is explained by means of retroreflective road signs in annex D.

Annex A: Relevant standards/regulations with the corresponding GRX equipment

Table A.1: Installed road signs and retroreflective sheeting materials.

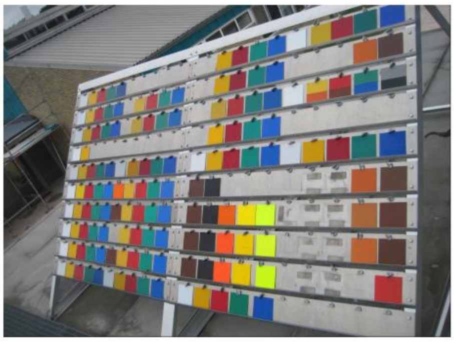
Measurement of the coefficient of retroreflection R_A of installed road signs and retroreflective sheeting materials and road signs for Factory Production Control and testing of durability		
EN 12899-1: 2007 “*Fixed, vertical road traffic signs - Part 1: Fixed signs*”	Clause 4.1.1.5 “Resistance to weathering” and measurement on installed road signs	
 	**Angles**	**Equipment**
	α = 0,33°	GRX-1 with α = 0,33°
		CEN Calibrator
	β_1 = 5°; β_2 = 0°	EN12899+5 adapter
	β_1 = 30°; β_2 = 0°	EN12899+30 adapter
	α = 0,33° β_1 = 5°; β_2 = 0°	CEN Ø10 calibrator for thin lines
	Clause 4.1.1.4 “Coefficient of retroreflection R_A”	
	Angles	**Equipment**
	α = 0,20°; 0,33° and 2,00°	GRX-3 with α =0,20°; 0,33° and 2,00°
		CEN calibrator
	β_1 = 5°; β_2 = 0°	EN12899+5 adapter
	β_1 = 30°; β_2 = 0°	EN12899+30 adapter
	β_1 = 30°; β_2 = 0°	EN12899+40 adapter
ASTM E1709-16 *Standard test method for Measurement of retroreflective Signs Using a Portable Retroreflectometer at a 0,2 Degree Observation Angle* *ASTM E2540 Standard test method for Measurement of retroreflective Signs Using a Portable Retroreflectometer at a 0,5 Degree Observation Angle* *ASTM D4956-19 Standard specification for retroreflective sheeting for traffic control*	**Angles**	**Equipment**
	α = 0,20° and 0,50°	GRX-3 with: α = 0,20° and 0,50°
	β_1 = -4°; β_2 = 0°	ASTM calibrator
	β_1 = 30°; β_2 = 0°	ASTM+30 adapter *)
	β_1 = -4°; β_2 = 0°	ASTM Ø10 calibrator for thin lines
	*) Additional adapters ASTM+10, ASTM+15, ASTM+40 and ASTM+45 are available	

Table A.2: High visibility clothing.

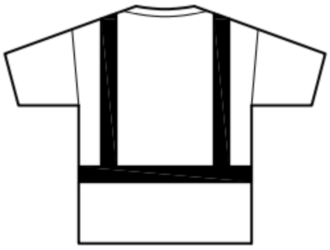
Measurement of the coefficient of retroreflection R_A of high visibility clothing		
EN ISO 20471: 2014 *High visibility clothing – Test methods and requirements (ISO 20471: 2013)* 	**Angles**	**Equipment**
	α = 0,20°, 0,33°, 1,00° and 1,50° β_1 = 5°; β_2 = 0° β_1 = 20°; β_2 = 0° β_1 = 30°; β_2 = 0° β_1 = 40°; β_2 = 0°	GRX-7 with: α = 0,20°, 0,33°, 1,00° and 1,50° CEN calibrator EN20471+5 adapter EN20471+20 adapter EN20471+30 adapter EN20471+40 adapter

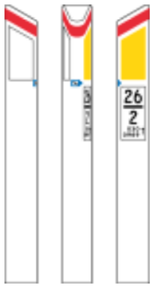
Table A.3: contour marking and rear marking plates of large vehicles.

Measurement of the coefficient of retroreflection R_A of contour marking and rear marking plates of large vehicles		
ECE Regulation No. 104 *Uniform provisions concerning the approval of retro-reflective markings for vehicles of category M, N and O*  ECE Regulation No. 70 *Uniform provisions concerning the approval of rear marking plates for heavy and long vehicles* 	**Angles**	**Equipment**
	α = 0,33° β_1 = 0°; β_2 = 5° β_1 = 0°; β_2 = 20° β_1 = 0°; β_2 = 30° β_1 = 0°; β_2 = 40° β_1 = 0°; β_2 = 60°	GRX-1 with: α = 0,33° ECE104 calibrator ECE104+5 Hor adapter ECE104+40 Hor adapter *)
	*) The ECE104+40 Hor adapter is a multi-angle adaptor that sets the angles of β_2 of 20°, 30°, 40°, 50° and 60°	

Table A.4: License plates.

Measurement of the coefficient of retroreflection R_A of license plates		
ISO 7591 *Road vehicles Retro-reflective registration plates for motor vehicles and trailers Specification* 	Angles	Equipment
	α = 0,20°, 0,33° and 1,50° β_1 = 5°; β_2 = 0° β_1 = 30°; β_2 = 0° β_1 = 40°; β_2 = 0°	GRX-3 with: α = 0,20°, 0,33° and 1,50° CEN calibrator LP+5 adapter LP+30 adapter LP+45 adapter

Table A.4: Retroreflectors.

Measurement of the coefficient of luminous intensity R_I of retroreflectors		
EN 12899-3 *Fixed, vertical road traffic signs - Part 3: Delineator posts and retroreflectors*	**Angles**	**Equipment**
	α = 0,20° and 2,00°	GRX-3 with: α = 0,20° and 2,00° ECE104 calibrator
	β_1 = 0°; β_2 = 5°	ECE104+5 Hor adapter
	β_1 = 0°; β_2 = 30°	ECE104+40 Hor adapter *)
	*) The ECE104+40 Hor adapter is a multi-angle adaptor that sets the angles of β_2 of 20°, 30°, 40°, 50° and 60°	

The above is an example, but the example applies for other retroreflectors:

a) Measure the area A of the retroreflector
b) Determine the geometries involved
c) For each geometry, measure the average R_A value over the surface of the retroreflector and calculate the R_I value by $R_I = A \times R_A$

Caution

Retroreflective elements that are only partly within the measured field, are not active and do not contribute to the R_I value.

This is no problem for retroreflective sheeting materials, whether they are glass beaded or microprismatic, because the dimensions of the glass beads and the microprisms are small fractions of 1 mm.

However, plastic molded reflectors with prisms of 1 mm or larger are not measured correctly.

Annex B: Relevant standards/regulations with the corresponding GRX equipment

Table B.1: Calibrators and adapters.

Name	Name in GRX	Calibrator	Main alpha angles		
ASTM Std.	ASTM	ASTM	0,20	0,50	1,00
ASTM +10	ASTM +10	ASTM	0,20	0,50	1,00
ASTM +15	ASTM +15	ASTM	0,20	0,50	1,00
ASTM +20	ASTM +20	ASTM	0,20	0,50	1,00
ASTM +30	ASTM +30	ASTM	0,20	0,50	1,00
ASTM +40	ASTM +40	ASTM	0,20	0,50	1,00
ASTM +45	ASTM +45	ASTM	0,20	0,50	1,00
ASTM Ø10	ASTM Ø10	ASTM Ø10	0,20	0,50	1,00
CEN Std.	CEN	CEN	0,33	0,50	1,00
CEN+10	CEN+10	CEN	0,33	0,50	1,00
CEN+15	CEN+15	CEN	0,33	0,50	1,00
CEN+20	CEN+20	CEN	0,33	0,50	1,00
CEN+30	CEN+30	CEN	0,33	0,50	1,00
CEN+40	CEN+40	CEN	0,33	0,50	1,00
CEN Ø10	CEN Ø10	CEN Ø10	0,33	0,50	1,00
EN12899 +5	EN12899 +5	CEN	0,20	0,33	2,00
EN12899 +30	EN12899 +30	CEN	0,20	0,33	2,00
EN12899 +40	EN12899 +40	CEN	0,20	0,33	2,00
EN20471+5	EN20471 +5	CEN	0,20	0,33	1,00
EN20471+20	EN20471+20	CEN	0,20	0,33	1,00
EN20471+30	EN20471+30	CEN	0,20	0,33	1,00
EN20471+40	EN20471+40	CEN	0,20	0,33	1,00
License Plate UK +5	LP+5	CEN	0,20	0,33	1,50
License Plate UK +30	LP+30	CEN	0,20	0,33	1,50
License Plate UK +45	LP+45	CEN	0,20	0,33	1,50
ECE 104	ECE 104	ECE104	0,33	0,50	1,00
ECE 104 +5 Horizontal	ECE104 +5 Hor	ECE104	0,33	0,50	1,00
ECE 104 +40 Horizontal	ECE104 +40 Hor	ECE104	0,33	0,50	1,00

Annex C: Two main types of geometries

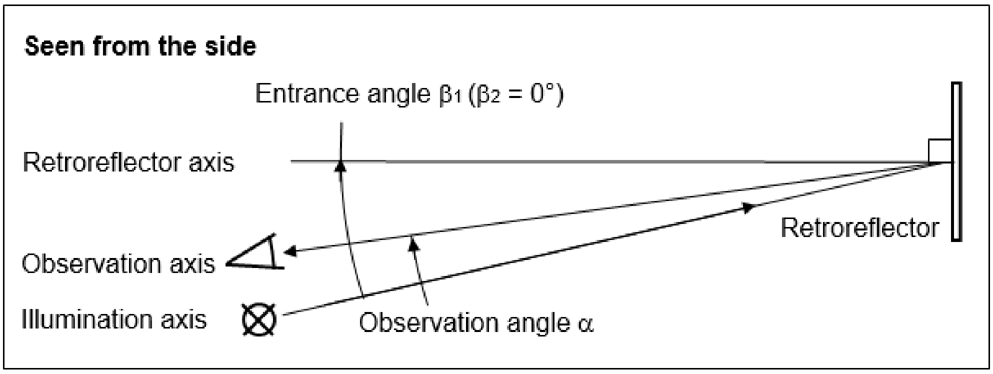


Figure C1: Geometry in a single plane.

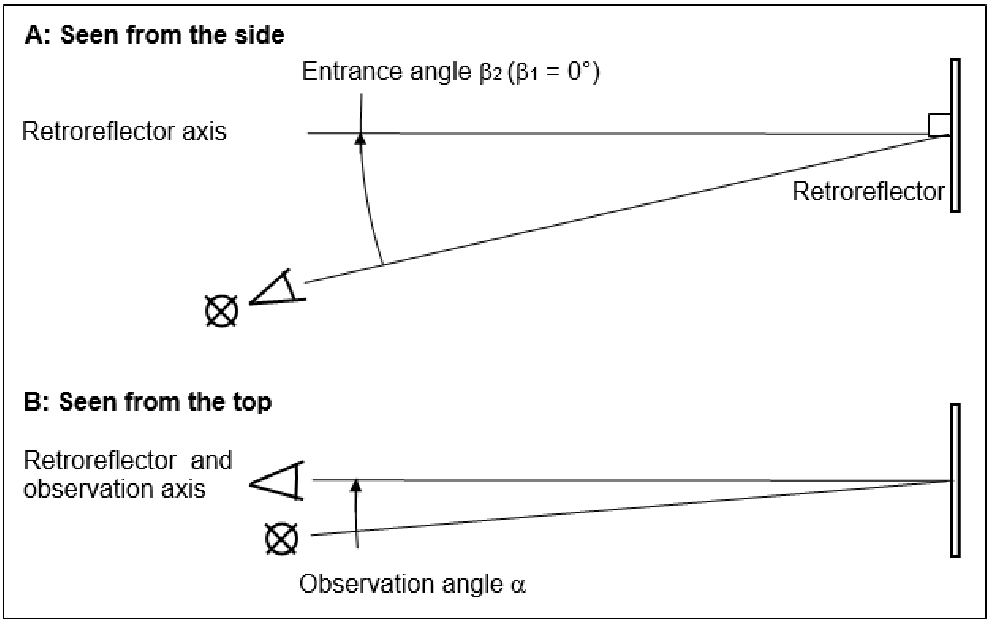


Figure C2: Geometry in two planes.

Annex D: The nature of retroreflection explained by means of retroreflective road signs

D.1 Introduction

Section D.2 presents a driving situation, that is used to explain retroreflection. It is shown that retroreflection is much more powerful than ordinary reflection.

Section D.3 gives some estimates of the luminance of retroreflective road signs that are mounted relatively high – excluding low mounted signs at for instance roundabouts and road crossings.

Section D.4 describes the variation of the luminance of retroreflective road signs with distance during a drive. It is concluded that there is a distance range, where the luminance of the sign is roughly constant and that this range should match the need of the drivers.

There is a wealth of retroreflective sheeting materials with different properties. The choice of types of materials for particular applications may be governed by national regulations.

D.1 A driving situation

Figure D.1 shows a location of a passenger car during a drive towards a retroreflective road sign.

Each of the two headlamps of the car illuminates the road sign. As shown in figure D.2, the road sign produces retroreflected beams of light back towards each of the two headlamps. As also shown in figure D.2, the beams provide a total illumination that includes the eyes of the driver.

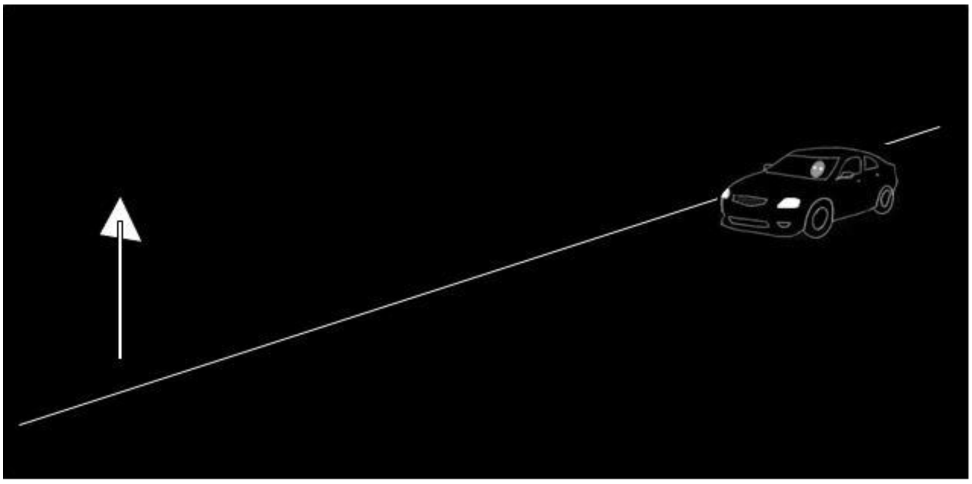


Figure D.1: Location of a passenger car during a drive towards a retroreflective road sign.

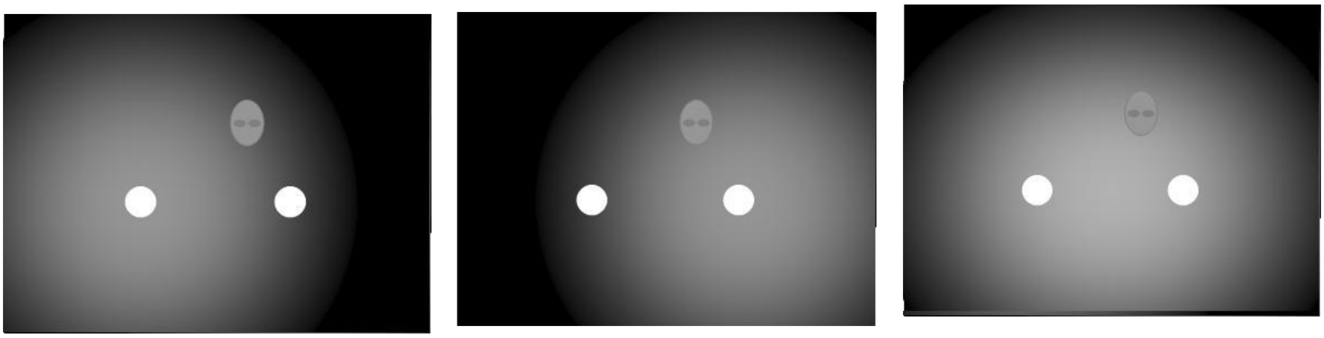


Figure D.2: Retroreflected illumination around the two headlamps (left and middle) and the total illumination (right).

White parts of road signs with ordinary reflection can have a luminance coefficient R_L of maximum $1/\pi = 0{,}318$ $cd \cdot m^{-2} \cdot lx^{-1}$, while a white retroreflective road sign has a coefficient of retroreflection R_A that is 100 to more than 1000 times higher.

NOTE: R_L and R_A values differ from each other by a factor that depends on the geometry but remains close to 1.

The wonder of retroreflection is that it is very powerful compared to ordinary reflection.

D.3 Estimate of levels of luminance produced by illumination and retroreflection

Figure D.3 shows a typical light distribution of low beam headlamps.

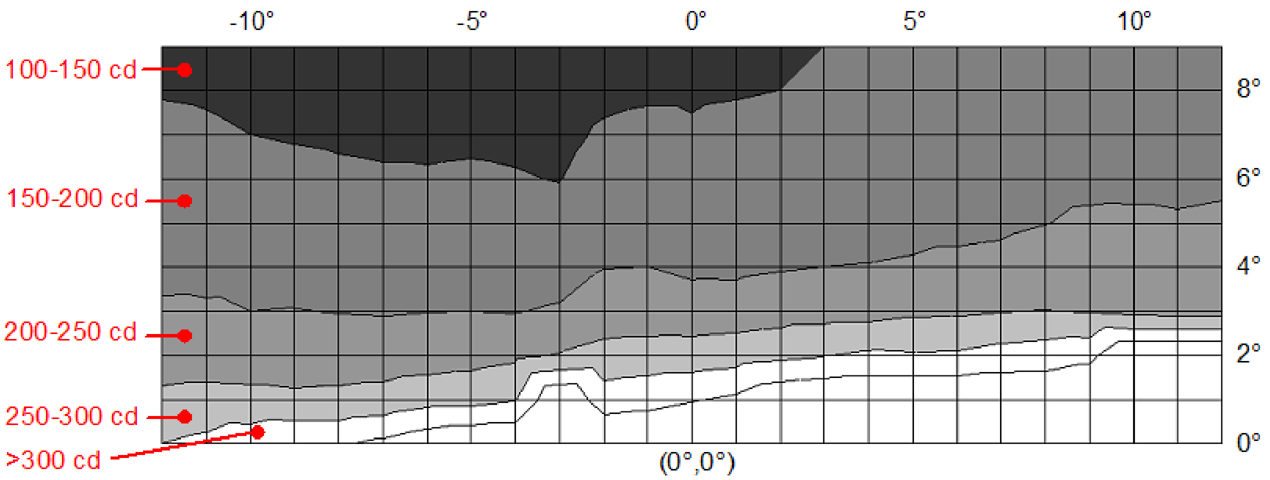


Figure D.3: A typical light distribution of low beam headlamps.

Most road signs are placed so high that the luminous intensity is low. Assume a typical luminous intensity of 200 cd.

Further, most road signs must be readable from a sufficient distance to provide enough time for the driver to read the road sign. Assume a typical distance of 70 m for an ordinary road.

In accordance with the distance law of illumination, the illuminance at the road sign is $E = 200/70^2 = 0{,}04$ lux for each headlamp and 0,08 lx for both together.

Ordinary reflection would then lead to a luminance of maximum $0{,}08 \times 0{,}318 = 0{,}026$ $cd \cdot m^2$, which is far from sufficient for reading.

Retroreflection, on the other hand, provides luminance values from 2,6 to more than 26 $cd \cdot m^{-2}$.

D.4 Variation of luminance with distance

Figure D.4 shows some relative distance locations of a sign during a drive,

It is normal during a ride that the luminance of the sign is low at the longest distance, increases to a maximum and then decreases to a low value at the shortest distance. This is due to the interaction of three factors:

a) the distance is high at the longest distance but decreases during the ride,
b) the luminous intensities of the two headlamps are at their highest but decrease during the ride,
c) the observation angles for the two headlamps α are at their smallest at the longest distance causing the highest R_A values but decrease during the ride.

In conclusion, there will be a distance range, where the luminance of the sign is roughly constant. It is an art to select the retroreflective sheeting material that makes the distance range match the need of the driver.

Further, the distance range depends on the road type. As an example, road signs on a motorway should be readable at long distances to provide sufficient time for reading. This calls for retroreflective sheeting materials with narrow retroreflected beams.

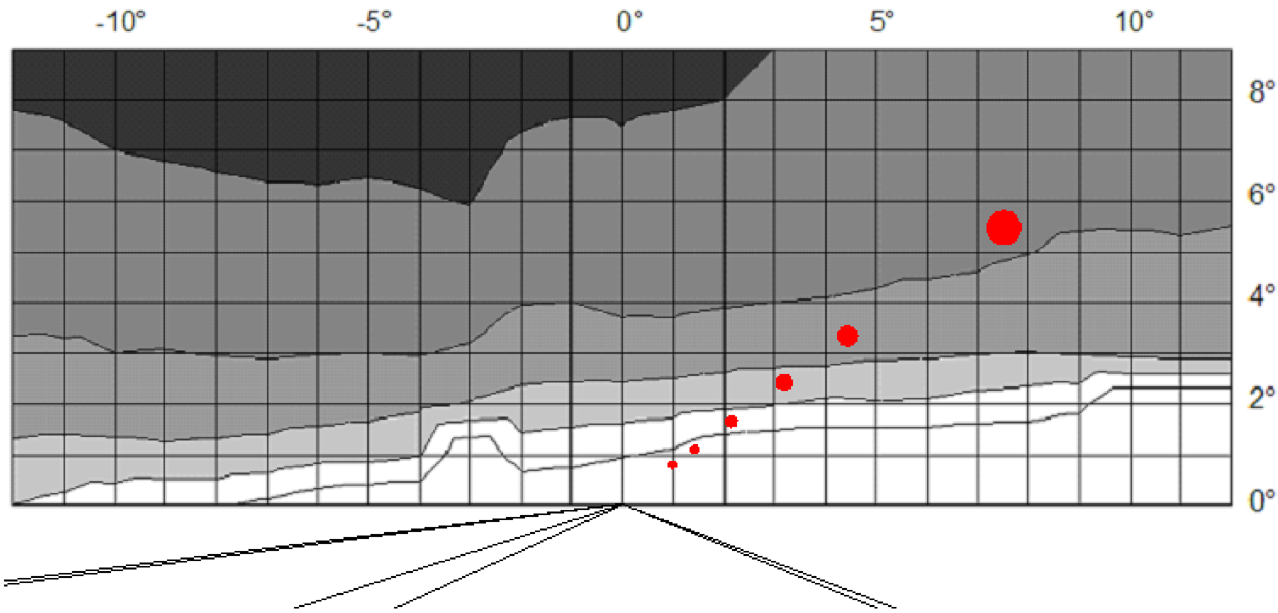


Figure D.4: Some distance locations during a drive.