Translated from German

FEDERAL MINISTRY OF HEALTH

124-3355/45
Our reference (Please quote on all replies)
Postal. address: Federal Ministry of Health - 53108 Bonn

Bonn, September 1996
Tel: (0228) 941-1243 or 941-0
Fax: (0228) 941-4917 or 941-4900

Handbook "Improving visual information in the public places"

Dear Sir,

The attached handbook is intended for all those who are concerned with the design of public spaces. In addition it should also be used by those who need to employ a high contrast display for better orientation in everyday life and, therefore, play a part at the local level with the planning in local authority areas. The document contains recommendations, which, with the help of brightness, colour and shape, can produce designs for public places which are pleasing to the public and suitable for disabled people.

It provides a useful help for their daily work.

There are still a few copies available here from the restricted number of copies printed so that if further copies are required I am in the position to supply these free of charge until supplies are exhausted. The printers of the handbook, of course, have copies available for sale.

The handbook will shortly be available on CD-Rom.

In conclusion, I wish you much success in your work.

Yours faithfully,

E. Vogel

Handbook for planners and experts

The German Library - CIP Standard copy

Improving the visual information in public places: Handbook for planners and experts for the design of the contrast, the brightness, the colour and the shape of visual signs and markings in traffic areas as well as in buildings that are pleasing to the public and suitable for disabled people Federal Ministry of Health, Bonn (Project co-ordination in the Federal Ministry of Health: Paper "Social integration of disabled people") - Bad Homburg printed by Fach-Media-Service-Verl. - Ges, 1996.

ISBN 3-926181-28-1

NE: Germany/Federal Ministry of Health

Project co-ordination by the Federal Ministry of Health:

Paper "Social integration of disabled people"
Am Propsthof 78a
D-53121 Bonn
Tel: (0228) 941-1243
Fax: (0228) 941-4917

ISBN 3-926181-28-1
Editor: Federal Ministry of Health
Publishing House: FMS Fach Media Service Verlagsgesellschaft mbH, 61352 Bad Homburg v.d.H.
Printer: Mintzel Druck, 95028 Hof/Saale

The proposals in this handbook were carefully developed and checked. Nevertheless the Authors, their assistants, the editor and also the Publishing House accept no responsibility for damage to people, goods and property.

The information given in this handbook does not belong to the official part of the publication. The editor is not responsible for it in any way.

Handbook for planners and experts

for the design of the contrast, the brightness, the colour and the shape of visual signs and markings in traffic areas, as well as in buildings that are pleasing to the public and suitable for disabled people

Improvement of visual information in public spaces

Federal Ministry for Health, Bonn 1996

THE FEDERAL MINISTER FOR HEALTH
Horst Seehofer, MdB

Foreword

Partially sighted people frequently have problems finding their way if they are outside their familiar surroundings. This has a considerable effect on the mobility of the people involved. They reduce their area of activity more and more in order to reduce the danger of accidents and their feeling of gross insecurity.

For almost all people visual design plays an important part in helping them to find their way around buildings and the technical environment. For this, contrast, brightness, colour and shape are very important. This is especially true for partially sighted people.

While not every sight impairment can be compensated with planning and building measures it is, however, possible with pieces of information that offer a strong contrast to make a contribution to extending the mobility and to improving the safety in public places. Contrasts are often the only way to help partially sighted people who live alone and to enable them to find their way around buildings and to use public transport or the PC screen.

Both in transport planning and in the design of public places, the interests of people who have limited sight and ability to find their way about - and this includes a growing number of older people - were in the past insufficiently or not at all considered. This was partly due to the lack of a scientific basis for the special requirements for the design of signs for the partially sighted.

This handbook fills this gap in the knowledge and provides information. It contains proposals and recommendations for use in practice, which when used consistently can be of advantage to all men and women in society. The information available to pedestrians and users of public transport and help in finding their way about was far below the standard which was available elsewhere, for example, for road traffic.

The proposed arrangements do not involve any special costs, if they are put into the scheme at the right time, that is to say at the planning stage. In addition it seems to me to be essential to include the expertise and the experience of people whose mobility is restricted because of a disablement, at an early stage in the planning and consultation. The subsequent correction of planning omissions is, on the other hand, much more difficult, and in any case more expensive.

The local self help groups are the proper and, in particular, the practically proven experts in their own field, whose support the local authority, the planning offices and, not least, the relevant training places should enlist.

Signed

This Handbook was prepared by
Research Association "Car sight safety" (ASS) E.V. Universitätsstraße 5,
D-50937 Cologne, Tel. 02 21/41 58 94, Fax 02 21/42 82 55
Editor: Prof. Dr. rer. nat. habil. Wilfried Echterhoff,
University Gesamthochschule Wuppertal, Psychology Specialist Group
Member of the Research Group "Contrast optimisation"
Technical Editor: Dieter Poll
Illustrations: Computer graphic Atelier Bella, Cologne

The following have assisted in the production of this Handbook:

Prof. Dr.-Ing. habil. K. Ackermann, Technical University Dresden
Prof. Dr. A. Blankenagel, University Heidelberg
Dipl.-Ing. M. Blaschke, Technical University Dresden
Dilp.-Ing. G. Burmeister, Buxtehude, Member of the Research Group "Contrast Optimisation"
Dipl.-Ing M. Enders, Technical High School Darmstadt, Member of the Research Group "Contrast Optimisation"
Dipl.-Psych. F. J. Esch, German Blind Studies Institute e.V. (BLISTA), Member of the Research Group "Contrast Optimisation"
Dipl.-Ing. G. Feller, Technical University Dresden
Dr. R. v. Gizycki, empirica Delasasse, Bad Nauheim, Member of the Research Group "Contrast Optimisation"
M. Guhr, Federal Ministry of Transport, Member of the Research Group "Contrast Optimisation"
Dr. A. Hohmann, Cologne, Member of the Research Group "Contrast Optimisation"
Prof. Dr. Dr. B. Lachenmayr, Ludwig Maximilians University Munich, Member of the Research Group "Contrast Optimisation"
Dr. K. Landwehr, Associate Professor, University GH Wuppertal
Dipl.-Vw. E. Lehning-Fricke, Bonn, Member of the Research Group "Contrast Optimisation" and Chairman of the Research Advisory Committee; Deutsche Retinitis Pigmentosa Vereinigung (DRPV)
Prof. Dr.-Ing. habil. H. Linder, Otto-von-Guericke-University Magdeburg, Member of the Research Group "Contrast Optimisation"
Priv.-Doz. Dr. D. Methling, Humboldt-University Berlin
Dr. S. Müller, Ludwig Maximilians University Munich, Member of the Research Group "Contrast Optimisation"
Dipl.-Ing. E.-O. Rosehahn, Technical High School, Darmstadt, Member of the Research Group "Contrast Optimisation"
Prof. Dr.-Ing. H.-J. Schmidt-Clausen, Technical High School, Darmstadt, Member of the Research Group "Contrast Optimisation"
Prof. Dr. W. Schneider, Research Association Car-Visibility-Safety e.V. Cologne
H.-D. Später, Bonn, German Society for the Blind

Representatives of the Federal Ministry for Health, Bonn and the Federal Work Association for Rehabilitation, Frankfurt a.M. were involved as observers.

Guericke University, Magdeburg.

Advice on the final version was given by the following people and Institutions:

1. Responsible offices of the Federal Counties: Members of the Ministers Conference of ARGEBAU (situation July 1995)

Federal Ministry for Regional Policy, the Building and Construction Industry and Urban Development, Bonn

Minister of Finance, Mainz
Minister of the Interior, Kiel
Minister of the Interior, Mainz
Minister for Building, Regional Development and Environment, Schwerin
Minister for Building and Housing, Düsseldorf
Minister for Town Planning, Culture and Sport, Düsseldorf
Minister for Town Planning and Transport, Potsdam
Minister for the Environment, Energy and Transport, Saarbrücken
Minister for the Economy, Stuttgart
Minister for Economic Affairs and Finance, Saarbrücken
Minister for Economic Affairs, Transport and Regional Development, Wiesbaden
Ministry for Housing, Town Planning and Transport, Magdeburg
Senior Planning Officer in the Baverian Ministry of the Interior, Munich
Representative of the Planning Officer, Hamburg, Hamburg
Senatorfor the City Development Authority, Hamburg
Senator for Building and Town Planning, Berlin
Senator for Building, Transport and Town Planning, Bremen
Social Minister, Hannover
County Minister for the Interior, Dresden
County Ministry of the Interior, Munich
Thüringer Ministry for Economic Affairs and Infrastructure, Erfurt
Ministry of Transport, Baden-Würtemburg, Stuttgart

2. Federal Organisations

Federal Institute for Roads (BASt), Bergisch Gladbach
Federal Ministry for Work and Social Affairs (BMA) Bonn
Federal Ministry for the Family, Pensioners, Women and Young People (BMFSFJ), Bonn
Federal Ministry for Environmental Planning, Building and Town Planning (BM Building), Bonn
Federal Ministry of Transport, Bonn
Railway Federal Office, Bonn
Otto Regenspurger, MdB, Bonn
Representative of the Federal Government for the interests of the disabled

3. Local Government Organisations

Federal Association of Local Government Top Federations, Cologne
German Counties Congress (DTL), Bonn

German Town and District Federation (DStGB), Düsseldorf
German Congress of Municipal Authorities (DST), Cologne

4. Interested Associations

Association to Promote the Interests of Partially Sighted People e.V. (BFS) Ratingen
Federal Association of Clubs for the Partially Sighted and their Friends e.V. (BAGcbf), Mainz
Federal Association of Helpers for Partially Sighted People e.V. (BAGH) Düsseldorf
Federal Association of Road Building and Traffic Engineers e.V. (BSVI), Hannover
German Retinitis Pigmentosa Association e.V. (DRPV), Aachen
German Association for the Blind e.V. (DBV), Bonn
German Club for Blind and Partially Sighted People who Study or are Working e.V. (DVBS), Marburg
Joint Technical Committee for the Interests of Partially Sighted People, Esslingen
Imperial Association of War and Military Service Victims, Disabled Social Pensioners and Surviving Dependents e.V., Bonn
German Association of War and Military Service Victims, Disabled and Social Pensioners e.V. (VdK), Bonn
German Electrical Engineering Association e.V. (VDE), Frankfurt on. M.
Association of German Engineers (VDI), Düsseldorf

5. Business Associations

Association of German Airports e.V. (ADV), Stuttgart
Association of German Domestic Shipping Companies e.V. (BDB), Duisburg
Association of Chemical Industries e.V. (VCI), Frankfurt on M
Association of Paint Manufacturers e.V. (VdL), Frankfurt on M
Association of German Shipowners e.V. (VDR), Hamburg
Association of German Transport Companies (VDV), Cologne

6. Professional Associations and Trade Associations

Association of German, Architects, Federal Secretariat (BDA), Bonn
Federal Association for Rehabilitation (BAR), Frankfurt on M.
German Lighting Association e.V. (LiTG), Berlin
Association of German Architects (VDA), Munich

7. Institutions for Standards and Guidelines

DIN German Institute for Standardisation e.V. Berlin

8. Technical Institutes

German Ophthalmic Society (DOG), Heidelberg
ETH Swiss Technical Highschool, Zurich, Institute for Transport Planning, Transport Technology, Tramway and Railway Construction (IVT)

Good Light Carriers Association, Frankfurt on M.
Research Company for Road and Transport e.V.(FGSV), Cologne
Hamburg Transport Association
Institute for Railway Technology GmbH (ifb), Bergish Gladbach
Institute of Lighting Technology of the Technical University of Ilmenau
Mobility Company and Municipal Consultancy GmbH, Cologne
Central Association of Eye Opticians (ZVA), Dusseldorf

9. Experts

Dipl.-Ing. D. Gellenbeck-Schmid, Civil Engineering Office of Münster Town Council
Dr. D. Gericke, Berlin
Architect Dr.-Ing. E. Hempel, Dresden
Dipl.Ing. V. König, Wedel
Prof. Dr.-Ing. D. Machule, Technical University Hamburg-Harburg
Dr. P. Manz, University Karlsruhe
Dipl.Phys. H. H. Meseberg, Federal Institute for Highway Engineering
Dipl.-Ing. O. Middendorp, Federal Transport Office, Berne
K. W. Moehler, AG Environment and Transport of the BSVS e.V. Chemnitz
Prof. Dr. A. Müller-Hellmann, Association of German Haulage Contractors, Cologne
Prof. Dr. B. Rassow, University Eye Clinic, Hamburg
Dipl.-Ing. N. Rudolph, Civil Engineering Office of the town of Münster
Architect Prof. Dipl.-Ing. A. Stemshorn, National Academy for Fine Arts, Stuttgart
Dipl.Ing. J. Usadel, Architectural Office d*Ing (Architecture, Town Building and Town Planning), Hamburg
Dipl.-Psych. C. Vogel, Architects Office d*Ing (Architecture, Town Building and Town Planning), Hamburg
Dipl.-Ing. A. v. Knobloch, Hamburger Hochbahn (Hamburg Rapid Transit) AG

10. Representatives of disabled people in the Federal Counties

Baverian State Ministry for Work and Social Affairs, Families, Women and Health, Munich
Representatives for People with Disabilities of the County of Schleswig-Holstein, Kiel
Representatives of the Disabled from the Administration of the County of Brandenburg, Potsdam
Representatives of Disabled from the County of Niedersachsen, Hannover
Representatives of the Disabled from the County of Rheinland Pfalz, Mainz
Representatives of the Disabled from the County of Sachsen-Anhalt, Magdeburg
Representatives of the Citizens of the County of Mecklenburg-Vorpommern, Schwerin
Hessisches Ministerium for Women, Work and Social Affairs, Wiesbaden
Representatives of the Disabled from the County of Berlin, Senate Administration for Social Affairs, Berlin
County Representatives for Questions to do with the Disabled in Saarland, Saarbrücken

Ministry for Work, Health and Social Affairs of the County of Nordrhein-Westfalen, Düsseldorf
Ministry for Work, Health and Social Affairs of the County of Baden-Württemburg, Stuttgart
The Sachsen Ministry for Social Affairs, Health and Family, Dresden, with comments from:
Social Association VdK Sachsen, Chemnitz
Leipzig Disabled Association e.V.
County Association to Help Disabled People in Sachsen e.V. Dresden
Blind and Partially Sighted Association Sachsen e.V. Dresden
Senate Representative for Questions to do with Disabled People, Hamburg
Senate Management for Health, Youth and Social Affairs of the Free Hansa City of Bremen, Bremen
Thüringer Ministry for Social Affairs and Health, Erfurt

Language Wording:

The use of the male grammatical form for people also includes people of the female gender.

Connection to other Codes of Practice and Standard Works:

A series of examples was recently developed and many of the examples used were prepared from data obtained from drawings from other documents, especially from the Handbook "Designs for public places which are pleasing to the public and suitable for disabled people" (Ackermann et al., 1992) in order to give details of dimensioning and other data.

Reference to nationally valid legal specifications and internationally valid agreements:

The purpose of this Handbook is to show the latest technical standards but it does not replace national legal requirements or internationally applicable agreements.

Signs and abbreviations:

➢ Boundary of the contrast between two surfaces or fields

☞ Refers to other places in this Handbook

🕮 Refers to literature; codes of practices and other documents

| Bar refers to the notes in the margin

Unit of measurement for the light density (starting point for the perceived brightness):

cd/m^2 = light strength (measured in candela) per square metre
(see Hentschel 1994, Pages 31 et seq; 36 et seq)

Simplified method of citation for final report of research project "Contrast optimisation"

The research report is cited in this Handbook just with the designation "Contrast optimisation" or research report "Contrast optimisation". In the bibliography list this report is referred to under the author Echterhoff et al. (1995).

The final report of the research project "Contract optimisation" can be seen in or borrowed from the following libraries (catalogued under "Echterhoff, W...." and the other authors) among other places:

Medical Central Library of the Otto-von-Guericke-University, Magdeburg
Leipziger Str. 44
D-39120 Magdeburg
Tel.: (0391) 671 4305
Tax: (0391) 671 4317

Library of the Bergischen University Gesamt Hochschule, Wuppertal
Gaußstr. 20
Gebäude BZ
D-42119 Wuppertal
Tel.: (0202) 439-2690 or - 2691

Summaries of the final report of the Research Project "Contrast-optimisation" can be obtained from

Federal Ministry of Health
Broschürenstelle
Am Propsthof 78a
D-53121 Bonn
Tel.: (0228) 941-1332 or - 1333
Fax: (0228) 941-4972

PART A

Recommendations

1 Objective and principles

1.1 Sight and visual perception

The problem

In September 1990 the Working Group "Designing the environment for disabled people" of the Federal Association for Rehabilitation discussed for the first time in depth how the mobility of people with impaired sight could be improved by designing buildings so that the features had a lot of contrast. There was some doubt as to whether black and white gave an optimum contrast.

A visual contrast is produced by a difference in brightness, but there were no agreed experimental results, or usable published recommendation available. It was still not clear to what extent the use of colour combinations could assist in providing a sufficiently strong contrast for people with impaired sight. In parallel to these considerations, initiatives were being developed with similar objectives by other Institutions, and of these special mention should be made of the work of the German Retinitis Pigmentosa Association (DRPV).

The initiative

In May 1991 a small group of experts met at the instigation of the Federal Ministry for Families and Pensioners, that was responsible at that time, in order to discuss these questions. They found that there was a lack of relevant scientific knowledge both for the areas of ophthalmology, perception psychology and for light technology, so that the question could not be answered reliably or even approximately. The discussion concentrated on the preparation of the scope for a research project, which of necessity had to be wide ranging and required the formation of a research group. After the necessary finance had been made available by the Federal Government, the project work was carried out from October 1992 to the end of 1994. The findings of the final report offer new planning criteria for the use of contrast, brightness, colour and shape to architects, civil engineers, interior designers, designers, lighting designers, graphic designers, as well as public, industrial and private customers, without taking into account the objectives of aesthetics, economic practicability and the technical quality.

The research group

Make possible sufficient contrast and aesthetics

The Federal Ministry for Health considered it advisable to give the main conclusions of the research report in a suitable form for use in practice. In this connection it should be mentioned, in particular, that it was not intended to prepare isolated special solutions for the different types of sight impediments but suggestions and recommendations which would be beneficial to all citizens.

The purpose of this Handbook is to help practical application

This Handbook gives the results of this objective. It is recommended for use by all planners in the public and private sector. The scientifically interested reader is at liberty to study the final report of the research group.

Main components in the design of the environment

Contract, brightness, colour and shape are the main components in the optical design of our buildings and technical environment. For the person who has to find his way around in this environment they are of crucial importance, since up to 90% of the signals which he picks up to find his way around are not needed by sighted people who have visual perception.

Finding ones way around is made easier if objects are recognisable by contrast, brightness, colour and shape. It is made more difficult when the light is poor, when things are lost in environments of similar colour or if the shape is not conspicuous.

People's visual system determines whether contrast, brightness, colour and shape are sufficient in a given environmental situation to enable people to find their way about in safety. Therefore it is important at least to know in principle how the visual system ▌ functions and what it can do under normal circumstances.

☞ *Appendix 1*

The eye and visual perception

▌ The construction of the eye - very much simplified - can be compared to a spherical shaped camera with attached "data processing". It has an optical system, which consists basically of the cornea and lens. The lens adjusts for distances in a similar way to an automatic focusing lens. With the iris the eye has an aperture which becomes larger or smaller depending on the brightness. Finally the retina at the back of the eye corresponds to the projection wall on the camera.

🕮 *Textbook by Lachenmayr (1995)*

Inside the eye between the lens and the retina is the so-called vitreous humour (see Figure 1).

GLOSSARY FOR FIGURE 1

1. Ciliary body
2. Lens
3. Cornea
4. Sclera
5. Pigment epithelium
6. Choriod
7. Optical nerve
8. Vitreous humour
9. Macula
10. Horizontal section
11. *Figure 1: Section through the human eye*

The retina provides coloured and black and white vision

The process, which decides whether we see in black and white or in colour, begins in the retina. The retina has various layers of sense and nerve cells in front of the layer of the actual sight cells (see Figure 2).

GLOSSARY FOR FIGURE 2

12. Ganglia cells
13. Synapsislayer
14. Inner
15. Outer
16. Fibres of the optic nerve
17. Amacrine
18. Cell bodies
19. Pigment epithialium
20. Cones and rods
21. Bipolar horizontal cells
22. *Figure 2: Section through the retina*

There are two types of vision cells. Cones and rods.

Cones are used for sharp vision and reading. In addition cones enable us to perceive colours in daylight or corresponding artificial light. There are three different types of cone for detecting the colours yellow, green and blue ❚.

📖 *See Campenhausen (1981), page 265*

These three types of cone enable all colours to be perceived with the help of the associated "data processing". These cones do not work when the light conditions are poor.

The rods, on the other hand, are only light-dark-sensitive and help to perceive rough shapes and movements. Since they enable people to see in the dark they are some 10 000 times more light sensitive than the cones. The rods need a period of about half an hour to become accustomed to the lighting conditions in order to reach almost their full performance in the dark (darkness adaptation).

Macula: Compression of cones

The vision cells are differentially distributed over the retina. The density of cones is greatest in the centre of the retina, called the macula. It is here that the picture resolution and colour differentiation are best and the sharpness of vision is greatest. On the periphery there are fewer cones and consequently vision is not so sharp. On the edge of the field of vision the sharpness of vision is only 1/50th of the sharpness of vision in the macula. The macula can be lined up with the object to be seen by eye and body movements ▮.

☞ *Appendix 1*

Under poor light conditions nothing can be seen at this central position however. Obstacles which are indicated on the macula under poor light conditions are, therefore, not detectable (dark skotom).

Reduction of the visual perception as a result of sight impairment

Each part of the eye can partly or completely loose its function, be it due to hereditary causes, because of an illness or due to age. Relatively frequent is a clouding of the lens (cataract), a degeneration of the retina material (macula degeneration) or increased eye pressure (Glaucoma), which damages the optic nerve and finally can completely destroy it ▮. If the rods do not work, people suffer from night blindness. If the cones fail then people become colour blind and if people suffer from total colour blindness then all three types of cones have failed. If colour blindness occurs it is most frequently the red-green defect (that occurs in 8% of men but only 0.4% of women), in which shades of grey are generally detected for the red and green.

☞ *Appendix 3*

The sensitivity of people with sight disabilities for contrasts is generally lower than for normally sighted people. Better contrasts consequently increase the mobility of partially sighted people, and, in addition, make it easier for normally sighted people to find their way around.

Partially sighted and normally sighted people differ in their ability to find their way about (see Figure 3).

Partially sighted people seek help in finding their way around in the immediate vicinity

Partially sighted people more frequently seek help in finding their way in the immediate vicinity than normally sighted people (e.g. large objects and moving objects) and especially for objects that offer a high degree of contrast. Large spaces, therefore, often cause partially sighted people big problems. The remedy for this is the visual structuring of the surface of the walkway or the careful positioning of large objects which have plenty of contrast (such as sculptures or valuable cultural historic works).

Figure 3: Orientation points of normally sighted people (triangles) and partially sighted people tested (circles) ▌

📖 *Research report "Contrast-optimisation" Fig 29, page 348*

In view of this technical background it is true to say, that a technically appropriate and suitable arrangement of contrast, brightness, colour and shape helps partially sighted people find their way about in buildings and the technical environment. Improvements in these features also benefit all normally sighted people, not only by making them more aware of their surroundings, but also by reducing the number of danger points and the associated reduction of accidents.

Basic aspects of the Handbook

This Handbook considers the following aspects:

- In daylight and under equivalent lighting the eye develops its full capacity because the cones work, and as a result the macula enables maximum sharpness of visibility to be obtained.

- The power of the eyes is very much reduced in darkness because the macula which is the place of sharpest visibility is not working, and because the sharpness of vision on the periphery of the retina falls very quickly.

- The absence of colour vision in darkness means that in place of colour signals only their brightness can be detected.

- The ability of people to find their way about in dangerous places or critical points on the road or in situations which require a fast decision should be made easier by full and shadow free lighting, which gives a high sharpness of vision and colour recognition ▌ and by the choice of high contrast colours or materials.

☞ *Section 1.3*

- Not only partially sighted people, but all citizens require optically clear and easy to understand visual information, to enable them to take on the spot decisions, and to fully understand a complete situation (e.g. the way up a flight of stairs or the design of the area around a bus stop).

Since the macula is no longer able to give maximum resolution when it is dark, objects and signs must be perceptible in darkness by shape and dimensions.

Various requirements for visual information are laid down in this Handbook. The planners and experts thus have the possibility to plan and carry out designs appropriate to the situation. Requirements from architecture, environmental protection, listed buildings as well from Town and Traffic Planning can be given additional support by the recommendations from this Handbook. The technical implementation into the practical situation depends on the local and individual possibilities and conditions. By integrating these recommendations into the daily work a community can reap a big advantage in functionality and in the quality of life.

1.2 Definitions

1.2.1 Angle of vision

The size of the angle of vision (α) is of major importance for the recognition of properties, objects, signs or lettering. If the angle of vision is increased, in general, the visual perception of an object is improved.

The angle of vision is that angle, which the rays of light from the outermost boundary points of an object form at their point of intersection in the eye. The distance of the observer from any object and the magnitude of the objective (see Figure 4) need to be considered.

Eye Object size

Figure 4: Illustration of the angle of vision α

If the observer approaches the object he will have a larger angle of vision (see Figure 5).

Eye 1 Eye 2 Object size

Distance 2

Distance 1

Figure 5: Different angle of vision α_1 and α_2 after coming closer (from eye_1 to eye_2) for the same size of object.

Approximate formula to calculate the angle of vision:

$\alpha = arc.\tan(\underline{\quad\text{object size}\quad})$

distance from eye

It should be remembered that if the angle of vision is too great, partially sighted people with a restricted field of sight can only pick out sections of the object.

1.2.2 Sharpness of vision

The sharpness of vision S or the letter V for visus is a measure of the ability of a persons visual system to recognise small structures, e.g. the recognition of two points which are only a small distance apart. The sharpness of vision S = 1 is achieved, if two points, which have a distance apart of one angular minute (1 = 0.01667°) can be perceived as separate points. The sharpness of vision S is defined as the reciprocal of the angle of vision (in minutes of arc) of two points **I**:

Hentschel, (1994, S. 55)

$$S = \frac{1}{\alpha'}$$

A person consequently has a visus of about 1, if he can see two points which lie 1.5 mm apart at a distance of 5 m. In practice the visus is also measured by the identification of signs (e.g. letters). In order to get identical visus values in these tests the test signs are made bigger by a factor of 5 in comparison to the distance apart of the points measurement described above (thus 7.5 mm here). The degree of sharpness of vision is used for the overall determination of individual performance limits and cannot be used to determine requirements for contrast, brightness, colour and shape of objects

1.2.3 Contrast

A distinction is made between light density contrast and colour contract (for a demonstration of contrasts see figure 6).

Figure 6: Demonstration of different contrasts

If the object and background both have neutral colours or if the object and background have equal colour density there is no colour contrast. In this case only the level of the light density contrast has a decisive significance for the perception of objects and situations **I**.

Appendix 1

Contrasts serve to differentiate between visual objects. From this it follows that the recognisability of objects is very much reduced, if the contrast (light density or colour contrast) is small. On the other hand a high contrast to the background makes it much easier to differentiate important objects.

1.2.3.1 Light density contrast

Light density and colour contrasts serve to differentiate visual objects

The light density contrast is a measure of the difference in the brightness of an object compared with its background.

The following definitions for the light density contrast K are used in the investigations carried out in the project "Contrast optimisation":

$$K = \frac{L_0 - L_s}{L_o + L_s}$$

L_o = Light density of the object (see Figure 7)
L_s = Light density of the background (see Figure 7)

Background with light density L_s | **Arrow with light density L_o (object)**

Figure 7: Illustration for the definition of light density L_o (object) and light density L_s (background or surrounding area) Small arrows (➢) mark the limit of the contrast between two surfaces or fields

With this formula it is possible to obtain a value for the contrast between -1.0 and +1.0. The values -1.0 and +1.0 are the maximum values. If the object is brighter than the background or the surrounding area, the contrast value is positive. Negative contrast values mean that the background or the surrounding area are lighter than the object. If it is merely a question of the absolute level of the contrast, the value of the light contrast K is taken absolutely (in this handbook negative contrast values are basically given in absolute values):

$$|K| = \frac{|L_0 - L_s|}{|L_o + L_s|}$$

| | = Designation of an absolute value
L_o = Light density of the object
L_s = Light density of the background

Contrast values can, however, also be used as analogue percentage values. Thus, for example, from the value +0.51 the value 51% is obtained.

Signs and information carriers

Visual information needs to be carried on a sign board, which must be considered with the design of the lighting (see Figure 8).

Luminous surroundings = Background with light density L

Figure 8: *Illustration for the definition of the light density of an information sign in relation to the luminous surroundings (light density L).*

Small arrows (➢) show the boundary of the contrast between the information sign and the luminous surroundings.

Information boards with a light that shines on them

An information board and a sign on it can reflect daylight or the light from an artificial illumination (information boards and signs lit by lights directed at them), and thus the visual information can be made recognisable.

Internally lit information signs

Internally lit information signs ❚ which already have a light density contrast inside them must have sufficient contrast to stand out from the surrounding area.

☞ Section 1.3.2

1.2.3.2 Colour contrast

Besides the light density contrast, a colour contrast can give additional information for orientation in a neighbourhood.

A colour contrast is achieved by a different colour arrangement (independent of light density differences) of object and background. The colour contrast describes the distance of the colour location of the object from the colour location of the background. Colourblind people obtain visual information depending on the degree of their disability in the first place by means of the light density contrast.

1.3 Lit and internally lit information signs

1.3.1 Lit signs

The lights shall be so arranged that a good colour and contrast perception is achieved. In addition the street lights should be above the pavement and not above the carriageway; at least they should shine their light in the direction of the walkway❚.

🕮 *DIN 5044*

It should be possible to use the arrangement of lights (e.g. in a row along or above a path) as a means of helping people to find their way. The light from lighting equipment should be as close as possible to the composition of the spectrum colour for daylight, in order to ensure that contrasts achieved by different colours are still recognisable.

Avoidance of light in a narrow wavelength band

In the transitional areas between spaces with artificial lighting and spaces or areas on which sunlight can shine directly, the brightness should be gradually changed, in order to make it easier for the eye to suitably adjust. In this way, for example, a necessary darkness adaptation for finding ones way can be achieved in cases of extreme light-dark-transitions.

The photometric figures for the surroundings must be known if practical decisions are to be taken on the type, strength and arrangement of the lighting fittings. If this is not possible, at least the light strengths given in standards and codes of practice (measured in lux, abbreviated lx) should be reached. If possible, measurements of light density should be made ▌.

DIN 5032

Optimum lighting is available for partially sighted people if a uniform light strength-level exists and the mean light density is between L = 100 cd/m^2 and L = 500 cd/m^2, and ideally in the range between 250 cd/m^2 and 300 cd/m^2 ▌.

Report "Contrast optimisation" pages 308/9

If a lighting level in a staircase of only 10 cd/m^2, is to be provided, in general, a horizontal lighting level of 200 lx is necessary at floor level with a dark grey floor ("Research report Contrast optimisation" ▌).

Section 4

Provided white markings with a higher degree of reflection are used, a lighting strength of e.g. 50 lx is sufficient. The material used for this is a white line with a light density coefficient of 0.20 ▌

Table 4.2.1 Appendix 4.

1.3.2 Internally lit signs

Information signs can also emit light themselves (so called internally lit information signs) and in this way convey the visual information. They should be used where lighting similar to daylight cannot be used.

Automatic adjustment of brightness to avoid blinding

To avoid blinding, self illuminated signs should be used which automatically control their brightness. By this means the minimum contrast between sign and background can be achieved under different light conditions. Retroreflecting materials can replace self illuminating signs, if the contrast properties are not changed by a change of lighting.

Only use intermittent lights and glittering objects when there are special reasons

Intermittent light produced, for example, by flashing lights, can considerably affect the visual perception and should only be used in exceptional cases for the purpose of drawing attention to areas of special importance for information. This also applies to highly reflective (very glittering) objects I.

☞ Appendix 4

Computer controlled information systems

Computer controlled information systems should meet the recommendations of this handbook on the monitor or on the display. Some of these recommendations can only be achieved if the software of the computer controlled information systems has been suitably changed. So, for example, the required brightness differences on a screen can be preprogrammed by corresponding software commands, checked or achieved by instructions to the user. The same is true for colour contrast.

1.4 The basis for the recommendations

The results of the research project "Contrast optimisation" confirm that suitable high contrast markings help partially sighted people to find their way about. The use of high contrast markings can also lead to better recognisability. Aids to orientation should be used where the following conditions apply:

Examples in which orientation help is particularly important

- High safety requirements, especially for partially sighted people (e.g. road crossings and traffic islands for pedestrians, railway platforms, steps, building sites and other dangerous obstacles: Road and railway station furniture, cordoning off rails and protective bars, advertising hordings, masts of all types in traffic areas, which are accessible for pedestrians, especially on footpaths),

- restricted visibility of the road area or buildings accessible to the public (e.g. pedestrian areas, large town road intersections, mixed areas, large squares, large halls and building areas),

- Areas which partially sighted people need to use a lot or areas and equipment that is highly frequented by partially sighted people (e.g. Reha-equipment, teaching equipment, partially sighted schools, eye clinics),

- dedicated guiding requirements for the disabled from and to certain areas, equipment and objects (e.g. entrances, stopping places, stations, waiting rooms, booking halls, telephone cabins, WCs etc.), and

- where several of these conditions occur at the same time (thus, for example, almost all of the above-mentioned criteria apply on stations and interchange places of the local public transport system).

Colour combinations with small light density differences, such as the combination of white and yellow (light/light) and of blue with black (dark/dark) are difficult to recognise. The colour combinations, which are considered advantageous have one or more of the following properties:

Neutral colours: from black through grey to white

- large differences in the light density (black on white, black on green),
- neutral component (white on blue, white on lilac, white on red, green on black),
- combination of complementary colours (yellow on blue) and
- use of red only as a dark component (white on red, yellow on red).

Light signs on dark background should be made larger

These general specifications apply to signs with a large surface area. A background that is too dark by comparison with the foreground is perceived differently by some partially sighted people as far as the subjective sensitivity of colour combinations is concerned. Light letters on a dark background (e.g. light times on a large dark timetable background) are more difficult to read than the other way round ▮.

📖 *Ackermann et al (1995), Table 2, Page 56, 111; DIN 1450, Table 1*

This is due, among other things, to the resultant reduction of the light density in the surrounding field. It is recommended, for example, that white letters on black ground should be about 25% bigger than black letters on a white ground.

Colour combinations can reinforce contrast effects

The combination "red/green" is not recommended since about 8% of all men and 0.4% of all women are affected to varying extents by red/green blindness ▮.

☞ *Section 1.1*

Besides light-dark contrasts (e.g. white on black) colour contrasts offer additional help in orientation. Yellow and green are recommended as colours on a neutral background (black through grey to white). For colour-colour combinations light foreground colours (yellow, green) should be chosen on a dark background (lilac, blue, red, black). Colour combinations with red have a special significance, since red obviously indicates a danger signal. Thus, it should be remembered that red should only be used as the dark component since in this case the lighter sign can also be seen by people with red/green colour blindness.

A list of contrast reinforcing colour combinations is given in Table 1:

Foreground	Background	Contrast display
Yellow	Lilac	Light on dark
Yellow	Blue	Light on dark
Yellow	Green	Light on dark
Yellow	Red	Light on dark
Yellow	Neutral	Light on dark
Green	Lilac	Light on dark
Green	Blue	Light on dark
Green	Red	Light on dark
Green	Neutral	Light on dark
Red	Neutral	Light on dark
White	Lilac	Light on dark
White	Blue	Light on dark
White	Green	Light on dark
White	Red	Light on dark
White	Neutral	Light on dark
Blue	Green	Dark on light
Blue	Neutral	Dark on light
Black	Green	Dark on light
Black	Neutral	Dark on light

Table 1: Recommended colour combinations (selected list) Summarised from the investigations in the research report "Contrast optimisation" ▮

📖 *"Contract optimisation" (Page 210, Appendix C 3/2)*

The light density contrasts, which are used for markings in public areas should always be over the established threshold contrast for that particular situation (the minimum contrast which just enables an individual object to be recognised ▮). In this connection the intended minimum recognition distance, the size of the object and the magnitude of the angle of vision need to be considered ▮.

☞ *Appendix 2*

Normal sighted people apparently need a lower contrast design. A contrast of $K < 0.16$ is considered, small $0.16 \leq K < 0.64$ as medium and $K \geq 0.64$ as high ▮.

☞ *Section 1.2.1*

A higher contrast than the threshold contrast favours recognition. Thus the contrast considered as optimum by partially sighted people is much higher than the threshold contrasts of normal sighted people, and is generally at a value $K \geq 0.83$.

📖 *Lindner & Schmolke (1976)*

Table 2 shows for some colour combinations the contrast ranges which were considered optimal by over 80% of the partially sighted people.

Colour combination		Optimum contrast
Foreground	**Background**	**(see contrast definition in section 1.2.3.1)**
White	Neutral	≥ 0.91 to ≤ 0.99
Black	Neutral	≥ |0.97| to ≤ |0.99| *
Yellow	Neutral	≥ 0.89 to ≤ 0.99
Green	Neutral	≥ 0.88 to ≤ 0.98
Blue	Neutral	≥ |0.84| to ≤ |0.95| *
Yellow	Lilac	≥ 0.90
Yellow	Blue	≥ 0.87
White	Lilac	≥ 0.92
White	Blue	≥ 0.98
Green	Blue	≥ 0.91
Yellow	Red	≥ 0.83

☞ *Threshold contrast for dark on light see Appendix*

☞ *For definition of "Neutral" see page 28*

Table 2: Optimum contrast (selection) according to the opinions of 231 partially sighted people **I**
(Selection condition: Both higher physical contrast and very frequent preference by partially sighted people)

📖 *Report "Contrast optimising"*

Surface of materials affects the light density

The light density and the formation of contrasts depends, among other things, on the surface of the materials used. The light density is a function of the lighting strength and degree of reflection of the surface on which the lights shine. The reflecting colour of a surface is frequently called the reflected colour.

Degree of reflection

Large differences in the degree of reflection of the materials used give high contrasts between the materials.

Information signs also require sufficient contrast within the complete field of vision. They should stand out from the background with a lot of contrast.

A list with examples of materials and the appropriate degree of reflection is given in Appendix **I**. It is recommended that signs should be as large as possible with no unnecessary details.

☞ *Appendix 4 Table 4.1.1*

Sharp contrast and systematically consistent design

When specifying equipment and signs for walkways the same sharp contrast design and system used for helping people find their way about should be used consistently. Visual information and help in finding the way should be suitable for the surrounding architecture and fit in with the remaining design.

1.5 Lettering

DIN 1450 gives rules for the legibility of lettering (see Table 3) on which the requirements selected below for the design of lettering should be based.

DIN 1450

Effect	Requirement	Note
Line width of the character	(1/7) *h* to (1/8) *h*	
Distance apart of Characters	≈ (1/7) *h*	A suitable distance apart for each font is recommended (for example see DIN 1451, Part 2)
Method of writing	mixed (large - small)	
Distance between words	≥ (3/7) *h*	See also notes on distance apart of "characters"
Distance apart of lines	≈ (11/7) *h*	
Length of lines	up to 65 characters per line	

DIN 1451

Table 3: Requirements for lettering (Extract from Table 1 of DIN 1450 page 29) h = size of character

The sizes of lettering for important signs is recommended in Table 4. The size of lettering is calculated from the minimum angle of vision, e.g. 1° or 2°.

Section 1.2.1

Distance at which the lettering can still be recognised	Size of lettering at 1° to 2° angle of vision	Examples
30 m	52 cm to 104 cm	Instructions on underground stations
25 m	44 cm to 87 cm	Departure times
20 m	35 cm to 70 cm	Platform numbers
15 m	26 cm to 52 cm	Street signs
10 m	17 cm to 35 cm	Instruction at selling points
5 m	9 cm to 18 cm	Door signs
2 m	3.5 cm to 7 cm	Line maps
1 m	1.8 cm to 3.5 cm	Monitors/displays
30 cm	0.5 cm to 1 cm	Timetables
25 cm	0.4 cm to 0.9 cm	Timetable books, information brochures

☞ *Examples are given in section 5.2 Figure 57*

Table 4: Recommended size of lettering for visual information

Design of lettering

When designing information signs and lettering care should be taken to see that the display is clear and simple, so that the signs are quickly and clearly visible. The fonts to be used are the standard fonts (e.g. Futura, **Frutiger,** Helvetica, **VAG Roundscript**) sans serif (with no small strokes at the end). This statement is restricted to individual words or to small groups of words and does not necessarily apply to flowing text (e.g. text in books or magazines). ▌Using the sans serif Linear-Antiqua the design and application of an easily legible type of lettering is described in DIN 1451. The boldness of the lettering and the distance between the letters should be so chosen that shapes and intermediate spaces are clearly recognisable. Lettering that is too bold should be avoided just as lettering that is too thin.

📖 *DIN 1451*

Disadvantage of letters that are too large

In most cases the distance between the reader and the lettering can be reduced and in this way the angle of vision increased. Large letters can be a disadvantage for people with a restricted field of view ▌if the distance cannot be increased.

☞ *Section 1.2.1*

SUCCESSFUL PLANNING

which puts together
product, design and colours

The careful search for market products and services of connected trades that are matched together and harmonised, in order to find the model orientiering and way finding system has come to an end

We offer to architects, planners and building owners a unique packet of:

- sign systems for guidance and information,
- light-switch elements
- door fittings-, door closers - lock systems
- doors, individual interior - exterior for nursing homes
- organisation instruments, care/visiting trolleys
- wall, door, doorframes
- edge protection systems
- handrail systems also with acoustic elements
- wall painting

Here there are very big advantages in the use of complete or also a part package of optimum colour matches, continuation of surface structures or design elements, harmonising small series or special colours.

Those who belong to the "Guiding system planning group" will find help in the development of a model system for giving directions and information. Finally 20 - 35% of the people in our population who have mobility restrictions expect improved information, sharply contrasting handrails, straps and lettering, which in the end, benefit all citizens.

- Brightness, colour and shape are important components and make for good aesthetic appearance.

PCA
PRODUCT COLOUR ALLIANCE
Representative Roland Hagen
Alte Bahnhofstr 174 D-44892 Bochum
Tel. 0234-291140 Fax 02 34 - 291107

Pavements to guide blind people

Colour and surface textures of concrete paving stones can be varied in many different ways. As a result it is much easier for partially sighted people to find their way around. With robust texturing of concrete surfaces even blind people can get around safely.

We can advise you on all matters relating to the use of concrete

Federal Association of the German Cement Industry e.V.
Cement Advisory Service
Pferdmengesstraße 7
50968 Cologne

1.6 Basic system for information

1.6.1 The principle of the closed information loop

Transport chain = Journey

In general, people with limited mobility need easy access to roads and means of transport. If roads and means of transport are all easy to reach then a complete journey is produced for the users. A complete journey should be accompanied by an associated information chain.

One of the most important jobs of the planning of information is to ensure that the information system is designed to the same standard. An example will be given of a system of information introduced for public commuter traffic to explain the principle **I**: In this handbook that part of the information chain is considered which lies between leaving the house and reaching the destination (see Figures 9 and 10).

📖 *European Commission 1995 page 19 and pages 32-34*

The unity of an information chain is guaranteed

Requirements

- by the consistency of the destination data
- by the consistency of the explanations
- by the confirmation of the intermediate destination
- by the confirmation of destinations
- by continuous adherence to the principles of arrangement in space
- by continuous adherence to the design principles within a closed information loop and
- by using identical pictogrammes and identical abbreviations.

Figure 9: *A closed information loop accompanies a complete journey transport chain (example) Translation from English* 📖 *European Commission 1995 page 33*

23 Start (e.g. at home)

24 Footpath

25 Bus stop

26 Vehicle e.g. low floor bus

27 Change

28 Journey

29 Destination

30 Information chain

31 Necessary information

32 e.g. on departure times, distance to bus stop

33 e.g. on help available on the way to the bus stop

34 e.g. on waiting time

35 e.g. on duration of the bus journey

36 e.g. on leaving the bus stop area

37 e.g. on the way to the destination

Figure 10: *Information elements of a unified information chain using public passenger transport as an example* ▌

📖 *Ackermann et al 1995, Figure 6 Page 19*

38 Information and orientation requirements

39 Before the journey

40 When setting out

41 During the journey

42 When changing

43 At the alighting stop

44
- Route
- Distance to boarding stop
- Departure time, duration of journey
- Ticket price
- Distance from the alighting stop to destination
- Accessibility of the stop and the vehicles for wheelchair users

45
- Finding the boarding bus stop
- Recognition of the bus stop
- Departure times, duration of journey
- Ticket price
- Purchase of the ticket
- Recognition of the correct line and direction
- Information on irregularities
- Entry and door operation on the vehicle

46
- If necessary purchase and cancelling of the ticket
- Seats and areas for certain groups of users
- Recognition of the alighting bus stop
- Changing and connection information
- Door operation
- Information on irregularities

47
- Finding the departure platform
- Recognising the correct route and direction
- Departure times, duration of journey
- Information on irregularities
- Entry and door operation on the vehicle

48
- Distance from destination
- Exit

In a closed transport system care should also be taken that once contrast values, brightness criteria, colour combinations and shapes or shape patterns have been chosen they should then be used generally throughout the system.

Avoid disturbing the information chain

The principle of the closed information chain should not be disturbed by overlapping systems or by the optical effects of advertising and other irrelevant information due to competitive brightness, competitive contrast, competitive shapes or because of competing colour combinations.

Visual contrasts should, if necessary, be accompanied by acoustic and tactile contrast. Acoustic contrasts can be produced on light signal equipment e.g. by acoustic clock units. ▌ The requirement of a release signal on the colour lights can be supplemented on the operating device by tactile means (e.g. by vibration) (Ackermann et al, 1992, page 122).

📖 *Ackermann et al (1992) page 122, page 91 et seq*

▌ Likewise announcements should stand out e.g. in buses above the surrounding acoustic noise (see Research Company for Roads and Traffic matters, 1992). In the footpath area, ground indicators (e.g. guide strips, attention fields) can, because of their roughness contrast give tactile information ▌ (see Ackermann et al 1992, page 91 et seq).

📖 *Research Company for Roads and Traffic matters (1992)*

1.6.2 Classification depending on priority

The importance of information can be classified by its arrangement and its design into priorities. A classification depending on importance enables the variability of this recommendation to be used depending on the objective. The consequent formation of priorities enables the arrangement and systematising of visual information, for not every piece of visual information must be allocated the highest grade of brightness, light density contrast, colour contrast and angle of vision. The object of the priority scale is to bring about a suitable design of colour contrasts for each individual objective.

Classification criteria

Priority 1 is given to signs that **warn** of danger and instructions for **emergencies**,
Priority 2 is given to signs connected with **decision functions** and
Priority 3 is given to signs which undertake the **guiding function**.

In any given priority class once an arrangement and design has been introduced it should be consistently used.

Table 5: Classification of information according to priority

Examples for classification criteria

Priority 1 consists, for example, of indications of abrupt and unexpected crossings between footpath and carriageway, between the bus stop waiting area and the roadway, between a walkway and a building site, with barrier type obstacles (where there is a risk of stumbling or similar danger) or at the entrance to stairways. To the highest priority belong signs indicating emergency access routes and of emergency equipment.

Priority 2 consists of timetables, signs with street names, lines and destination names on public and private transport systems, as well as direction and information tables.

Priority 3 consists of continuous guide strips to mark routes or repeat information, when there is sufficient time to recognise them or information alternatives are available.

(Illustration)

1.7 Recommendations for the use of contrast, brightness, colour and shape in practice

The recommendations on contrast, brightness, colour and shape are subordinate to the recommendations for prioritising of information (see tables 6 to 9). Colour combinations that have been successfully used in practice are given preference here.

Priority	Colour combinations (see Tables 1 and 2) Light on dark (for exceptions see below)	Examples from previous practice
Priority 1: Warnings, emergency e.g. indications of abrupt and unexpected crossings between footpath and roadway, between bus stop waiting area and roadway between footpath and building site, with barrier type obstacles or the start of a staircase	Blue on green (dark on light) Yellow on lilac Yellow on blue Yellow on red Yellow on black Green on lilac Green on blue Green on red Black on white White on red White on lilac White on neutral*	Warning beacons
Priority 2: Deciding functions e.g. timetables, signs with street names, line and destination indications on public and private transport facilities, as well as direction and information boards	Yellow on green Black on neutral (dark on light) White on blue White on green	Timetables German motorway signs European road signs
Priority 3: Guiding functions e.g. continuous guide strips to mark the routes or repeat information, for which sufficient time is available for recognition or information alternatives are available	Blue on neutral (dark on light) Yellow on grey Green on neutral Red on neutral Black on green (dark on light) White on neutral*	Diversion markings Lay-by markings Cycle tracks Road markings

Further examples are given in chapters 2 to 6

For definition of "neutral" see page 28

*Table 6: Proposals for the classification of colours for the three priorities (examples). The recommended colour combinations are based on the general recommendations given in section 1.4 based on the research project "Contrast optimising" *Contrast in priority 1 should be set higher*

☞ Section 1.4

The colour red should have enough difference of brightness compared with the surroundings, so that sufficient contrast is obtained, in particular, in combination with a neutral component. Signs which have bright red or magenta on grey that are found in practice are generally not suitable.

Priority	Value for light density (for explanations see text)	Examples
Priority 1: Warnings, emergencies	**300 cd/m^2 up to 500 cd/m^2* on the surfaces of signs and markings e.g. located in spaces with bright lighting (light flashes in the outer area for emergencies are considerably above 500 cd/m^2)**	**Blocking off building sites, signs for emergency exits**
Priority 2: Decision functions	**30 cd/m^2 to 299 cd/m^2 on the surface of signs and markings e.g. found in the area of weak room lighting up to the lightness of areas in front of well lit shop windows**	**Internally lit traffic signs**
Priority 3: Guiding functions	**3 cd/m^2 up to 29 cd/m^2 on the surface of signs and markings e.g. located in areas with weak street lighting**	**Markings (see also Table 6)**

*** This relatively high value (see section 1.3.1) helps to make signs more conspicuous**

Table 7: Classification of light densities on the surface of signs and markings for the three priority groups

Proposal for internal spaces and for areas with artificial lighting

A grading of light densities assists designers in meeting minimum values which, in general, helps to make visual information more conspicuousness and consequently hold the attention. Light densities below about 100 cd/m^2 can make the perception of contrasts more difficult because of the lack of adaptation of the eye. In daylight, in the open air the values in Table 7 are almost always exceeded, so that differences in priorities can be achieved just by changing the colour as well as by grading the angle of vision and contrasts. The subjective contrast effect is not only determined by the light density on the surface

of signs and markings, but also by the background lighting density of the surroundings. Optimum illumination ▮ is available for partially sighted, if a uniform illumination level exists and the average light density lies between 100-500 cd/m^2.

📖 *Report "Contrast optimisation" page 507*

Priority	**Value for contrasts** (for explanation see text)	**Examples**
Priority 1: Warnings and emergencies	**0.83 <K ≤ 0.99** **Reason:** **Estimation of the optimum contrast**	**- K= 0.99 for markings on places where people are likely to fall, achievable by retroreflecting materials or internally lit information signs** **- K = 0.95 for light lines on unexpected stairs, achievable by coating and colours that stand out on dark stairs ("Contrast optimisation" page 373)**
Priority 2: Decision functions	**0.50 < K ≤ 0.83** **Reason:** **K > 0.50 is necessary for the decision function "lettering" and" pictogrammes" ("Contrast optimisation" page 509)**	**- |K| > 0.50 for lettering and pictogrammes ("Contrast optimisation" page 509)** **- K| = 0.51 for light materials on dark background** **- K = 0.56 for light small paving stones on dark background ("Contract optimisation" page 376)**
Priority 3: Guide functions	**0.28 < K ≤ 0.50** **Reason:** **The minimum necessary contrast is K = 0.28;** **K > 0.50 is already necessary for decision functions.**	**- K > 0.28 for a light strip on dark background, 30 cm wide ("Contrast Optimisation" page 508)** **- K> 0.30 for light obstacles on dark background ("Contrast optimisation" page 509)** **- K > 0.30 for light lines as additional step marking ("Contrast Optimisation" page 507) and for light hand rails ("Contrast optimisation" page 508); see also priorities 1 and 2** **- |K| > 0.40 for dark obstacles on light background ("Contrast optimisation" page 509)** **- |K| > 0.40 for dark lines as**

stair markings ("Contrast optimisation" page 507) and for dark handrails

("Contrast

optimisation" page 508)
- **K > 0.43 is recommended, if supporting information or decision aids are lacking ("Contrast optimisation", page 366 and page 376)**

Table 8: Classification of contrasts into the three priorities on the basis of a pragmatic subdivision

The graduations of contrast given in Table 8 depending on the significance of the information involved make it possible to comply with different economic and architectural requirements. Although contrasts are independent of the light density from a physical point of view, it is advantageous to have a sufficient, that is to say an average light density (about 100 cd/m^2) since with a lower light density the eye does not pick up physical contrasts sufficiently from the physiological point of view ▮.

☞ Appendix 2

The angle of vision can likewise be classified pragmatically for the three priorities. The angles of vision given in table 9 are minimum figures. It appears sensible, however, not to exceed the figure of 2 degrees in practice. The reason for this lies in the fact that increasing the size of the lettering or figures gives hardly any improvement in perception, since because of the large area of the sign, people with a field of sight restriction may have difficulty reading it.

Priority	Values for the angle of vision (For explanation see text)	Examples
Priority 1: Warnings, emergencies	2° (degrees) for graphical symbols and lettering	Emergency exit Escape route Danger of tripping
Priority 2: Decision functions	1.5° (degrees) for graphical symbols 1° (degree) for lettering	Timetables Street names House numbers
Priority 3: Guide functions	1° (degrees) for graphical symbols 0.8° (degrees) for lettering	Continuous marking on paths and on walls

☞ Section 1.5 Table 4

Table 9: Classification of minimum angles of vision for the three priorities pragmatic arrangement on the basis of the ▮ report "Contrast optimisation"

🕮 Report "Contract optimisation" page 490 et seq

Relations between the size of objects and sizes of the related angle of vision depending on the distances chosen from eye to object can be seen in Figures 11 to 13.

Figure 11: *Graphs showing the size of objects for a given minimum angle of vision plotted against the distance eye to object*

49 For distances of between 5 cm and 50 cm and for object sizes up to 2.5 cm

50 Object size to be seen

51 With given minimum angle of vision α of 1.0°, 1.5°, 2.0° and 2.5°

52 Distance from eye to object

53 Read off example:
If a person needs an angle of vision of 1°, in order to be able to recognise an object then this object must have a size of 0.52 cm if it is 30 cm away.

Figure 12: Graphs showing the size of objects for a given minimum angle of vision plotted against the distance eye to object

54 For distances between 0.5 m and 5 m and for object sizes up to 25 cm

55 Read off example:
If a person needs an angle of vision of 2.0°, in order to be able to recognise an object, then this object must have a size of 15.7 cm if it is 4.5 m away.

Figure 13: Graphs showing the size of objects for a given minimum angle of vision plotted against the distance eye to object

56 For distances between 5 m and 50 m for object sizes up to 2.5 m

57 Read off example:
If a person needs an angle of vision of 1.5°, in order to be able to recognise an object, then this object must have a size of 1.05 m if it is 40 m away.

The investigations in the research project "Contrast optimisation" aim at testing the best possible conditions for critical situations and specifying them for practical planning. Thus the recommendations derived from these apply generally for the requirements of priority 1.

The classifications given in Tables 6 to 9 put forward a system for the preparation of visual information.

Requirements shall be met simultaneously

The requirements in the individual priorities are met if the respective components recommended (colour combinations, light densities, contrasts and angle of vision) are met simultaneously.

Variants

The following variants are possible within the priority system:

- The same colour combinations can be achieved with different contrasts, e.g. white on red with highest contrast difference for warning signs and with lower contrast difference for decision assistance and guiding functions.
- Reducing the angle of vision at maximum light density. However, only the requirements of the lower priority groups would be fulfilled by this method.

Variants of this type reduce the priority level so that in the two lower priority levels, the planner can find plenty of colour combinations.

Merely upgrading individual values does not increase the priority level

An increase of the priority level by merely upgrading some values slightly (colour combinations, light densities, contrasts or angles of vision) is on the other hand not possible. To improve the conspicuousness and to make some partial elements clearer, it is however sensible to use the features of higher priority levels.

Information on monitors and displays (e.g. with departure times or as individual reading help) in general belong to priorities 2 or 3. The recommendations formulated in this section apply correspondingly.

Technical advice

Technical advice on the design for brightness, contrast, colour and shape: The research company ASSe.V. (see page 8) can make the necessary lighting value measurements and give suitable advice.

2 Design suggestions for visual information in pedestrian areas and at the road side

2.1 General comments

From the results and recommendations given in Chapter 1, suggestions are given for the design of visual information in pedestrian areas and at the road side.

The limits of contrasting surfaces, which must give a sufficient threshold contrast to one another are marked with arrows (➢). The values for contrasts, for light densities and the recommendations for colour combinations are given in ▮ Chapter 1.

☞ *Chapter 1*

2.1.1 Optical guide strips

Large areas need salient features

Guide strips on the surface of walkways or on floors can help visual orientation.

Partially sighted people often have problems finding their way around large areas that have few salient features. Guide strips can provide help. At the same time these can provide tactile information. The wider a guide strip is, the more conspicuous it is.

The same contrast is easier to recognise with a wider strip than with a narrower strip. Since a guide strip turns into an area if it is extremely wide, the recognisability can fall again. Because of the limited field of sight of partially sighted people ▮ a maximum width should be recommended.

☞ *Appendix 3*

Requirements:

- Minimum width 10 cm with ▮ contrast K > 0.35 consisting of light strips on dark background,

  with a contrast |K| > 0.50 with dark strips on light background.

  ☞ *Contrasts: Section 1.2.3*

  Maximum width 30 cm with a contrast K > 0.28 for light strips on dark background, with a contrast |K| > 0.35 for dark strips on light background ▮.

  🕮 *"Contrast optimisation" page 508*

- For the coloured design the same applies as for the lines in the staircase area: For light strips on dark background white or yellow are recommended, for the reverse case black is recommended as the strip colour. Further colour recommendations are given in ▮ section 1.7.

  ☞ *Section 1.7*

If guide strips with a tactile function are used for partially sighted people then they should meet the following specification: A width of 30 cm, since otherwise they would be missed ▮. It is sufficient if the optical guide strips form part of the tactile guide strip.

🕮 *Ackermann et al (1992 page 92 et seq)*

The requirements for the design of guide strips will depend on the particular situation. In areas in which there is a big need for guiding (junctions, pedestrian crossings, large squares etc.) and the guide strips make a big contribution to safety, a strip which is close to the maximum width is recommended. In large pedestrian areas the requirements can be reduced.

2.1.2 Obstacles

The marking of obstacles such as poles, posts etc. is best done by making the complete object light in front of its dark background. For large obstacles, e.g. traffic light masts it is sensible to mark parts of them (striped, sleeve like). The foot of the pole should also be marked like a sleeve, so that partially sighted people are better able to judge the distance to the object (see Figure 14). This marking should, if possible, be light compared with the surroundings and should have a contrast of $K > 0.83$ and an area of at least 150 cm^2 (minimum height or width 8 cm) and for dark markings corresponding to a larger surface area of 250 cm^2 (minimum height or width 8 cm) or a greater contrast of $|K| > 0.4$.

Proposal for the visual emphasis of poles and masts

The foot can also be marked by a ring on the ground around the mast of light material in front of a dark background or in the contrast to a dark mast. At the same time a divided marking should be provided at a height of about 1.30 m (chest height). A divided marking is also suitable for objects which are smaller, but do not have sufficient contrast against the background so that it is sensible to produce the contrast necessary for recognition on the object itself.

With a light (white or yellow) marking on the base or at chest height the area between these markings should, if possible, be given with a surface with low light density coefficients (for definition see Appendix 4.2) ▮.

☞ *Appendix 4.2*

With regard to the colouring the same requirements apply as for guide strips and for steps.

Beside the examples given above these recommendations should also be applied, for example, to wastepaper baskets, letter boxes, vending machines, telephone boxes, fountains, sculptures, flower beds, play and sports equipment, business displays, bicycle stands.

2.2 Basic models

📖 *On the subject of acoustic and tactile support of signal equipment see Ackermann et al (1992) Section 6.5*

An arrow ➢ indicates the limits between two contrasting surfaces:

Request knob

Marking of the base by a circle of natural coloured stones (example)

Figure 14: *Visual design of a signal operating mast with push button for pedestrians. The visual information of the traffic light including that of the mast should be supported by acoustic signals as specified by RiLSA (release signal, orientation signal). Tactile information makes the operation of the equipment easier, especially at complex junctions (see also Ackermann et al, 1992, page 101 et seq).*

📖 *Ackermann et al 1992, page 101 et seq*

58 Road

59 Curb

60 Signal mast

61 Walking direction

62 Pavement

63 Edge of pavement

63a Indicating strip

📖 *Figure 31 in Ackermann et al (1992, page 96)*

Figure 15: *Marking of an indicating strip at a pedestrian crossing.*

Boundary strips and protection strips should contain tactile information in addition to visual information

64 Protection strip

65 Single lane cycle track

66 0.50 to 0.60 m boundary strip

67 0.25 to 0.30 m wide margin

📖 *Figure 6 in Ackermann et al (1992, page 31)*

Figure 16: *Example for the demarcation of cycle track and pavement*

In practice the bright red on grey boundary marking between cycle track and pavement has not been successful for partially sighted people (see also Table 6 in Chapter 1.7).

68 Boundary strips

69 Safety distance

70 Minimum width that can be used

71 Margin strip

72 Building

73 Light

74 Lay-by

75 Bench

Figure 17: Examples for the design of a pavement

📖 *Figure 4 in Ackermann et al (1992 page2?)*

📖 *Figure 7 in Ackermann et al (1992, page 38)*

76 Protection strip, that can be detected by touch (e.g. small paving stones)

77 Boundary strips

Figure 18: Example for junction with connection to a mixed surface (Part 1).

Explanation: The junction is shown in two illustrations Figures 18 and 19 so that it can be better understood. The relevant areas are emphasised by making them stand out optically. Consequently the proposals from the two figures need to be implemented together.

📖
Illustration Ackermann et al (1992, page

78 Indication strip

Figure 19: Example for junction with connection of a mixed surface (Part 2) (see also Figure 18).

regarding Figures 18 and 19:

- Guide strips, which form the surface on which traffic runs should be protected by measures that meet the law (e.g. traffic lights or other system that gives pedestrians priority).

- Lowered kerbstones have a height of 3 cm (Ackermann et al, 1992, page 20 et seq)

📖
Figure 8 in Ackermann et al (1992, page 39)

79 Protection strip

80 Kerb height

81 Extension

Figure 20: *Example of a crossing place at a road junction (Part 1)*
The waiting area for pedestrians on the central reservation should be carefully planned and built so that its size and visual appearance make a big contribution to safety and to orientation of partially sighted people.

Explanation: The crossing place is shown in two Figures 20 and 21 to make it clearer. The relevant areas are emphasised by making them stand out optically. Consequently the proposals from the two figures need to be implemented together.

📖
Illustration Ackermann et al (1992 page 30 et seq).

Figure 21: Example of a pedestrian crossing at a road junction (Part 2) (see also Figure 20)

regarding figure 20 and 21:

- lowered curbstones have a height of 3cm (Ackermann et al, 1992 page 30 et seq)
- there are specific recommendations for planning and designing indicator strips (Ackermann et al, 1992 page 39 et seq and page 91 et seq)

82 Kerb height 0.03 m

Figure 22: Marking of a lowered kerbstone

Partially sighted people often cannot detect surface obstacles, thus lowered kerbstones and other surface obstacles should be marked.

83 Building site wall

84 Double handrail

85 Touch strip

86 Hole

Figure 23: Example of a barrier round a building site or workplace

📖 *RSA-Commentary of Schönborn & Schulte (1995)*

If necessary a double handrail at the heights of 0.60 m and 0.90 m should be fitted to the wall ■.

📖 *Ackermann et al 1992 page 68 et seq.*

2.3 Examples

87 Poles

88 Bicycle stands

89 Pedestrian area

90 Display

91 Guide strip (width 0.10 to 0.30 m)

92 Door Entrance area

93 Attention field

94 Information board

95 Indication strip (width 0.50 to 0.60 m)

96 Building site

97 Cycle track

☞ *For details see following illustrations No. 25 to 33*

Figure 24: Example of a pedestrial area with adjacent street (outline)

There are specific recommendations for the planning and building indicating and guide strips ▮.

📖 *Ackermann et al 1992, page 91 et seq*

98 Contrast shown here K = 0.51

99 Contrast shown here K = 0.80

100 Doctor

101 Buses Suburban railway

102 Entrance

103 Buses

104 Light density: 30 to 299 cd/m^2 under artificial lighting
Contrast: $0.50 < K \leq 0.83$

Figure 25: Example of an information board as shown in Figure 24
Priority 2, see Section 1.7

105 Information board

106 Wheelchair users can pass underneath

107 Attention field

108 Guide strips

109 0.30 to 0.50 m

110 Light density: 300 to 500 cd/m² with artificial lighting
Contrast: $0.83 < K \leq 0.99$

📖 *Ackermann et al, 1992 page 84 DIN 18024 Part 1*

☞ *For further details see Section 2.1*

Figure 26: Example of the poles for the information board as shown in Figure 24
Priority 1, see Section 1.7

111 Light grooved plate

112 Dark small paving stone

113 Accompanying strips (e.g. light natural paving stones) specially suitable for indicator strips in the area close to the road

bright bright

114 Light surroundings

115 Version 1 shown here contrast K = 0.31

116 Version 2 shown here contrast K = 0.48

117 Version 3 shown here contrast K = 0.28

118 Light density: 3 to 29 cd/m^2 with artificial lighting
Contrast: $0.28 < K \leq 0.50$

Figure 27: Example for the visual design of a guide strip as shown in Figure 24
Priority 3, see Section 1.7

📖 *Ackermann et al, 1992, page 87 et seq*

☞ *For width of the accompanying strips see markings in Section 2.1.2*

119 Transparent sliding door right

120 Safety markings

121 Light density: 300 to 500 cd/m^2 with artificial light
Contrast: $0.83 < K \leq 0.99$

122 Design variants for safety marking

123 Several strips

124 Points

125 Squares

📖 *DIN 18024 Part 2*

Figure 28: Example of an entrance area (version 1) as shown in Figure 24, Priority 1, see Section 1.7.

Only the left part of the sliding door was drawn, to make the illustration clearer. The colour combination can be chosen from Table 6 ▮.

☞ *Section 1.7 Table 6*

126 Size of the figures:
17 cm high
(reading distance ≤ 10 m)

127 Size of the graphical symbol:
26 cm high
(reading distance ≤ 10 m)

128 Shown here contrast K = 0.51

129 Size of the lettering: 17 cm high
(reading distance ≤ 10 m)

130 Shown here contrast K = 0.51

131 House number

132 Table

133 Size of lettering 1.8 cm high
(reading distance ≤ 1.0 m)

DIN 18024, Part 2

134 Light

135 Speak

136 Light density: 30 to 299 cd/m^2 with artificial lighting
Contrast: $0.50 < K \leq 0.83$

137 Company

Figure 29: Example of an entrance area (version 2) as shown in Figure 24
Priority 2, see Section 1.7

138 Warning lights

139 Handrail (continues in the direction of walking)

140 Transverse bar (continues in the direction of walking)

141 Contrast:

142 Light density: 300 to 500 cd/m^2 with artificial lighting

📖 *RSA commentary from Schönborn Schulte (199?)*

Figure 30: Example for the marking of the barrier wall of a work site in Figure 24

Priority 1, see Section 1.7

The colour of the transverse bars (green here in the example) should be chosen depending on the surroundings and on the actual importance of their function.

☞ *Section 1 Table 6*

143 Bicycle stand (side view)

144 Transverse bar

145 Surface of walkway

146 0.30 to 0.50 m

147 Light density: 300 to 500 cd/m^2 with artificial light

Figure 31: *Example for the marking of a bicycle stand as shown in Figure 24*
Priority 1, see Section 1.7

The colour of the transverse bar (green here in the example) should be chosen depending on the surroundings on the actual importance of its function ▮.

☞
Section 1.7, Table 6

148 (Mobile) business window display

149 (Mobile) transverse barrier in the main walking direction

Figure 32: Example for the marking of a business window display in the footpath area as shown in Figure 24
Priority 1, see Section 1.7

150 Alternative: Marking of a base point by a circle of natural paving stones (see from above)

Ackermann et al (1992, page 76 et seq)

151 Pole

152 Width

153 Attention field

Figure 33: Example of the marking of a pole in the pavement area as shown in Figure 24
Priority 1, see Section 1.7

3 Design suggestions for visual information on vehicles and on the premises of Public Passenger Transport (ÖPNV)

3.1 General information

Suggestions for the design of visual information on vehicles and premises of public passenger transport undertakings based on the results and recommendations from Chapter 1 are given below. Typical simplified basic models are contained in Section 3.2. Complex examples for use in practice are given in the following section, Section 3.3. The boundaries of contrasting surfaces, which must have a sufficient contrast threshold are marked with arrows (⮞). The values for contrasts, for light densities, for shapes and the recommendations for colour combinations are given in Chapter 1 referred to above.

Visual information and help in orientation are essential for the preparation and making of a journey. This comprises information on the journey time (departure time, journey time, connection times) on the route (system, route, composition of the route) on the tariff and special information on the current public transport services (closure, changes, increases services, etc.,). Information boards, signs and system diagrams make it easier to find the stop and the platform.

Visual information and orientation systems must fulfil a number of design criteria, in order that they can be understood by partially sighted people and older people with restricted eyesight. An important design feature is the size of the lettering. It should be chosen as large as possible depending on the distance away of the reader, and care should be taken to make the lettering sufficiently bold ▮.

☞ *Section 1.5*

It is recommended that the size of the lettering should be optimised depending on the number of journeys or stops on each timetable, bearing in mind the minimum size of lettering. If it is not possible to get close up to the timetable notice (e.g. because there is a panel of glass in front of it) correspondingly bigger minimum lettering sizes shall be used. The choice of different lettering sizes and the use of horizontal and vertical lines to guide the eye often make information sheets clearer and easier to read. Also symbols, pictogrammes and arrows are useful to make notices easier to understand: Mixed styles (that is to say the use of large and small letters) and fonts without serifs (that is to say letters without strokes at the ends) also make the document easier to read ▮.

☞ *Section 1.5*

In addition different contrasts - e.g. departure times in the timetable in black on white - make it easier to find the information required.

In notice boards information headings can be emphasised by light characters on a dark background. However it should be noted that - to achieve the same legibility - white characters on a black background should be about 25% larger than black characters on a white background I. Black lettering on a white ground has been found to work well.

☞ *Section 1.4*

A medium eye height of about 1.30 m enables both disabled and non disabled people to read the information. With a sufficient size of lettering reading from further away by wheelchair users and dwarfs is not a problem.

All visual information and orientation aids should be sufficiently well lit. Since partially sighted people are often sensitive to being dazzled, the reflection from notice boards and indicators can be reduced by using anti reflection glass.

In addition to visual information, if possible audio and tactile information, should be offered especially to partially sighted people:

- At colour light signals on the path to the bus stop additional equipment - such as orientation signals and the release signal for finding the transmitter mast for the colour light signal and to recognise the green period - when it is safe to cross the street.

- At bus stops where there is a lot of boarding and alighting it is useful to reinforce visual information such as, for example, boarding signs with acoustic information.

- Where there are irregularities in the service (late running) announcements are desirable.

- In vehicles, details of the stops, the interchange possibilities and, if necessary, the hold ups in the service can be given to passengers.

Verbal announcements should be preceded by a signal tone and should be repeated at least once. They must be clear and understandable. Tactile orientation help for blind and partially sighted people, such as ground coverings (grooved plates) in some cases with acoustic or visual support, have proved successful in certain areas of the transport systems - e.g. bus stops, stations and crossing places. In addition, guide strips, indicator strips and attention fields can also be used. So, for example, the boarding edge along the bus stop can be marked by a guide strip that runs parallel to it. In addition it is possible to mark the entry area with an

attention field for people who have restricted mobility. Maps in relief which give an overview of the respective bus stop are a further aid for the orientation of blind people.

In general, implementation of these measures helps not only the old and disabled passengers but all the others as well.

3.2 Basic models

Illustration Ackermann (1992, page 59)

154 Attention field
Guide strip 0.10 to 0.30 m wide
Boundary strips
Indicator strips
Lowered curbstone, step 0.03 m

Figure 34: Example for the visual design of a bus stop (Part 1)

Explanation: The bus stop area is shown for clarity in the two figures 34 and 35: Attention is drawn to the relevant areas. Consequently the proposals from both illustrations should be introduced together.

📖
Figure 18 in Ackermann et al (1992, page 59)

155 Attention field
Seat
Information
Parts of the bus shelter
(e.g. posts, glass panes etc.)

Figure 35: Example of the visual design of a bus stop (Part 2)

Regarding Figure 34 and 35:

- Variant: Self coloured shaped stones to show boundaries of bus stop waiting area and bus driving area ▮.

📖
Low floor transport system 1992, Chapter 4.2 and Figure 20, Chapter 6

Advert

That our products go all over the world is nothing new. We began exporting about 130 years ago. First sewing machines and bicycles, then cars. In 1939, as can be seen in the picture, the first "Opel Kapitän" was loaded onto a ship. When we send Opel models, engines or spare parts on long journeys today there is a new dimension: Opel is developing more and more to serve a world model. The models designed in Opel's Technical Development Centre at Rüsselsheim are now built in 18 countries. From Brazil to Taiwan, from Finland to South Africa, and further factories will quickly be built. But not only the know-how for technology and manufacture comes from Germany, but also several components - direct from our factories in Rüsselsheim, Bochum and Kaiserslautern. In this way the globalisation of Opel also strengthens our home base. And that is good for Germany.

156 Bus/train

157 Attention field

158 Indicator strip

159 Bus stop mast

160 Direction of walking

161 Pavement

162 Edge of pavement

📖 *Illustration Ackermann (1992 page 27)*

Figure 36: Marking of an indicator strip and an attention field on a station or bus stop waiting area. For the building design of bus stops see Ackermann et al (1992) ▮.

📖 *Ackermann (1992, Section 3.5.5.1, page 58)*

163 Version

Figure 37: High contrast design of above ground building equipment in public passenger transport (example)

The best way to obtain contrasts is to use dark foreground colours on a light background. However, when the light conditions are unfavourable light foreground colours on a dark background give better conditions for partially sighted people.

The markings of the base points can, in addition, be done as shown in Figures 14 and 33.

3.3 Examples

164 Bus shelter with information

165 Door

166 Escalator

167 Stairs

168 Approach area

169 Lift

170 Covered area for underground railway entrance

171 Information board

172 Exit

173 Station building

☞ *For details see the following Figures No. 39 to 42, No. 49 and No. 50 in Section 4.3 and No. 69 in Section 6.3*

Figure 38: Example of a bus stop or underground station for public passenger transport (overview)

Ideas and other hints on the design or conversion of new stops for public passenger transport are given in volume 46 **I**, volume 47 **I** of the series "direct" of the Federal Ministry of Transport (BMV) and the handbook for the design of stops for public passenger transport of the BMV (in preparation).

🕮 *Low floor transport system (1992)*

🕮 *Ackermann et al (1992)*

174 Tram stop

175 Direction

176 Monday to Friday

177 Hour

178 Minutes

179 to

180 Saturday

181 Journey time in minutes

182 Valid from 25.05.1997

183 Light density 30 to 299 cd/m^2 with artificial light
Contrast: $0.50 < K \leq 0.83$

📖 *Ackermann et al (1992)*

Figure 39: Example for a timetable
Priority 2, see Section 1.7
Reader approx 30 cm away from departure times

184 Size of the lettering for 1° angle of vision distance away of reader

185 Displayed over bus stop (overhead)

186 Connection U4 in 5 minutes

Figure 40: Example of a dynamic indicator at a bus stop. Priority 2, see Section 1.7

The details of the minutes as variable characters are emphasised in this example by increasing the contrast, by increasing the saturation (the shade value) of the surrounding colour to the Figure.

Figure 41: Example of a U-Bahn (underground railway) sign
Priority 2, see Section 1.7

187 Border as contrast element (3 to 8 cm wide)

188 a) Destination indicator at the front

189 Border of sign as contrast element (1 to 4 cm wide)

190 Door border as contrast element (3 to 8 cm wide)

191 b) Destination indicator on the side

Figure 42: Example for the destination indicators of buses
Priority 2, see Section 1.7

☞ *Section 1.3.1*

4 Design proposals for the visual marking of facilities to overcome the difference in height

4.1 General instructions

Of the results and recommendations contained in Chapter 1, proposals are given below for the arrangement of visual information on facilities to overcome height differences. Typical simplified basic models are shown in Section 4.2. Complex design examples are shown in Section 4.3.

The limits of contrasing areas, which must have sufficient threshold contrast, are marked with arrows (➢). The values of contrasts, light densities, shapes and the recommendations for colour combinations are given in Section 1.7 above ▮.

☞ *Section 1.7*

Operating equipment should at least offer the following information:

- Visual characters should lead the user straight to the operating equipment,
- The operating condition (e.g. of lifts) should be visually recognisable e.g. with information on which function has already been demanded, and
- it must be recognisable, what function can be controlled by what knob ▮.

🕮 *DIN 18025*

The use of internally lit information signs is useful in this connection. The visual information should, if possible, be supported by audible and tactile features (plastic embossed operating controls).

4.1.1 Marking of stairs

The first and last steps of a flight of stairs (including the landing) should be marked with a continuous line immediately on the front edge of the step. Three step staircases can be similarly marked on all steps. The line should have a width of about 8 cm. This marking should be applied on (horizontal) and in front of (vertical) the edge, so that they can be seen from above and below. Continuous lines should be used.

Light markings on dark background are preferred:

- e.g. light lines on dark steps
- White and yellow are the recommended colours (green is also possible)

- Contrast: K > 0.83; the same light density contrast is required for all colours.

If the background is in a mid-grey range, so that it is not possible to use light or dark markings, the following solution is recommended. It is possible to use a light line in connection with a black accompanying line to produce sufficient contrast on the front edge of the first step.

In critical cases, a basic light density of at least $L = 10\ cd/m^2$ should be available for partially sighted people. If it is desired to produce this minimum light density, then with a mean reflection coefficient of $q = 0.05\ cd*m^{-2}*lx^{-1}$ a horizontal light strength of $E = 200$ lx is necessary in the floor plane (current recommendation $E = 15$ lx).

4.1.2 Handrails

For handrails, which are very often used by partially sighted people to find their way about, the same contrast requirements apply for the light density difference between handrail and wall as are used for the line marking on the stairs. If the transition from stair material to the wall offers only a small contrast then a high contrast line, such as already described above, is useful to help partially sighted people find their way about.

4.2 Basic models

📖
Illustration Ackermann et al (1992 page?

Figure 43: *Example for the marking of handrails on steps. In addition markings should be put on staircase handrails by direction arrows (up or down) combined with the floor number embossed 2 mm in a size of lettering of 2 to 3 cm with conspicuous contrast.*

192 Approx

193 Dark stairs
Light step front edges
(first and last step of a flight)

Figure 44: *Example for the marking of first steps (above and below)*

📖
DIN 18025: Figure 26 in Ackermann et al (1992, page 73)

Figure 45: Example for the marking of lift facilities (entrance area)

📖
DIN 18025: Ackermann et al (1992, page 74)

194 Contrast shown here

195 Contrast

Figure 46: Example for the marking of lift facilities (operating equipment) Reading distance approx 1 m for warning signs and for door opener

The operating equipment should be fitted inclined to the handrail (DIN 18025). The controls should be made embossed 2 mm. See also Figure 64: marking of switches.

196 Direction of movement of the escalator

197 Fixed cover/contact plate

Figure 47: Example for the marking of escalators
Plan view

The step plate should give an acoustic signal to warn of the start of the escalator.

Figure 48: Example for the marking of travelators (running belts)

The step plate should give an acoustic signal to warn of the start of the escalator.

4.3 Applications

198 Width

199 Contact plate

200 Down escalator

201 Cover strip recommended width

202 Attention field

203 Light density: 300 to 500 cd/m^2 with artificial light

Attention fields see Ackermann et al. (1992, page 95)

Figure 49: *Example of the approach area of steps and escalators in Figure 38*
Priority 1, see Section 1.7
Priority 2 for attention field

204 Light density: 30 to 299 cd/m^2 with artificial lighting
Contrast: $0.50 < K \leq 0.83$

Figure 50: Example for indication of a lift
Priority 2, see Section 1.7
Reading distance approx 1.5 m
Graphical symbol to indicate steps and escalators shall be done in the same way

5 Design proposals for visual signs and for lettering

5.1 General instructions

Proposals are given below for the design of visual information based on the results and recommendations listed in Chapter 1 ▮. Among the visual orientation help are graphical symbols as defined in DIN Standards and other publications. The values for contrasts, light densities and shapes as well as recommendations for colour combinations, and angles of vision are given in Chapter 1. Typical, simplified basic models are given in Section 5.2. Complex examples as used in practice are given in Section 5.3.

☞ For lettering see Section 1

5.2 Basic models

Figure 51: Selected basic models for graphic symbols and lettering

205 Basic example

206 Exit

207 Exit towards the left

208 Exit straight on

209 Exit towards the right

210 Entrance

211 Entrance to the left

212 Extrance straight on

213 Extrance to the right

Figure 52: Graphical symbols (new) for entrances and exits. These graphical symbols are proposed for the general marking of entrances and exits. (For Emergency signs see Figure 53).

📖
DIN 66079

Figure 53a: The Emergency sign for an escape route as specified in DIN 66079.

At the time that the corresponding DIN standard was being prepared it was not known that the colour combination yellow on lilac was the most conspicuous. In general, where the specifications and the circumstances permit the colour combination yellow on lilac (or another colour combination of Priority 1 from Table 6) is recommended for emergency signs (see Figure 53b).

Figure 53b: The Emergency sign for an escape route from the report of the project "Contrast optimisation" Priority 1, see Section 1.7

214 Lettering size: 52 cm (can still be seen from 30 m)

215 Exit

216 Sale

217 Books

218 Lettering size: 17 cm (can still be seen from 10 m)

219 Lettering size: 9 cm (can still be seen from 5 m)

220 Angle of vision 1 degree respectively

221 Areas specified for information shall not be used for advertising

Figure 54: Three dimensional arrangement of indication signs in transport buildings (example 1)

The details given on the required size of lettering are based on Section 1.5, Table 4 (see also Section 1.2.1).

222 Timetable

223 Departures

224 Arrivals

225 - Reflection free readable
- Enable people to approach to within 5 cm
- Mean sight height: 1.30 m

226 Design of timetables see Chapter 3

Figure 55: Three dimensional arrangement of indicating signs in transport buildings (Example 2)

The details given on the size of lettering required are based on Section 1.5, Table 4 (see also Section 1.2.1).

227 Wall

228 Design variants:

Several stripes
Points
Squares

Figure 56: Path guiding with guide strips on walls within a building to reinforce the signs (Example)

229 Maximum distance 15 m

230 Angle of vision

231 Position of a person

232 Height of eyes

233 Lift

The maximum distance of the walkway in front of the text is 15 m. It is necessary that partially sighted people should be able to recognise this sign.

Procedure: According to Table 9 (in Section 1.7) a minimum angle of vision of 1° is required in priority 2. In Table 4 (in Section 1.5, see also Figure 13 in Section 1.7) for the minimum angle of vision of 1° at 15 m away a minimum size of 0.26 m is required. Extremely poorly sighted people can increase their angle of vision still further by coming closer to the text.

Figure 57: Practical determination of the size of a sign (Example)

234 Projector (colour projection)

235 Contrast

236 Meeting

Figure 58: *Light protection of signs. This type of visual information enables immediate changes to be made to the contents and optical presentation including an intermittent display.*

This applies in the same way to monitors and dynamic displays.

5.3 Example

237 Pavilion

238 Overhead lighting

239 Green surface

240 Lawn

241 Walkway

242 Overhead indicator

243 Notice board

☞ *For details see following Figures 60 & 61*

Figure 59: Example of an exhibition area in the open air (plan)

244 Contrast shown here K = 0.64

245 Size of the lettering:
for 1 degree angle of vision,
distance to reader ≤ 10 m 17 cm high

246 Contrast shown here K = 0.59

247 Lower edge of sign at above head height

Light density: 30 to 299 cd/m^2 with artificial lighting
Contrast: $0.50 < K \leq 0.83$
Size of the graphical symbols: for 1.5 degree angle of vision,
distance of reader 10 m, 26 cm high

248 Telephone

249 Pond

250 Exit

251 Pavilion

Figure 60: Examples for an information board,
Priority 2, see Section 1.7

252 Rosarium Pond Pavilion

253 First aid room

254 Priority 2
Size of lettering: for 1 degree,
≤ 25 m reading distance,
44 cm high
Contrast: $0.50 < K \leq 0.83$
Light density: 30 to 299 cd/m^2
with artificial lighting

255 Priority 1
Size of lettering: for 2 degrees,
≤ 30 m reading distance
104 cm high
Contrast: $0.83 < K \leq 0.99$
Light density: 300 to 500 cd/m^2
with artificial lighting

256 Walkway

257 Boundary strips, contrast: $0.28 < K \leq 0.50$

Figure 61: Example for an overhead notice above the walkway Priority 2 for indication of the exhibition area and Priority 1 for indication of the emergency service, see Section 1.7

6 Design proposals for visual elements in the buildings and vehicles of public passenger transport undertakings

6.1 General instructions

Proposals are given below for the design of visual information from the results and recommendations listed in Chapter 1.

The values for contrasts, light densities, and shapes, the recommendations for colour combinations, as well as angle of vision, are given in Chapter 1. Typical simplified basic models are given in Section 6.2. Complex examples for practical use are given in Section 6.3.

6.2 Basic models

Figure 62: Marking of door frames

258 Reflections on handle and on lock (glitter effect, see section 1.3.2) can make it easier to attract the attention.

259 Door that is not transparent

260 The narrow side (fold) of the open door should likewise have a high contrast

261 Transparent door leaf

262 Minimum height

263 Safety markings

Figure 63: Marking of a door

264 Call button

265 Light switch (staircase lighting)

Figure 64: Marking of switches

- It is possible to mark a switch with an internally lit sign (e.g. integration of a glow lamp in the switch or a light ring around the switch).

- The function of a switch can be indicated by graphical symbols or another sign.

- The pressure surface should be of the order of 25 cm^2 (DIN 18025)

- The finding and the function of the switch shall be reinforced by touch

- Specially in public areas the following operating controls shall be similarly designed:

    - Door opener
    - Call button for lifts
    - WC flush knob
    - Water tap and similar

266 Side wall

267 Floor

Figure 65: Marking of seats (side view)

268 Seat

Figure 66: Marking of seats (view from above)

269 Version

Figure 67: *Marking of parts in rooms (Version 1). The high contrast boundary of floor and wall can also be obtained by a skirting board.*

Figure 68: *Marking of parts in rooms (Version 2). The high contrast boundary of floor and wall can also be obtained by a skirting board.*

6.3 Example

270 Size of lettering for 1 degree
Distance from reader ≤ 30 m
52 cm high

271 Contrast shown here

272 Size of the graphical symbols for 1.5 degrees
Distance from reader ≤ 30 m,
79 cm high

273 Exit

274 Contrast

275 Marking for door edge approx 8 cm wide

276 Minimum width 8 cm

277 Border round edge of door approx 8 cm

278 Glass door

279 Safety marking

280 Attention field

281 Light density: 30 to 299 cd/m^2 with artificial lighting

282 Approx. 1.30 m

Figure 69: Example of the marking of the exit area of a station building.

Priority 1 for the door and Priority 2 for the approach area, see Section 1.7

283 Stop request button

284 Light density: 300 to 500 cd/m^2 with artificial light

Figure 70: *Example for the marking of handrails in a bus*
Priority 1, see Section 1.7

Handrails and stanchions in front of a window should be intermittently marked, since there is no stable visual background.

285 Size of the lettering: 17 cm high (distance from reader ≤ 10 m)
Contrast of lettering in front of the background $0.50 < K \leq 0.83$
Light density: 30 to 299 cd/m^2

286 a) Stop indicator (above head)

287 Size of the equipment: approx. 150 to 200 cm^2
Height of the opening (flat mouth): approx 4 cm
Contrast: $0.50 < K \leq 0.83$
Light density: 30 to 299 cd/m^2

288 b) Ticket cancelling machine

289 Size of the knob: approx 25 cm^2
Contrast: $0.83 < K \leq 0.99$
Light density: 300 to 500 cd/m^2

The signal should be acknowledged by an optical and acoustic signal

290 c) Stop request button

291 *Figure 71:* *Example for visual signs and for the marking of operating equipment within a bus*

Priority 2, see Section 1.7

7 Specifying the colours

7.1 Description of colour scales

Colours are generally specified by comparison with colours of a standardised colour scale. Some of the systems used are the colour specification system of the German Institute for Standardisation e.V. (DIN), Küppers, the Swedish Standard, the colour chart specified by CIE and the RAL colour shade card. In Germany the RAL scale is the most frequently used.

A description of the colours red, yellow, green and blue for use as safety colours is given in DIN standard 4844.

DIN Standards (selection)

DIN 4844	**Safety markings**
Part 1/05.80	Terms, principles and safety signs
Part 2/11.82	Safety colours
Part 3/10.85	Additional requirements to Parts 1 and 2
DIN 5033	**Colour measurement**
Part 1/03.79	Basic terms of colour measurement
Part 2/05.92	Standard colour metric systems
Part 3/07.92	Colour measurement figures
Part 4/07.92	Spectral method
Part 5/01.81	Equality method
Part 6/08.76	Three areas method
Part 7/07.83	Measurement conditions for body colours
Part 8/04.82	Measurement conditions for light sources
Part 9/03.82	White standard for colour measurement and photometry

DIN 6164	**DIN colour card**
Part 1/02.80	System of DIN colour cards for the 2 degree standard observer
Part 2/02.80	Specification of colour samples
Part 3/07.81	System of DIN-colour cards for the 10 degree standard observer
DIN 6169	**Colour reproduction**
Part 1/01.76	General terms
Part 2/02.76	Colour reproduction - properties of light sources in lighting technology

Table 10: List of DIN specifications (selected) to determine colours

Küppers Colour System

Küppers H. (1987a). The big Küppers-colour atlas, systematic colour charts for screen colour printing. Munich: Callwey.

Küppers, H. (1987b). Colour. Origin - System - Use - Introduction to the theory of colour. Munich: Callwey.

Küppers, H. (1989). Harmonised theory of colours. Theoretical basis for the arrangement of colour. Cologne: DuMont.

Table 11: Colour systems according to Küppers

7.2 Definition of the printed colours used in the examples

The Europa-scale for four colour reproduction uses as base colours cyan (light blue), magenta (red), yellow and black (see colour shade atlas). The versions used in the examples in sections 2.3, 3.3, 4.3, 5.3 and 6.3 are given separately in Figure 72 individually depending on the contrast value.

The samples in Figure 72 show the difference between the different versions. At the same time the examples can be reproduced with the help of the colour figure in percent and the given contrast values. It is recommended that beside the visual check an investigation should be made with the help of measuring instruments to measure the brightness, contrasts and colours.

The colours printed in the figures in this handbook can only be approximately correct. In this case they are defined by the Europa scale (see Figure 72). Obviously other colour versions and other colour systems than that given in Figure 72 can sensibly be used, provided they meet the requirements of Section 1.7 **I**.

For specialist advice see note at end of the Section.

With the help of special measuring equipment the achieved results (contrast, brightness, colour, shape) can be checked to see they are close to that used in practice.

292 Colours

293 Contrast shown here

294 White on green

295 White on blue

296 White on red

297 Yellow on green

298 Yellow on black

299 Green on blue

300 Yellow on lilac

301 Green on white

302 Red on white

303 Black on white

304 Black on grey

305 Black on green

306 Blue on neutral

307 Yellow on neutral*

308 Yellow

309 Black

310 Light blue

311 See Tables 6 and 8, Priority 3

Figure 72: Colour combinations and contrast values from the examples

Part B

Appendix

The text in the Appendix gives the background material for this Handbook.

The contributions that are marked with a name are the sole responsibility of the Authors.

Appendix 1

How the human eye works

Klaus Landwehr

Each of the two individual eyes can react to light independently of the other. However an appropriate use of the perceivable information which a structured light distribution produces can only be achieved by the coordinated working of both eyes, including the independent movement of the body and the head.

Our eyes can so converge, that an object can be formed, centred in the middle of both eyes and focused in both eyes at the same time. This is only possible if there are marked contrasts, thus, for example, not in fog. Also the focusing mechanism can only work if there is sufficient total brightness.

Both types of receivers in healthy eyes ("rods" and "cones") require a certain adjustment time until they are completely acclimatised. While the cones which specialise in daylight and colour vision adapt very quickly when going from a dark environment into the light (within a few seconds), the rods which are responsible for seeing in the dark require a much longer time when going from light surroundings into the dark. The adaptation process of the rods takes place in two phases: Half of the capacity is reached in 7 to 12 minutes, the full capacity only after at least half an hour.

The adaptation condition of the rods is not affected by yellow or red lighting. If the inner room, roads and vehicle lighting contains a proportion of green or blue, the condition of optimum darkness adaptation is only very seldom achieved.

For the light receivers to work properly it is necessary to have a constant change of contrasts. This is already achieved by a microtremor of the eyes (eye shake) but is better achieved by eye and head movements made on purpose. Many partially sighted people tend to make more eye movements than normally sighted people, since they must explore their surroundings more intensively, in order to compensate for the reduced perception.

Appendix 2

Physical and physiological contrast
Heinrich Linder

If the eye is presented with two surfaces of different brightnesses and/or different colours, which are immediately adjacent to one another or lie one within the other, then this situation is sensed as contrast.

The perception of contrasts is the prerequisite for being able to see at all. Only when an object stands out from its surroundings because of a difference in brightness and/or a colour difference is it perceptible. Then such sight activities as separation sharpness, shape recognition or even reading are possible.

Two things are necessary for a contrast to be perceptible:

1. The contrast must have a certain value, which is called the threshold contrast. This physical contrast is measurable and is determined by the brightness (light density) of the individual surfaces **I**.

☞ *Section 1.2.3*

2. The person, who perceives a contrast or wants to find his way about with its help, must have a certain contrast sensitivity. This contrast sensitivity is an expression of an active physiological ability of the visual system. People speak of a physiological contrast as opposed to a physical contrast. Thus, as a result of the way the receptive fields, to which the retina receiving elements (cones and rods) are connected, work and due to a calculation procedure designated, lateral inhibition, adjacent brightness signals undergo a physiological reinforcement of contrasts on the boundary line. White becomes still "whiter" on the boundary line and black still "blacker".

These processes depend on the individual contrast sensitivity. A reduction of the individual contrast sensitivity can thus be caused by many conditions:

- by clouding of the optical media
- by damage to or failure of the retina receptors
- by damage to the "visual computer"

If a medical treatment of this damage is not completely or not sufficiently possible, then compensation is only possible from outside, by increasing the physical contrast of the objects to be perceived.

Consequently the threshold contrast is an individual quantity. It is the physical contrast, which, with the available individual contrast sensitivity, is just perceptible. Thus the threshold contrast depends on that lighting level to which the eye must be adapted.

The following contrast thresholds are given for normal sighted people:

- with moonlight — K = 0.10
- with street lighting — K = 0.05 - 0.03
- with interior lighting — K = 0.03 - 0.01
- with daylight — K = 0.01

For partially sighted people, the threshold values lie considerably higher according to the investigations of the "Contrast Optimisation" Research Association. In daylight it was found that for:

- light objects on dark background K = 0.28 - 0.45
- dark objects on light background $|K| = |0.45 - 0.70|$

Optimum contrasts are desirable, which the partially sighted feel are ideal for their reduced ability to see. These lie (also for normally sighted people) in the range $K \approx 0.9$.

Appendix 3

Description of selected sight impairment
From research report "Contrast Optimisation"
Bernhard Lachenmayr & Susanne Müller

The parameter initially used for the definition of sight impairment is the sharpness of vision for long distance and close vision. The criterion of the German Ophthalmological Association from 1967 to define sight impairment was accepted:

Sight impairment

- Long distance visus 0.05 - 0.3 or
- Short distance visus under 0.3 (Nieden V, 30 cm distance) or
- Considerable reduction in the fields of sight

High level of sight impairment

- Long distance visus, short distance visus 0.02 - 0.05 with free field of sight, or
- Long distance visus, short distance visus under 0.1 with additional field of sight restriction

The best corrected binocular long distance visus of the partially sighted should also lie in the field between 0.02 and 0.3. Patients with better sharp vision were included if serious other functional defects were present as, for example, defects in field of sight.

The partially sighted people investigated by us were divided, depending on the type of main disease, into the following six groups:

In one group all the partially sighted people were arranged who had exclusively or mainly cloudiness of the refracting media, since similar or comparable functional defects result from these, such as reduction of the central sharpness of vision and contrast sensitivity, increased stop sensitivity or generalised reduction in the field of view.

Group 1: Cloudiness of the refracting media

Cornea cloudiness e.g. cornea scars after injury, etched or perforated Cerato plastic, after cornea inflammation or ulcers, as part of a cornea dystrophy, as medication side effect, with ceratokonus

Lens clouding, e.g. cataract senilis, post traumatic lens clouding, congenital cataract lens clouding by material change illness

Nachstar formation after successful cataract operation

Glassbody clouding, e.g. glass body bleeding with diabetes of vessel locks, asteroid hyalose, uveitis

Other problems

The second group contains all partially sighted people, for which the predominate defect was a pathological change of the macula, thus the rear eye terminals. Most frequently these patients have senile macula degeneration, but also all other diseases of the back eye terminals can be included in this group. A typical example is a reduction of the central sharpness by daylight with clear optical media, an outlined central relative or absolute failure in the field of sight, in general also a reduction of the ability to see in the dark.

Group 2: Pathological change to the macula

Senile macula degeneration, dry or damp type

Juvenile macula degenerations, e.g. viteliform macula degeneration, Morbus Stargardt

Macula changes after inflammatory diseases of the rear eyepole, e.g. uvetis posterior, macula changes due to a diabetic retinopathy

Macula changes with venenast occlusion, arterial occlusion or central venenthrombosis

Other diseases of the macula

The third group contains those partially sighted people whose field of sight failure is the dominant functional defect. This is the typical case with the glaucoma patients. In addition this group contains those patients who have a disease of the affected sight track (optical nerve, chiasma or supra-chiasmal sight track), which likewise include a defect in the field of sight. Consequently the sight loss due to failure of the field of view is relevant in practice, defects must be present on both eyes, the assessment was, therefore, based on the test of binocular field of sight. Typical examples for the effects on sight impairment are shown in the following illustrations.

Figure 3.1: *The most important sight impairments*

A *Clouding of the refractive media (simulation of the lack of sharpness)*

B *Pathological change of the macula (simulation of a defect in the field of view)*

C *Pathological change of the macula (absorption of the retina)*

The light density contrasts, which are used for the markings in public spaces, should always lie above the established threshold contrasts for that particular situation. In this connection the contrast requirements depend on the intended minimum recognisable distance and the size of the object, as these sizes determine the angle of vision. Since the subjectively desirable contrasts clearly lie higher than the threshold contrasts of most objects and because of the measurements on objects in the public area, such high contrasts seldom appear, and thus the danger of using too high a contrast does not exist. However the glare from light sources must be excluded.

In the design of the information signs and lettering, efforts should be made to use a clear and simple display, in order to enable signs to be quickly and clearly recognised. It is recommended that as large an area as possible is used and it should contain no unnecessary details.

In a direction indicator care should be taken to provide continuously high contrast design and efforts should be made to keep clear the orientation help which has been given (barrier free corridors).

Appendix 4

Degree of reflection of photometric materials
From: Research report "Contrast Optimisation"
Ernst-Olaf Rosenhahn & Hans-Joachim Schmidt-Clausen

4.1 Types of reflection

When light falls on a surface part of it is reflected. A distinction is made between directional, partly directional and diffused reflection (Figure 4.1.1.). The special case of backwards reflection (Figure 4.1.1 D) is not considered here, since in public areas it occurs almost exclusively in the traffic signs during the journey in daylight and in most cases cannot be used by pedestrians, (for the definition of backwards reflection see Buschendorf, 1989) ❚.

Buschendorf, 1989

Figure 4.1.1 Various types of reflection (A: diffused reflection, B: partly directional reflection, C: mirrored reflection, D: backwards reflection)

Mirrored reflection (Figure 4.1.1 C) occurs on polished metal surfaces or glass panes. The images reflected in the glass panes are relatively weak due to the low degree of reflection, but can lead to irritations because of their high light density. They are really too weak, to contribute to the sufficient recognisability of the glass door or other glass surfaces.

The reflections on large metal surfaces are often blinding and are, therefore, only useful for orientation in a few cases, so, for example, bannisters made of stainless steel are much lighter than the wall because of the high light density of the reflection. Unfortunately it is not possible to generalise, since the reflective image always depends on the geometry of the lighting and observation. Painted surfaces or smooth plastic surfaces show a partly directional reflection (Figure 4.1.1 B), that is to say a light flux, which reaches the surface at a certain angle, is mainly diffused and a small part is directionally reflected.

The diffused reflection provides the uniform light density of the surface (Figure 4.1.1 A). It produces the coloured impression of the object. For floor coverings there is a mirrored and a diffused reflected component. For a rough concrete surface the reflection is almost completely diffused. With smooth floor coverings (e.g. ground or polished floor tiles, marble slabs etc.) the mirrored reflection makes up a relatively large part of the reflected light flow. This mirrored reflected component only has a clear effect - either positive or negative - if certain geometry regarding the angles of incidence and reflection of the light are observed.

With ideal diffused light it does not matter how the reflected percentages are distributed. With directional incidence of light (e.g. sunlight) on the other hand the direction in which the pedestrian looks can cause the contrast, that was previously easy to recognise under diffused lighting, to disappear. It is on the pavement that this effect of the mirrored reflection has an important role, for with a damp surface the reflected component increases strongly and can make a big change to the contrast situation. Diffused reflecting surfaces are found to be advantageous, since their light density does not change much under the different lighting conditions, at constant lighting strength on their surface.

These aspects play an important role in the choice of material. In the open air and in large buildings with a high percentage of daylight in the lighting it is difficult to choose the material, since the lighting situation changes during the day and moreover in the open air is dependent on the weather. In inner spaces the type of lighting (lighting strength level, freedom from blinding, directional percentage, etc.) has a considerable effect on the quality of the design for the partially sighted.

The wear of materials that occurs with time - both the wear caused by use of man made products or the effects of weather - can lead to a worsening of the contrast and consequently a worsening of the perception of objects or markings.

Table 4.1.1 contains examples for the degree of reflection of photometric materials ▮.

📖 *Hentschel, 199?, Table 6.2, Page ?*

Photometric materials	Degree of reflection %
Building materials	
Granite	20 to 25
Sandstone	20 to 40
Cement, concrete, rough	20 to 30
Brick, red, new	10 to 15
Colours	
Light grey	40 to 60
Pink	45 to 55
Light yellow	60 to 70
White	75 to 85

Table 4.1.1: Degree of reflection of photometric materials
Materials with the same degree of reflection neglecting possible colour differences - no contrast

A photometric description for further building materials and other materials is given by Hentschel **I**.

Hentschel (1994, Table 6.1, page 156, Table 6.3, page 158, Table 7.8 and Table 7.9, page 208)

4.2 Characteristics of different materials

In order to describe the reflection behaviour of materials comprehensively, it is necessary to determine the complete light strength distribution curve of the surface for different lighting geometries. Then it would be possible to draw conclusions for all geometries and methods of lighting on the light density and consequently the possibilities of producing contrast. By far the most frequent and consequently the most important case is, however, the consideration of the objects from the pedestrian's point of view under diffused lighting. For this geometry the light density coefficients were determined for different materials used in the surfacing of walkways. The light density coefficient under diffused lighting is defined as follows:

$$q = \frac{L}{E} \qquad \text{Unit: cd . m}^2\text{ . lx}^{-1}$$

The quotient is formed of all the light density L (from the perspective of the observer) and lighting strength E (in the sample plane under diffused lighting). A material characteristic is obtained from the light density coefficients, with which the light density of the surface can be calculated for any lighting level. The contrast of two materials, which are adjacent to one another can be calculated exactly as the light density contrast by using the following formula:

$$k = \frac{qo - qu}{qo + qu}$$

The material can be classified with this light density coefficient.

When objects are marked which can be painted or given simple coatings there are hardly ever problems in achieving the required threshold contrast, for by mixing with neutral components (black or white) the desired light density coefficients can be produced, in order to reach a certain contrast. A very high contrast of K = 0.95 (black-white) can be produced with exclusively passive materials (that is to say no active light source) without a flourescing component. The critical area for marking is the surface of walkways. Here it is not possible just to put on a coat of paint, for example, for guide strips, landing and stair markings because of the heavy wear. In many cases the marking must be put into the material itself without a coating so that the long term stability of the contrast is guaranteed. Therefore, firstly, the light density coefficient of many walkway materials was measured, in order that for any lighting intensity the light density or the contrast between two materials could be determined.

Secondly the light density coefficients for the surfaces and floor materials were calculated from the light density measurements. The mean light density coefficient obtained in this way is $q = 0.049$ cd.m^{-2}.lx^{-1}. With an assumed light strength of $E = 8011$ lx a mean light density was obtained of $L = 392.5$ cd . m^{-2}.

The light density coefficients of different floor materials and marking materials are given in Table 4.2.1:

Object/material	**$q/(cd \cdot m^{-2} \cdot lx^{-1})$**
White line (as in use)	0.066
White line (cold plastic, new condition)	0.20
Yellow line (new condition)	0.16
Blue line	0.048
Green line (blue green)	0.080
Red bicycle track	0.035
Asphalt	0.030
Concrete block (light grey)	0.050
Basalt small paving stone	0.030
White small paving stone	0.130
Reddish small paving stone	0.037

Table 4.2.1: Typical light density coefficients for various materials

The values given in Table 4.2.1 are values, which were obtained from measurements of typical samples of these materials. They can be used as a rough guide, but should be measured exactly for particular cases, since, for example, concrete blocks can be coloured and so can be arranged to have any light density coefficient between $q = 0.015\ cd \cdot m^{-2} \cdot lx^{-1}$ and $q = 0.13\ cd \cdot m^{-2} \cdot lx^{-1}$. The age and the degree of soiling also play an important part. In Figure 4.2.1 two different concrete slabs can be seen, which are separated by natural stone paving. Although they are of the same design, the light density coefficients differ by a factor of 2 to 1. This shows that the table above gives rough reference values, but it is quite possible, for example, for a combination of two natural stones to give a design with a strong contrast. The contrast of $K = 0.3$ in Figure 4.2.1 was not, however, considered to be sufficient.

Figure 4.2.1: Separation between walkway and cycle track

A series of measurements of the light density coefficients q of samples of different paving materials give the following distribution for the q-values (Figure 4.2.2):

312 Number

313 Series

Figure 4.2.2: Distribution of the light density coefficients of various paving materials

From the distribution of the light density coefficients it can be seen that a lot of these materials have light density coefficients between q = 0.02 and q = 0.06. By combining these materials it is possible to achieve in the most favourable case a contrast of K = 0.5. The number of materials with a high light density coefficient, with which a "light on dark contrast" can be produced is low. It can be done by, for example, white and yellow cold plastic materials for ground marking, white natural paving stone or very light concrete blocks. Considering all materials a mean light density coefficient of q = 0.047 $cd.m^{-2}.lx^{-1}$ was obtained. The same materials in a wet condition had an average of q = 0.037 $cd.m^{-2}.lx^{-1}$.

In addition when materials are used together, it must be remembered that in the damp condition the light density coefficients vary by different amounts from the dry condition, and so the contrast can vary as well. This effect can be clearly seen when concrete blocks are used with natural stone, since the concrete blocks take up water, and thus the light density coefficient in the damp condition falls sharply, with natural stone, however, the reduction of the light density quotient is only 25% on average. The difference from damp to dry condition with concrete blocks is an average of about 50%. Because of these results concrete blocks should not be used as a marking line (e.g. as guide strips) in conjunction with a dark natural stone.

4.3 Example calculation

A paving surface is shown by way of example in Figure 4.3.1, which is produced by the light density difference between the surface and the white pavement line. This contrast can be calculated from the light density coefficients of the two materials. For the small white paving stones, Table 4.2.1 gives a light density coefficient q = 0.13 $cd.m^{-2}.lx^{-1}$ and for the small red paving stone q = 0.037 $cd.m^{-2}.lx^{-1}$. From these figures the contrast can be calculated using formula (1). The contrast is, therefore, K = 0.56. It can be seen that for this line with a width of 10 cm the

contrast lies over the threshold contrast (K = 0.43) and, therefore, this line can be used as a guide strip for partially sighted people. It would, however, be better to widen this line to 30 cm, since then all partially sighted pedestrians would find it easier to recognise.

Figure 4.3.1 Small paving stones as guide strips

A similar result for the contrast is achieved for the white cold plastic marking on a dark asphalt surface, which is used to make the boundary of the cycle track (Figure 4.3.2). With the values from Table 4.2.1 a contrast of K = 0.74 is achieved here, which lies significantly above the threshold contrast. The light density difference of the asphalt to the cycle track is interesting. This gives a contrast value of K = 0.10 - that is to say the light density difference is very low. The relatively good discernability for this small light density-contrast is due to the colour shade difference of the two surfaces.

Figure 4.3.2: White cold plastic marking as separating line

Appendix 5

Experimental station at U-Borgweg in Hamburg

Gerhard Burmeister

As part of a series of tests the station at U-Borgweg in Hamburg has been converted, so that it meets the requirements of disabled people better than previously I. Some selected results on the improvement of visual information are briefly given here.

Macnule et al 1995

It is frequently not possible to reach the desired light intensity with the conventional lighting strength used in public areas as specified in DIN, EBO or BOStrab. The E-Bau Guideline for BOStrab (1990 level) specifies e.g. for open platforms a nominal light strength of 15 to 30 lux, and for booking halls and tunnel platforms 120 lux. On platforms, light densities between 3 and 32 cd/m^2 were measured with an average nominal lighting strength of about 120 lux. For the floor surfaces in Hamburg U and S-Bahn (underground and suburban railways) stations even with nominal lighting strengths of over 200 lux no higher light density than 50 cd/m^2 was found, apart from white comparative surfaces, which reached a maximum of 130 cd/m^2. The results show, however, that with favourably selected surfaces with lux values between 60 and 120 sufficient contrast can be obtained.

The contrast obtained with reasonable lighting is what matters. This is being increasingly decided by economic and energy saving considerations. The corresponding regulations have, of course, taken these factors into account in the past. The values were reduced everywhere. The recommendations from this Handbook should counteract this development.

Appendix 6

An improvement in the visual information helps to integrate people with restricted mobility into the community
Manfred Guhr

6.1 Improved information benefits all citizens

In order to participate in and cope with complex transport systems, as well as the complicated structured architectural and technical environment, every citizen needs clear and understandable information. Information technology offers many possibilities especially in the field of transport. The big question, however, is whether the introduction of these will meet the requirements and be within the abilities of the users. Even normal sighted people have difficulties in many cases, and these can be magnified for partially sighted people. Improvements in this area help to promote the independence and autonomy of citizens and make it easier for them to use public transport. They consequently help to make the public investment in the transport system effective.

6.2 The potential: Estimation of the number of mobility restricted people who can profit from improved information system.

In 1988 the Age Report II of the German Federal Government appeared (Federal Ministry for family, OAPs women and children)

▌On 31.12.1993, every 12th inhabitant (or about 5.57 million) people in the old West Germany had an identity card to show they were seriously disabled (i.e. they were 50% and more disabled) which is around 8.5% of the population.

📖 *Report "Contrast optimisation" Chapter III*

In the former East Germany on this date every 19th inhabitant had this identity card (or about 0.81 million). This was 5.2% of the population.

In the whole of Germany, at the end of 1993, it seems that there was a total of some 6.38 million recognised disabled people or about 7.8% of the complete population ▌.

📖 *Hein, 1995, Page 376 f*

The percentage of that upper statistical upper category that have mobility restrictions is not entirely clear and remains to be calculated: In the data given disabled people appear whose mobility is only partly or indeed not at all restricted. If only the upper category is calculated "lost or part loss of limbs", functional restrictions of the spine..." "blindness and partial sight" and "paraplegia..." as features of the restriction on mobility, then it is approximately 3.23 millions or 50.6% (of the recognised disabled). Almost every 10th severely handicapped person, who has reduced mobility is blind or partially sighted (9.7% based on the approximate value of 3.23 million).

There are 314 404 blind and partially sighted people which is 4.9% of the recognised severely disabled, of which about half of this figure are completely blind. This figure does not consider the people who suffer from red/green colour blindness.

Beside the officially recognised partially sighted there are also the disabled with levels of disability under 50% who need to be considered with regard to their mobility restrictions (old people, small children, pregnant women, people with the temporary results of accidents or post operative impairments, .people with prams or heavy luggage etc.).

Earlier investigations in some towns (e.g. Munich, Nürnberg, Düsseldorf, Bremen) have shown, that in the area previously called West Germany about 20% of the population suffered from some disability (seriously disabled and other mobility restrictions), and in the area previously called East Germany this figure has been estimated at 35%.

Dann & Bonk 1990, page 3 Ackermann et al 1991 page 2

The potential includes far more than 20% of the total population. These citizens should be specially born in mind when the design and the operation of transport services are considered and the fixed installations for the traffic system are installed. This is an order of magnitude, which cannot be dealt with by the instruction for special journey services or so-called supporting measures. Consequently it is also clear that the conventional view is no longer valid.

This assumed that the people who had reduced mobility were a small percentage of the total population and therefore concluded that from the business management and cost-benefit points of view they should be neglected in the investment decisions. In the meantime the view has been accepted that special journey services and benefits for disabled people can only partly solve the problem of their use of the transport system and consequently more needs to be done.

6.3 Reference documents for the improvement of information

Startings points for the improvement of information can be obtained in:

- Provision for the disabled in railway building and operating instructions
  (§ 2 para, 3 EBO), of the regulation for the building and operation of tramways (§ 3 para. 5 BOStrab) and in the Municipal Transport Financing Law (§ 3 Figure 1d GVFG) as well as the

Mag-Lev Railway Building and Operating Instructions (MbBO)

- Rules for the special arrangements for parking and waiting for disabled people in the road traffic regulations (StVO)

- "Text book for the design of inland waterway passenger ships to make them suitable for disabled people", Regulations of the UN-economic committee for Europe (ECE).

- "Recommendations for the improvement of passenger transport for disabled people" of the IMO (International Maritime Organisation of the UN) which have been in force since 1991.

  At present IMO is preparing "Recommendations for the building and operation of ships with regard to older and disabled passengers".

- For air travel, discussions are at present taking place with the participation of the Federal Ministry of Transport under the umbrella of the European Civil Aviation Conference (ECAC) on recommendations for suitable design for disabled people.

- EU "Action programme of the Community for the movement of people whose mobility is affected" (second version dated October 1994). The action programme should contain: Proposals for legal specifications for the minimum requirements (e.g. on the fitting out of buses and coaches), coordination activities for research (e.g. to improve the local services), cooperation with the information programmes (e.g. traffic information systems for disabled people and people with restricted mobility).

  The European research coordination project COST 322 "Low floor buses" summarises the research and development experience, as well as the practical experience on low floor buses (see European Commission, 1995).

  The new COST project 335 "Access of older and disabled people to the rail transport systems" will also consider the availability and quality of information in railways.

- As a result of the 1992 amended GVFG, Counties and Municipalities (especially in the former East Germany) are better equipped than previously to consider the interests of disabled and reduced mobility passengers/users of public transport (requirements for buses and trams as well as stops, conversion measures on vehicles in the former East Germany, requirement for operating equipment etc.).

- According to the regionalisation law from 1996 the Counties alone decide the tasks and the financial responsibility for all areas of local public passenger transport.
- With the modification of Art. 3 GG which came into force on 15 November 1994 "No one may be disadvantaged by his disability" (Art. 3 para 3 sentence 2 GG) - all the legal requirements and other specifications which relate to transport, as well as the vehicles and the equipment involved shall be so applied that discriminating effects are avoided.

Bibliography

Ackermann, K., Burmeister, G., Echterhoff, W., Gerlenbeck-Schmid, D., Kockelke, W. & Meyer, L., (1992). Bürgerfreundliche und behindertengerechte Gestaltung des Straßenraums.(Reihe direkt des Bundesministers für Verkehr, Bonn. Verbesserung der Verkehrsverhältnisse in den Gemeinden, Heft 47) [Design of roads so that they are suitable for citizens and the disabled (Direct series of the Federal Ministry of Transport, Bonn, Improvement of Traffic in towns, Volume 47)] Frankfurt on Main: Fach Media Service.

Ackermann, K., Blaschke, M. & Feller, G. (1995). Nutzungserleichterungen des ÖPNV für Ältere und Behinderte durch bessere Informations - und Orientierungssysteme [Making public passenger transport easier for older and disabled people by better information and orientation systems] (Research report FE No. 70 444/94), Dresden: Technical University Dresden.Department of Traffic Management "Friedrich List" Chair for Transport and Infrastructure Planning.

Arbeitsgemeinschaft Deutscher Verkehrsflughäfen (ADV). (1974). Piktogramme zur Orientierung auf Flughäfen. [Pictographs for Orientation at Airports] Stuttgart (unpublished)

Bundesarbeitsgemeinschaft für Rehabilitation BAR (1994). Behindertengerechte Gestaltung des Regionalbusverkehrs. [Design of regional bus services to make them suitable for disabled people.] Symposium final recommendation. Frankfurt on Main: Author.

Buschendorf, H. G. (1989). Lexikon Licht- und Beleuchtungstechnik. [Lexicon of lighting and illumination technology]. Berlin: VEB

Bundesarbeitsgemeinschaft Hilfe für Behinderte e.V. (1990). Kommunikation zwischen Partnern. Blinde - Sehbehinderte - Taubblinde. [Federal Association for Disabled e.V. (1990). Communication between partners. Blind - partially sighted - deaf blind]. Düsseldorf: Author.

CIE Publikation 17.4 Internationales Wörtebuch der Lichttechnik. Wein: Commission Internationale de l'Eclairge. [International dictionary of lighting engineering. Vienna. International Lighting Committee].

Campenhausen, Ch. von (1981). .Die Sinne des Menschen. Bd. 1. Einführung in die Psychophysik der Wahrnehmung. [The senses of man. Vol. 1. Introduction to the psychophysics of perception]. Stuttgart: Thieme.

Dann, U. & Bonk, R. (1990). Die Eingliederung behinderter Menschen in den Verkehr. [The integration of disabled people into transport systems]. Bonn: Federal Ministry of Transport.

German Lower House of Parliament 12th period (1994). Third report of the Federal Government on the position of the disabled and the development of rehabilitation. Document 12/7148 dated 24.03.94. Bonn: Federal Gazette.

DIN 1450; Lettering (July 1993).

German Institute for Standardisation. Berlin: Beuth

DIN 1451, Lettering; Sans serif Linear Antiqua.

Part 1: General (May 1981)
Part 2: Business lettering (February 1986)
Part 3: Printed lettering for labelling (December 1987)
Part 4: Stencil lettering for engraving and other processes (August 1897)
German Institute for Standardisation. Berlin: Beuth.

DIN 18024: Building measured for disabled and old people in the public sector

Part 1: Planning documents, streets, squares and paths (November 1974)
Part 2: Buildings and workplaces accessible to the public (July 1994, draft)
German Institute for Standardisation. Berlin: Beuth.

DIN 18025: Homes without barriers

Part 1: Homes for wheelchair users: Planning documents (December 1992)
Part 2: Planning documents (December 1992)
German Institute for Standardisation. Berlin: Beuth

DIN 4844 Safety marking

Part 1: Terms, principles and safety signs (May 1980)
Part 2: Safety colours (November 1982)
Part 3: Further requirements to Part 1 and 2 (October 1985)
German Institute for Standardisation. Berlin: Beuth.

DIN 5032, Light measurements

Part 1: Photometric methods (July 1978)
Part 2: Operation of electric lamps and measurement of the appropriate values (January 1992)
Part 3: Measurement conditions for gas lights (May 1976)
Part 4: Spectral methods (July 1992)
Part 6: Photometers. Terms, properties and their marking (December 1985)
Part 7: Class allocation of lighting strength and lighting density measuring equipment (December 1985)
Part 8: Data sheet for lighting strength measuring equipment (September 1986)
German Institute for Standardisation. Berlin: Beuth.

DIN 5033, Colour measurements

Part 1: Basic terms of colour measurement (March 1979)
Part 2: Standard colorimetric system (May 1992)
Part 3: Colour measurement figures (July 1992)
Part 4: Spectral methods (July 1992)
Part 5: Parity methods (January 1981)
Part 6: Three sector method (August 1976)
Part 7: Measurement conditions for body colours (July 1983)
Part 8: Measurement conditions for light sources (April 1982)
Part 9: White standard for colour measurement and photometry (March 1982)

German Institute for Standardisation. Berlin: Beuth.

DIN 5044, Fixed street lighting
Part 1: Lighting of streets for motor vehicle traffic. General quality features and guide values (September 1981)
Part 2: Lighting of streets for motor vehicle traffic. Calculation and measurement (August 1982)
German Institute for Standardisation. Berlin: Beuth.

DIN 6164, DIN Colour charts
Part 1: System of the DIN colour charts for the 2 degree normal observer (February 1980)
Part 2: Definition of the colour samples (February 1980)
Part 3: System of the DIN colour cards for the 10 degree normal observer (July 1981)
German Institute for Standardisation. Berlin: Beuth.

DIN 6169, Colour reproduction
Part 1: General terms (January 1976)
Part 2: Colour reproduction - properties of light sources in lighting technology (February 1976)
Part 4: Methods for the designation of colour reproduction in colour photography (May 1976)
Part 5: Methods for the designation of object based colour reproduction in multi-colour printing (January 1976)
Part 6: Methods for the designation of colour reproduction in colour television technology with picture recording equipment (January 1976)
Part 7: Methods for the designation of colour reproduction in television colour film scanning (September 1979)
Part 8: Methods for the designation of colour picture based colour reproduction in multicolour printing (September 1979)
German Institute for Standardisation. Berlin: Beuth.

DIN 66079, Graphical Symbols for the information of the public
Part 1: Picture content and example for the pictorial representation
Part 2: Development of symbols for the information of the public and principles for their use (April 1992)
Part 4: Symbols for the disabled (April 1992)
Part 5: Symbols to enable people to find their way around transport systems (April 1992)
German Institute for Standardisation. Berlin: Beuth.

Echterhoff, W., Gizycki, v. R., Müller, H., Lachenmayr, B., Müller, S., Buser, A., Lindner, H., Beyer, I., Rohl, F-W., Schmidt-Clausen, H-J., Enders, M. & Rosenhahn, E-O. (1995).

Orientierungshilfen für Sehbehinderte im öffentlichen Bereich durch Verbesserung der visuellen Kontraste. Abschlußbericht für das Bundesministerium für Gesundheit (BMG) [Help for partially sighted people to find their way around public areas by improvement of the visual contrasts. Final report for the Federal Ministry for Health]. (BMG). Darmstadt: Technical High School Darmstadt.

European Commission (1995). COST 322. Low Floor Buses. Directorate General for Transport. Luxembourg: Office for Official Publications of the European Communities. Transport research series, EUR 16707.

Europa-Skala (Vierfarb-Reproduktionen) [four colour-reproduction] see shade value atlas.

Farbton-Ubersichtskarte nach RAL Colour shade - overview charts as specified by RAL, Hilden: Association for colour and design

Fischer, H. (1994). Entwicklung der visuellen Wahrnehmung. [Development of visual perception]. Weinheim: Pyscologie-Verlags Union.

Forschungsgesellschaft für Straßen und Verkehrswesen (Arbeitsgruppe Verkehrsführung und Verkehrssicherheit) (1992) Richtlinien für Lichtsignalanlagen [Research Association for Roads and Traffic Technology (Working Group, Traffic Management and Traffic Safety)) Code of Practice for colour light signals] (RiLSA), Cologne: Author

Gibson, J. J. (1950). The perception of the visual world. Boston: Houghton-Mifflin.

Gibson, J. J. (1979). The ecological approach to visual perception. Boston: Houghton-Mifflin.

Gibson, J. J. [German version] (1982). Wahrnehmung und Umwelt. Der Ökologische Ansatz in der visuellen Wahrnehmung. [Perception and surroundings. The ecological approach to visual perception]. Munich: Urban & Schwarzenberg.

Guski, R. (1989). Wahrnehmung. [Perception]. Stuttgart: Kohlhammer.

Hein, B. (1995). Schwerbehinderte [Seriously disabled] 1993. Wirtschaft und Statistik, May edition, page 376 et seq.

Hentschel, H-J. (1994). Licht und Beleuchtung. Theorie und Praxis der Lichttechnik. [Light and lighting. Theory and Practice of lighting technology]. Heidelberg: Hüthig.

Jansson, G. (1990). Non-visual guidance of walking. In: R. Warren & A. H. Wertheim (Hrsg.). Perception and control of self-motion (pages 507-521). Hillsdale, NJ: Erlbaum.

Johansson, R.. (1993). Streets for Everybody. Stockholm: Swedish Association of Local Authorities (see also: Johansson, 1994 stekgraz...)

Johansson, R (1994). stekgraz. Straßen für alle. [Streets for everybody]. Graz: Town building management (see also Johansson 1993 Streets...)

Küppers, H. (1987a). Der Große Küppers-Farbenatlas. Systematische Farbtabellen für den Sieben-Farben-Druck. [The big Küppers colour atlas. Systematic colour tables for seven colour printing]. Munich: Callwey.

Küppers, H. (1987b). Farbe. Ursprung - Systematik - Anwendung. Einführung in die Farbenlehre. [Colour. Origin-Systems-Use. Introduction to colour theory]. Munich: Callwey.

Küppers, H. (1989). Harmonielehre der Farben. Theoretische Grundlagen der Farbgestaltung. [Harmony theory of colours. Theoretical basis for colour design]. Cologne: DuMont.

Lachenmayr, B. J. (1995). Sehen und gesehen werden. Sicher unterwegs im Straßenverkehr. [Seeing and being seen. Crossing the road safely]. Aachen: Shaker.

Landwehr, K. (1994). Straßenverkehrszeichen: Zeichen, Bilder und Gegenstandstextur. [Traffic signs: Signs, pictures and preferred orientation of objects.] In: C. Dreyer, H. Espe, H. Kalkofen, I. Lempp, P. Pellegrimo & R. Posner (Hrsg.). Lebenswelt Zeichenwelt (pages 711-757). Lüneburg: Jansen.

Lindner, H & Schmolke, D. (1976). Zur subjektiven Bestimmung von Helligkeitskontrasten. [The subjective determination of brightness contrasts] Der Electropraktiker, 30, 170-174.

Lork, C. (1995). Zur semiotischen Systematik von Orientierungszeichen und Orientierungssystemen an Flughäfen. Dargestellt am Beispiel des Flughafens Koln/Bonn. [Semiotic systems of orientation signs and orientation systems at airports. Shown by examples from Cologne/Bonn airport]. Mainz: Wissenschaftsverlag.

Machule, D., Wehner, T., Usadel, J., Vogel, C. & Rust, B. (1995). Experimentierhaltestelle U-Borgweg. Schlußbericht. Optimierung behindertenfreundlicher Gestaltungselemente für Neu- und Umbaumaßnahmen in Schnellbahnhaltestellen und deren Umfeld sowie Aufstellung und Fortschreibung von Empfehlungen und Richtlinien. [Experimental station at U-Borgweg. Final report. Optimisation of the design features for new buildings and converted buildings that are useful for disabled people at rapid transit stations and their surroundings as well as the preparation of recommendations and codes of practise]. Hamburg: Research Group U-Borgweg at the Technical University of Hamburg-Harburg.

Niederflur-Verkehrssystem: Gestaltung von Haltestellen in den alten und neuen Bundesländern. [Low floor transport system: Design of stops in the former West and East Germany] (1992) (Direct series of the Federal Ministry of Transport, Bonn. Improvement in the transport conditions in Municipalities, No. 46).

Petrova, E. (1993). Visual contrasts (unpublished). Diploma work. Technical High School Darmstadt.

Pugh, E. N. Jr. (1988). Vision: physics and retinal physiology. In: R. C. Atkinson et al. (Hg). Stevens Handbook of experimental psychology - second edition. Bd. 1. Perception and motivation (pages 75-163). New York: Wiley.

Pfundt, K. (1991). Handbuch der verkehrssicheren Straßengestaltung. [Handbook of Road Design for Safer Traffic] (Published by the advisory Office for Accident Prevention of the HUK-Association in connection with the Police Staff College and the Federal Ministry for Transport). Dortmund: Traffic sheet.

RAL see colour shade - chart

Rassow, B. (1988). Zur Bestimmung der Kontrastempfindlichkeit. [The determination of contrast sensitivity]. Clinical monthly bulletin of eye medicine, 193, 93-98.

RICA (1992b). Verkehrsinformationen für Behinderte. [Traffic information for the disabled]. A report of the Research Institute for Consumer Affairs commissioned by the European Commission. London: Research Institute for Consumer Affairs

Schmidt-Clausen, H.-J., Damasky, J. & Wambsganß, H. (1992). Einfluß der Helligkeit von Fahrbahnoberflächen auf die Seh- und Wahrnehmungsbedingungen von Kraftfahrern bei Nacht [Effect of brightness of road surfaces on the conditions that affect the ability of vehicle drivers to see objects at night] (Forschung Straßenbau und Verkehrstechnik, Number 629). Bonn: Federal Minister of Transport. Road Building Department

Schober, H. (1959). Aktuelle Probleme der physiologischen Optik in der Verkehrsmedizin [Current problems of physiological optics in traffic medicine]. In K. Wagner, H. Schulten, A. Großjohann & J. Kühn (Hrsg.), Aktuelle Probleme der Verkehrsmedizin [current problems in traffic medicine] (pages 63-68). Stuttgart: Enke.

Schönborn, H. D. & Schulte W. (1995). RSA-Handbuch. Sicherung von Arbeitsstellen an Straßen. Band 1: RSA mit Kommentar.[RSA-Handbook. Protection of people who work on roads. Volume 1: RSA with commentary]. Bonn: Kirschbaum.

S/S Farbatlas Schwedische Norm [Swedish Standard] Natural Colour System (NCS).

Stadier, M., Seeger, F. & Raeithel, A. (1977). Psychologie der Wahrnehmung. [Pyschology of perception]. Munich: Juventa.

Steger, G. (1988). Behindertengerechte Gestaltung des öffentlichen Personennahverkehrs in der Stadt Wuppertal (Endfassung). [Design of local public transport systems in the town of Wuppertal to make them suitable for disabled people (final version)]. Berlin: Local Services Study Association.

Stemshorn, A. (1994). Barrierefrei bauen für Behinderte und Betagte. [Designs to help the old and disabled move without barriers]. Leinfelden-Echterdingen: Alexander Koch.

Tonwertatlas für Vierfarb-Reproduktionen. [Colour shade atlas for four colour reproduction]. Prepared by R. F. Krause & N. Bendixen. Celle: Hostmann-Steinberg GmbH.

Verband Deutscher Verkehrsunternehmen VDV. [Association of German Transport Companies VDV]. VDV Publications:

- Passenger information in trams and bus systems. Technical series, VÖV 1.69.2 (1985).
- Passenger information in rapid transit systems Technical Series VÖV 1.69.1 (1988)
- Information for people with restricted mobility. VDV-Mitteilung (1994)
- Information for blind and partially sighted people VDV-Mitteilung (1996)

Verkehrsinformationsdienst für Behinderte im öffentlichen Personennahverkehr [Traffic information for disabled people in local passenger transport] (EU-Project). Bergisch Gladbach: Institut für Bahntechnik. 1995.

Wahl, K. (1953). Lichttechnik. [Light technology]. Leipzig: Fachbuchverlag.

Zwaga. J. G., Boersema, T. & Hoonhout, H. (1994). Public Graphics. Visual information for everyday use. Utrecht: Stichting Public Graphics Research.