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**Environmental Engineering (EE);
Colour and marking of DC cable and connecting devices**

Reference

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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Introduction

The present document has been developed to assist the ICT industry in their development and wider use of DC powering solutions above the DC voltage range mainly used until now for Telecommunication networks equipment (-48 V ETSI EN 300 132-2 [7]).

The present document has been jointly developed by ETSI TC EE and ITU-T Study Group 5 in order to ensure an equivalent technical content. It is published respectively by ITU as Recommendation ITU-T L.1203 [1] and ETSI Standard ETSI ES 203 408.

DC has been the main source of power of Telecommunication industry since the very beginning as it is efficient, reliable and easily scalable.

This solution is a well proven arrangement that has been used for a century in almost all of the sites in cohabitation with AC for servers and other buildings services (lighting, facility plugs, lifts, etc.).

It is recognized that DC has many potential applications further to those for ICT and that such applications could benefit from the standards defined in ITU/ETSI. It is also recognized that further standardization activities on LVDC is now starting in other standardization organizations such as IEC. Thus ITU-T/ETSI will pursue cooperation with such organizations to reach maximum international alignment.

ETSI and ITU-T have standardized the widespread DC power interface at inputs of Telecom/ICT equipment used in Telecom networks, Data centers, and customer sites. The legacy interface for billions of equipment is the SELV voltage range so called -48V, where the plus pole is grounded as defined for example for interface "A" in ETSI EN 300 132-2 [7]. Other complementary ETSI standards define a whole DC distribution including earthing and bonding such as ETSI EN 300 253 [9].

Higher voltages than 48 V are already widely used in Telecom networks for remote powering of signal repeaters on copper or optical Telecom transmission lines, with a usual operation in symmetrical voltage up to +/- 200 V in RFT-C or RFT-V telecom remote power feeding standardized in ETSI EN 302 099 [i.1].

Higher power density of ICT equipment and overall site power in MW for Data centers, have led to the use of higher voltage firstly in AC single or 3 phases up to 400VAC at the input of servers. The need for resilience, energy efficiency and cost optimization has pushed the introduction of the up to 400VDC power feeding interface standardized in ETSI EN 300 132-3-1 [8] and in Recommendation ITU-T L.1200 [2]. This is now available on many servers and network equipment.

As there is a progressive introduction of the new DC power interface in cohabitation with existing -48 V and AC distribution, a new standard ETSI EN 301 605 [10] has been introduced to ensure safety and proper operation especially in mass bonding of EMC sensitive equipment and correct earthing connection to the building structure earthing network.

It appears that there is also a strong need for Telecom/Data centers operators, equipment manufacturers or installers and end customers to clarify the colour and marking of cables in their installations. This would avoid confusion and errors between the different AC and DC power interfaces and distributions used in the building and inside ICT systems.

Considering the user side, and very long background experience in use of DC of the Telecom sector, the present document makes Recommendations directly contributing to safety principles laid down in IEC Guide 104 [i.9] and ISO/IEC Guide 51 [i.10]. It accelerates and encourages the preparation of international standards of cable identification intended for use by manufacturers, users or certification bodies. The present document makes reference to existing IEC standards such as IEC 60445 [3] and IEC 60050-195 [i.2].

For useful information, colours of cables inside equipment are considered in annex A as DC is already widely used, e.g. all the electronic being working only in DC, car and trucks electric circuit being in DC, solar PV power plants, etc.

1 Scope

The scope of the present document is to define common practice for identification of cabling or parts of the DC electric distribution for the Telecom sites (buildings/rooms) feeding ICT and facilities equipment (power plant, cooling, building access systems, monitoring, etc.).

This applies to 400VDC cabling for Telecom, ICT equipment and environment equipment using interface defined in ETSI EN 300 132-3-1 [8] or Recommendation ITU-T L.1200 [2] and avoids confusion between the DC colour and marking of up to 400VDC distribution and the other power interfaces identification: -48VDC distribution for A interface, AC and uninterrupted AC given by inverters or UPS used in the building.

The Recommendation defines:

- requirements for the colour and identification of separate wires used in DC distribution systems and installations, and as much as possible inside equipment between A or P interface and end use;
- marking and identification of DC multiwire cables, connectors and any associated equipment for DC power distribution;
- marking identification for sui-distribution boards and interconnection boxes.

For DC wires in multiwire cables Recommendations are given for harmonization with separate wire requirements.

Recommendations are given on other distribution items (wires, cables and interconnection items) including the functional earthing and bonding arrangement for distribution outside and inside equipment to avoid any confusion with DC distribution identification of the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

- | | |
|-----|---|
| [1] | Recommendation ITU-T L.1203: "Colour and marking identification of up to 400VDC power distribution for ICT systems". |
| [2] | Recommendation ITU-T L.1200 (2012): "Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment". |
| [3] | IEC 60445 Ed 5.0 2010-08: "Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors". |
| [4] | IEC 60757 (1983): "Code for designation of colours". |
| [5] | IEC 60417DB (2002): "Graphical symbols for use on equipment". |
| [6] | IEC 60617DB (2012): "Graphical symbols for diagrams". |

NOTE: IEC DB documents refer to Database of Graphical Symbol. Some are joint with ISO e.g. IEC 60417 and ISO 7000.

- [7] ETSI EN 300 132-2 (2016): "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)".
- [8] ETSI EN 300 132-3-1 (2012): "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V; Sub-part 1: Direct current source up to 400 V".
- [9] ETSI EN 300 253 (2015): "Environmental Engineering (EE); Earthing and bonding of ICT equipment powered by -48 VDC in telecom and data centres".
- [10] ETSI EN 301 605 (2013): "Environmental Engineering (EE); Earthing and bonding of 400 VDC data and telecom (ICT) equipment".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI EN 302 099: "Environmental Engineering (EE); Powering of equipment in access network".
- [i.2] IEC 60050-195 (1998): "IEC Terminology International Electrotechnical Vocabulary - Part 195: Earthing and protection against electric shock".
- [i.3] IEC 60050-826 (2004): "International Electrotechnical Vocabulary - Part 826: Electrical installations".
- [i.4] British Standard BS 7671 (2008): "Requirements for Electrical Installations. IET Wiring Regulations".
- [i.5] HD 308 S2:2001: "Identification of cores in cables and flexible cords".
- [i.6] HD 324 S1 (1977): "Colored insulation and bare wire identification package".
- [i.7] HD 384.5.514: "Identification, including 514.3: Identification of conductors, now withdrawn".
- [i.8] IEC 60364-1 (2005): "Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions".
- [i.9] IEC Guide 104: "The preparation of safety publications and the use of basic safety publications and group safety publications".
- [i.10] ISO/IEC Guide 51: "Safety aspects - Guidelines for their inclusion in standards".
- [i.11] ISO 6722 (2006): "Road vehicles - 60 V and 600 V single-core cables - Dimensions, test methods and requirements".
- [i.12] ISO 2574 (1994): "Flying machine electric cable - Identification marking".

NOTE: Available at http://www.iso.org/iso/fr/home/store/catalogue_ics/catalogue_detail_ics.htm?ics1=1&ics2=70&ics3=&csnumber=7536.

- [i.13] ISO 9247 (1990): "Ground work machine - electric wire and cables -- identification and marking principles".

NOTE: Available at http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=16897.

[i.14] IEC EN 60204-1 (2000): "Safety of machinery -Electrical equipment of machines -Part 1:General requirements".

NOTE: IEC/EN 60204-1 is now "Appliance of reference designations on machinery" in accordance with ISO/IEC/EN 81346 (September 2010) EU Directive 2006/42/EC on machinery (www.81346.com).

[i.15] IEC 60304 (1982): "Standard colours for insulation for low-frequency cables and wires".

[i.16] RAL® colour system.

NOTE 1: Referred to as "RAL" in the present document, available at <http://www.ralcolours.com/>.

NOTE 2: RAL® is the trade name of a colour matching system supplied by the RAL gGmbH (RAL non-profit LLC), which is a subsidiary of the German RAL Institute. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

[i.17] United States Federal Standard Colour system.

NOTE: Available at <http://www.federalstandardcolour.com/>.

[i.18] Pantone® colour system.

NOTE 1: Available at <http://www.pantone-colours.com/>.

NOTE 2: Pantone® is the trade name of a colour matching system supplied Pantone Inc. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

[i.19] IEC 60446 (withdrawn) (2007): "Basic and safety principles for man-machine interface, marking and identification - identification of conductors by colours or alphanumerics".

[i.20] CCSA YD/T 2378 (2011): "240V Direct Current Power supply system for Telecommunications".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

48VDC: -48 Volt Direct Current voltage as defined in ETSI EN 300 132-2 [7]

400VDC: up to 400 Volt Direct Current voltage as defined in Recommendation ITU-T L.1200 [2]

electrical equipment: item used for purposes like generation, conversion, distribution or utilization of electric energy (e.g. electrical machines, transformers, switch gear and control gear, measuring instruments, wiring systems, current-using equipment, etc.) (IEC 60050-826 [i.3])

identification: colour, graphical symbol, text in alphanumeric notation located on or adjacent to wire or cable terminals or junction boxes

IT (Isolation Terra): Isolation Terra earthing as defined in IEC 60364-1 [i.8]

NOTE: The two letters IT are coding one of the 3 families of electrical distribution where connection to earth is made through high resistance or impedance device i.e. HRMG in ETSI EN 301 605 [10].

line conductor: AC phase conductor or DC pole conductor (deprecated) conductor which is energized in normal operation and capable of contributing to the transmission or distribution of electric energy but which is not a neutral conductor (IEC 60050-195 [i.2])

RAL: colour coding for industry use [i.16]

TNS: AC distribution earthing arrangements as defined in IEC 60364-1 [i.8] where earthing and neutral wires are separated

3.2 Symbols

For the purposes of the present document, the following symbols apply:

A (interface)	ICT/Telecom equipment -48VDC power interface in ETSI EN 300 132-2 [7]
A3 (interface)	ICT/Telecom equipment up to 400VDC power interface in ETSI EN 300 132-3-1 [8]
P	ICT equipment up to 400VDC power feeding interface in Recommendation ITU-T L.1200 [2]

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3-D	3 Dimension
AC	Alternative Current
CMYK	Cyan, Magenta, Yellow, Key black
DC	Direct Current
EMC	Electro Magnetic Compatibility
HRMG	High Resistance Middle point Grounding
HTML	HyperText Mark-up Language
ICT	Information and Communication Technologies
IT	Information Technology
LVDC	Low Voltage Direct Current
MW	MegaWatt (unit)
OFC	Oxygen Free Cable
PE	Protected Earthing conductor
PEL	Protective Earthing conductor and Line conductor IEC 60050-195 [i.2]
PEN	Protective Earthing conductor and Neutral conductor IEC 60050-195 [i.2]
PV	Photovoltaic
RA	Remote Access
RFT-C	Remote Feeding Telecom-Current
RFT-V	Remote Feeding Telecom-Voltage
RGB	Red Green Blue
RYB	Red Yellow Blue
SELV	Safe Extra Low Voltage
UPS	Uninterrupted Power Supply
VAC	Voltage Alternating Current
VDC	Voltage Direct Current

4 Electrical Distribution identification coverage

The DC Electrical Distribution needs marking at the following different points:

- DC distribution lines (wires and cables)
- DC cabling inside DC power sources
- DC outputs from DC power systems with protective devices
- DC sub-distribution boards (with protective devices)
- DC interconnection boxes
- DC power plugs strips inside ICT equipment rooms and cabinets

Typical building and room distribution are provided in the following drawings:

- Building distribution with A interface (-48V), AC grid and inverter outputs power and A3 or P interface (up to 400VDC). The interface shall comply with:
 - for A interface ETSI EN 300 132-2 [7];
 - for A3 interface ETSI EN 300 132-3-1 [8];
 - for interface P Recommendation ITU-T L.1200 [2].

Figure 1 shows such building where distribution DC and protective earthing-[PE] bonding shall comply with ETSI EN 301 605 [10] and ETSI EN 300 253 [9].

- Example of power feeding distribution of DC from centralized or decentralized permanent power supply at building or technical room level (figure 2).

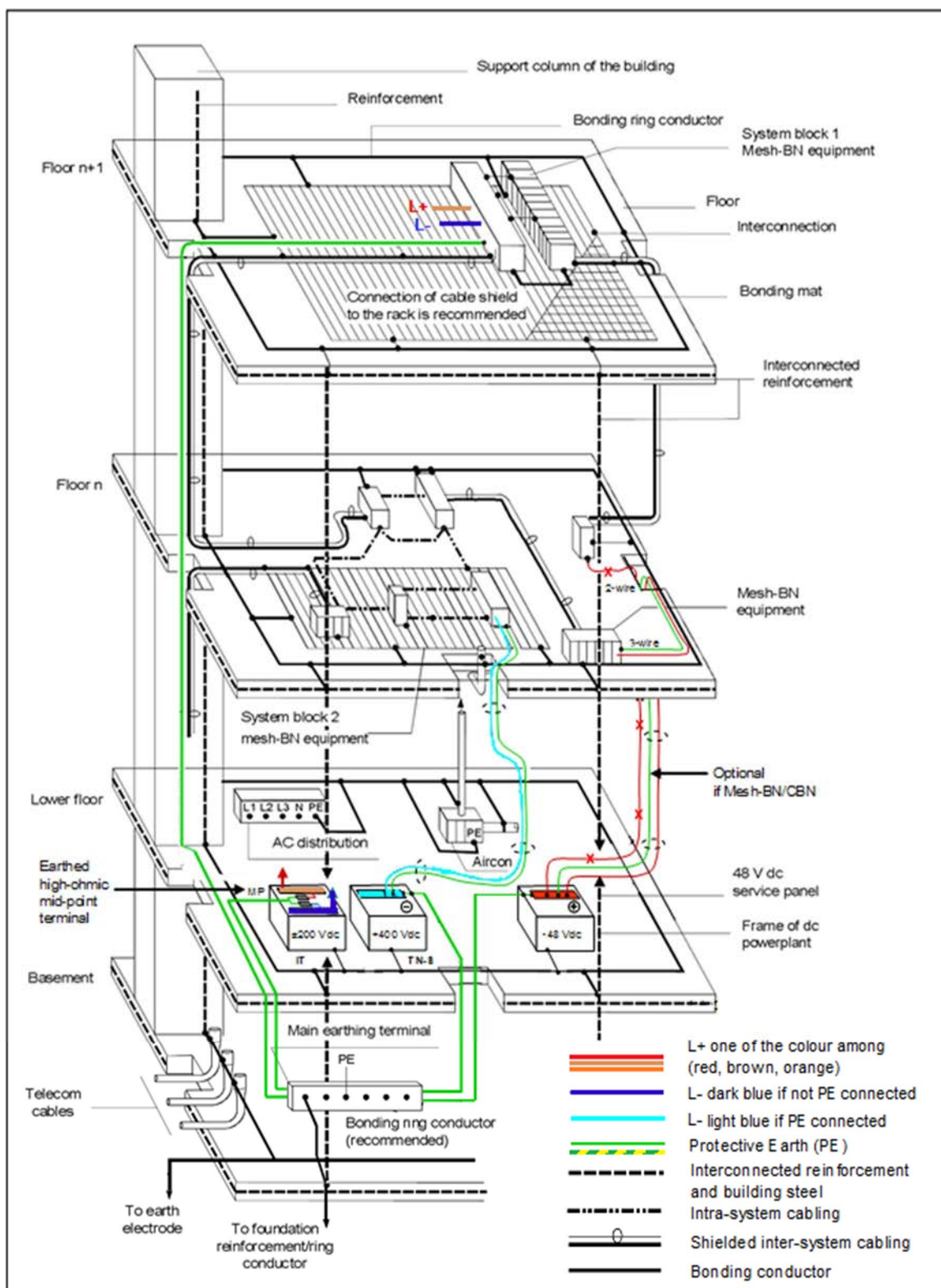


Figure 1: DC distribution at building level from DC source to ICT/telecom systems

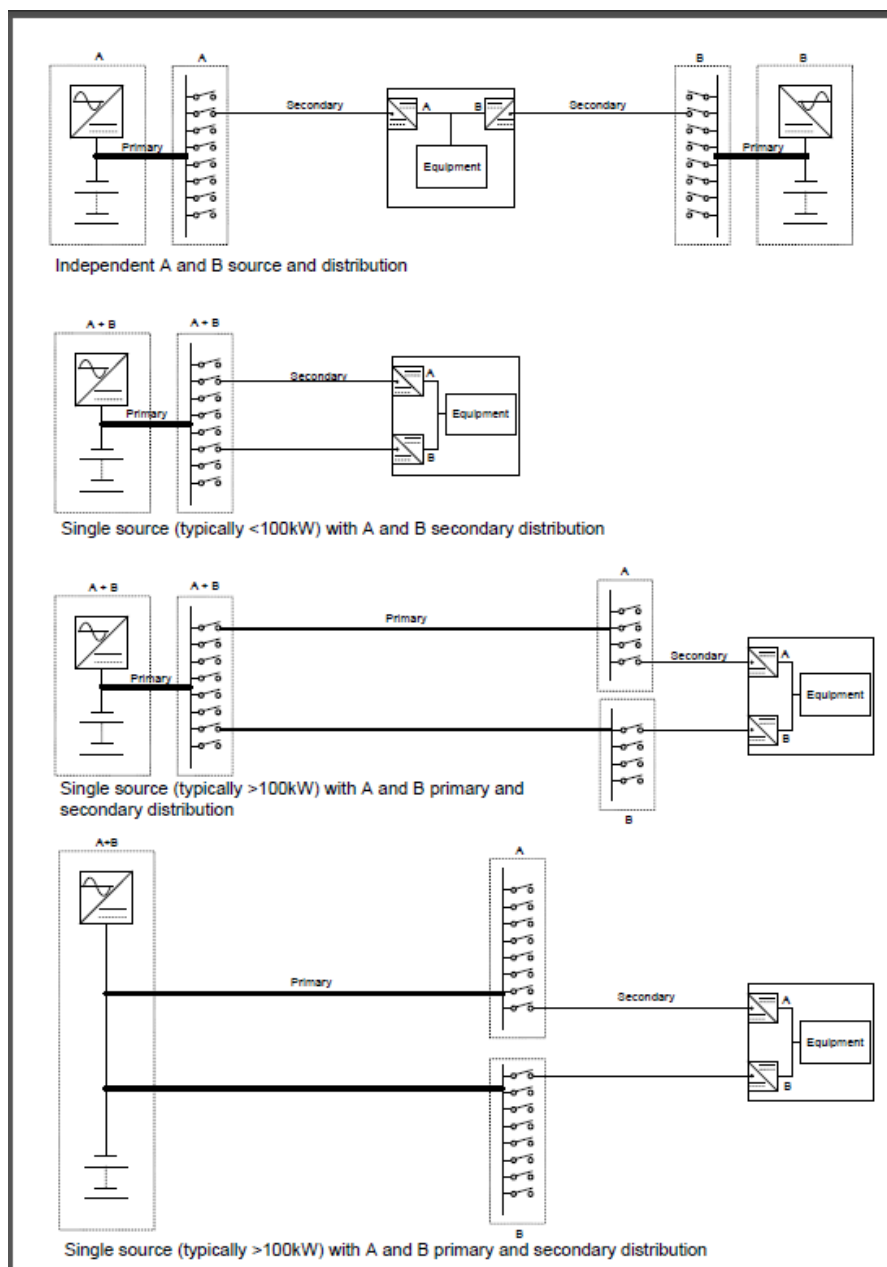


Figure 2: Example of different DC architectures and distributions at building or technical room level from DC source to ICT/telecom equipment

5 Identification principle

5.1 General rules

The Recommendation ITU-T L.1203 [1] shall be applied.

The identifying colour, graphical symbol or alphanumeric notation shall be located on, or adjacent to the corresponding terminal.

There shall be no confusion between the different identification modes i.e. wire insulation colour or coloured sleeve, interconnection device colour and graphical symbol or text.

For identification of conductors, only colours and code among those permitted in IEC 60757 [4] shall be used (see annex A).

The identification of colour is required end to end in the installation for DC from DC source to interface A3 or P and inside equipment till internal end use inside ICT or facilities equipment (Cooling, Power conversion, Sub distribution, etc.).

DC cabling inside power source equipment is recommended to use the same marking and colour as defined in the power feeding distribution.

It is accepted to have different identification marking solution along an end to end distribution (insulation colour, markers, sleeves, symbol and text, etc.) provided they are compliant to the present document. In that case wires and cables termination shall use these clear marking solutions.

The colour and marking identification requirements shall be applied on new installation at level of room or building and on new equipment. It may be partially applied or not applied on an existing electrical installation. When partially applied the alteration of existing installation shall be fully documented for avoiding confusions in colour and marking.

5.2 Colour and marking of up to 400VDC conductor wires and cables for A3 or P interface

The identification by colour of each conductor segment of the installation shall be used at each termination and should be added preferably throughout all the length of the conductor. The colour markers shall be integral colour of the insulation of the conductor when possible. It can be added text markers e.g. by using sleeves or attachable text rings at short enough distance to avoid confusion (e.g. in cable paths filled with many wires).

NOTE 1: Text marking should be used as much as possible as it is non ambiguous and is clear.

For bare conductors the colour identification shall be at termination and connection points.

If the separate wire insulation is using the colour defined in table 1, no other colour markers are required on the wire.

Single wire:

Single wire of new installation shall use identification by the colours and marking defined in table 1. It is highly recommended to use wire with insulation having the colour defined in table 1 for user and maintenance simplification.

In case of extension or alteration of existing installation, it shall be added marking respecting table 1 on wires that are not yet using colours defined in table 1. Identification markers such as sleeves or rings following rules defined in clause 3.1 are possible.

Multiwire cables:

If the wire inside a multiwire cable has not the colour defined in table 1 (see possible reason in clause 3.1), it shall be added marking colour respecting table 1 with describing text e.g. by sleeves or ring at both ends.

For single and multiwire cable, the functional identification of the wire by labels or rings with alphanumeric character shall be the same.

NOTE 2: Clause 4 is defining how the multiwire cable itself is labelled to identify the voltage type and level (e.g. DC 400V) in coherence with other distribution elements.

The colour and marking requirements do not apply for existing equipment distribution and cabling.

It shall be applied on completely new installation and equipment.

Additional markings to table 1, for example alphanumeric and colour marking, are allowed provided they do not introduce any ambiguous understanding for users.

NOTE 3: Table 1 does not define terminals/conductors marking used for earthing with their different purposes of earthing (divided as two basic concept of protective earthing and functional earthing), but requires to use colours and marking of existing IEC standard. In compliance with IEC 60445 [3], the requirements for functional earthing should be defined by the manufacturer or the relevant product committee and should be specified within the documentation of the equipment. Other requirements for handling EMC issues are defined in ETSI EN 301 605 [10].

Other conductor types:

Identification by colour or marking is not required for:

- concentric conductors of cables;
- metal sheath or armour of cables when used as a protective conductor;
- bare conductors where permanent identification is not practicable;
- extraneous-conductive-parts used as a protective conductor;
- exposed-conductive-parts used as a protective conductor.

Table 1: Requirements for up to 400VDC colour and marking for separate wires and for wire in multiwire cables

DC lines	Colour marking	Text Marking	Optional Graphic symbol marking	Standard bases
Circuit or installation downstream and upstream interface A3 or P external or internal to equipment	Integral to wire insulation material or on markers (sleeves, rings, ...) for wire in multiwire cables or wires in installation alteration	Text on cable jacket/label or attached to connectors	On wire jacket or label	For colour and graphical symbols
Positive line	Red (brown or orange tints according to RAL note 3) (note 1)	L+ and voltage level e.g. 380VDC	+	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
Negative line HRMG	Blue (dark or violet tints according to RAL note 2) (note 1)	L- and voltage level e.g. 380VDC	-	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
Negative line connected to PE	Light blue (note 1, note 2)			
NOTE 1: For multiwire cables and alteration of existing installation with separate wires (e.g. for extension), when the insulation colours of wire is different from the one of table 1, identifiers of clause 3.1 should be used (e.g. sleeves).				
NOTE 2: The blue colour of L- of HRMG type (IT network) should be clearly different from the turquoise or light blue (blue + green) usually chosen for conductor connected to PE. It should be a dark, marine, violet or night blue RAL type. Refer to annex B for colour range and annex C for choice of RAL colour.				
NOTE 3: The colour of L+ conductor is chosen in a set of RAL colour (red, red-brown or red-orange) - Refer to annex B for colour range and annex C for choice of RAL colour.				
NOTE 4: It is not easy to distinguish between Light blue and blue for negative line HRMG: It is suggested to use text marking for L+ and L- with (+190VDC, -190VDC) or (+ 380VDC, 0V). which can help clearly distinguish the two different earthing systems.				

It is suggested to use text marking with +190VDC, -190VDC or +380VDC, 0VDC which can help to distinguish the two different earthing systems clearly.

5.3 Additional recommendation for other DC voltage distribution cabling than up to 400VDC voltage of A3 interface

Table 2 adds some recommendations for -48V distribution colour and marking, to avoid at maximum confusion with up to 400VDC distribution. The -48V corresponds to interface A of ETSI EN 300 132-2 [7].

It should be applicable also to other LVDC voltage than up to 400VDC defined for A3 interface.

Table 2: Recommendation for -48VDC colour and marking

DC lines	Colour marking	Text Marking	Optional Graphic symbol marking	Standard bases
Circuit or installation downstream and upstream interface A external or internal to equipment	Integral to wire insulation material or on markers (sleeve, ring, etc.) for wire in multiwire cables or wires in installation alteration	Text on cable jacket/label or attached to connectors	On wire jacket or label	For colour and graphical symbols
Positive Line	not defined (note)	L+ (-48V)	+	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
Negative Line	not defined (note)	L- (-48V)	-	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
NOTE: Colours are not defined as many national and industry standards are already widely deployed. The use of the colour of L- of HRMG type (IT network) of table 1 should not be used to avoid confusion with line connected to PE.				

6 DC distribution devices additional colour and marking

6.0 Colour and marking of up to 400VDC other distribution device than wires and cables

Table 3 gives requirements for colours and marking of electrical boxes.

Table 3: Requirement for colours and marking electrical boxes

Interface	Material or label background colour (note 1)	External Text writing colour on background	Single voltage Compartment Text	Standard bases
	Box external marking	Box external marking		For colour and graphical symbols
A3 (400VDC)	different from A and AC	(note 2)	DC voltage level e.g. 380 V earthing arrangement: HRMG or L- to earth or L+ to earth	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
A (-48VDC)	different from A3 and AC	(note 2)	DC -48 V L+ to earth	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
AC	different from A3 and A	(note 2)	AC (nominal voltage) Voltage level e.g. 230 V IT, TNS, etc.	IEC 60617 [6] IEC 60417 [5] IEC 60757 [4]
NOTE 1: For the background colours, it can be integral colours of the box plastic material or painted colour, or an added wide label using the defined back and text colours of table 3 on new installation.				
NOTE 2: Symbols for DC and AC of IEC 60417 [5]. The chosen colour should be very readable on the chosen background colour.				

6.1 General requirements

In general in a building the distribution cables are not going directly from source to equipment (see figure 2) for many reasons: cabling length consideration, maintenance and extension, protection selectivity, power architecture and reliability optimization, etc.

Interconnection boxes or distribution boards are used in Data centers or in Telecom network sites in many places along the electrical distribution e.g. in elevated floor, in wall mounted configurations, at heads of Telecom equipment or servers rows, etc.

There should not be mixed distribution of 48VDC, AC and 400VDC inside the same box or there should be separated compartments for each with proper marking.

NOTE: National electrical safety rules have to be applied for this matter.

In addition to conductors colour and marking, there shall be additional identification to avoid any risky confusion [6] between -48VDC, 400VDC, and AC outputs at level of cabinets, racks or shelf and sui-blocks or modules inside.

Interconnection arrangements with different voltage range and type shall have different colours for easy identification. The table 3 requirement shall be applied for up to 400VDC distribution (A3) and should be applied for -48VDC (A) and AC distributions.

6.2 DC outputs from DC power systems with protective devices

The colours and marking should be the same as for DC interconnection boxes in table 3:

- Writing and background colours on labels
- The frames itself should be of the background colour of the labels (e.g. white, orange, blue)
- Marking of terminals and voltage

There shall not be mixed distribution of 48VDC, 400VDC, AC in the same mechanical module without proper insulation separator.

6.3 DC sub-distribution boards (with protective devices)

The colour and marking should be the same as for DC power systems outputs.

There shall not be mixed distribution of 48VDC, 400VDC, AC in the same mechanical module without proper insulation separator.

6.4 DC power plugs strips inside ICT equipment rooms and cabinets

The colour and marking should be the same as for DC power systems outputs.

A coloured round circle around each socket using respective colour of table 3 for respective voltage type could be used rather than full plastic colour.

7 Durability of Marking and reading errors limitation

All clause 7.1 of IEC 60445 [3] shall be applied.

Annex A (informative):

Review of Standards or common use of colour and marking of distribution cabling in AC and DC in buildings and equipment

A.1 Recommended colours for wires in IEC 60757 and IEC 60445

The recommended colours of wires are given in Annex B of IEC 60757 [4], table B.1- Recommended colours and code.

The following are preferred:

- Black BK Blue BU, Brown BN, Green GN, Orange OG, Red RD, Violet (purple) VT, White WH, Yellow YE.
- Other colours may be used based on agreement between customer and supplier (see IEC 60757 [4]).
- More colours and codes are in national standard such as DIN transposition of IEC 60757 [4]:
 - GreY GY, PinK PK, GolD GD, TurQuoise TQ, SilveR SR.

IEC 60445 [3] permits the following colours for identifying conductors:

- Black BK, Blue BU, Brown BN, Green GN, Orange OG, Red RD, Violet (purple) VT, White WH, Yellow YE, GreY GY, PinK PK, TurQuoise TQ.

The colours green and yellow on their own are only permitted where confusion with the colouring of the green/yellow protective conductor is unlikely. Combinations of the above colours are permitted, but green and yellow should not be used in any of these combinations other than as green/yellow for the protective conductor.

If a circuit includes a neutral or midpoint conductor, then it should be identified by a blue colour (preferably light blue). Light blue is the colour used to identify intrinsically safe conductors, and should not be used for any other type of conductor.

A.2 Other Norms or specifications

A.2.0 Introduction

Other activity sectors have standardized cabling and marking for their specific sector:

The International Standard ISO 6722 [i.11] specifies the dimensions, test methods, and requirements for single-core 60 V cables intended for use in road vehicle applications where the nominal system voltage is lower than 60 VDC or 25 VAC. It also specifies additional test methods and/or requirements for 600 V cables intended for use in road vehicle applications where the nominal system voltage is in the range between 60 VDC or 25 VAC to 600 VDC or VAC. It also applies to individual cores in multi-core cables. It does not define colours of wire.

A.2.1 Single and bicolours cables used in transportation sector

To avoid any confusion, it is important to know that some industry sectors such as transportation (car, vans, boats, planes) are defining specification of single or bicolour wires for specific use of DC power e.g. motor sensors or auxiliary circuits. Figure A.1 is giving examples of bicolour wire insulation.



Figure A.1: Example of bicolour wire insulation

A.2.2 Cables used in flying aircrafts, ground works machines and boats

ISO 2574 [i.12] provides Flying machine electric cable identification marking and ISO 9247 [i.13] provides Ground work machine electric wire and cables identification and marking principles.

NOTE: The ship and boat sector also has specifications.

A.2.3 Colour of personal computer power cables

There is a common practice for colours cabling mostly used in "ATX" design of personal computer tower as defined in table A.1.

Table A.1

Wire colour	Function	Wire colour	Function
Black	ground power	Green	Power on
Orange	+3,3 V power	Purple	+5 V standby
Red	+5 V power	Grey	Power good
Yellow	+12 V power	Brown	+3,3 V sense
Blue	-12 V power	White	-5 V

A.2.4 Machine Cabling

IEC EN 60204-1 [i.14] standard on electric machines cabling was imposing light blue for neutral if the equipment has a DC circuit and dark blue for the negative pole in order to better discriminate AC and DC circuits.

A.2.5 Family of cables coding

This clause is giving indication on cable type codification and showing that transparent insulation is used in some case. Each type of wire or cable has a coding for a wide variety of use as seen in following examples:

Fixed Installations and electric board cabling

H07VU or VR, H07VK cable

- H: harmonised
 - 07: max voltage 700 volt.
 - V: Polyvinyl Chloride (PVC).
 - U: single core copper.
 - R: hard multicore conductor.
 - K: flexible multiwire.

U1000R2V cable

- 2V: double insulation PVC.

Codification (G or X) indicates ground cable, number of wires and section.

- Example: U1000R2V 3G 1,5 mm².
- U1000R2V 3 × 1,5 mm² means 3 wires, without ground yellow/green.

H03VVF/H05VVF

- VV: insulation with PVC material.
 - 03: <1 mm² (2 wires).
 - 05: > 1 mm² (2 to 5 wires, for single or 3 phases).
 - F: soft wire.

H03VVH2F

- H2F: harmonised with 2 soft wires.

H07RNF

- Elastomeric insulation - (Neoprene).

H03RTF

- **Transparent** or sleeved copper for lighting, or other household device.

Hi-fi Wires

- For audio equipment including in vehicles and home cinema.
- Blue, red, black, white and **transparent**.
- Section: 0,75 to 6 mm².

Better in OFC (Oxygen Free Cable), less oxidized.

A.3 Building distribution cable colour and marking standards

A.3.1 Introduction

The standard about colour cable has changed with time from IEC 60446 [i.19] withdrawn to new IEC 60445 [3].

NOTE: The IEC 60446 standard Third edition 1999-02 of IEC 60446 [i.19] has been withdrawn but was giving information on the "Basic and safety principles for man-machine interface, marking and identification - Identification of conductors by colours or numerals".

The scope was focused on general rules for the use of certain colours or numerals to identify conductors with the aim of avoiding ambiguity and ensuring safe operation. These conductors may be applied in cables or cores, busbars, electrical equipment and installations. It is based on the principles given in IEC Guide 104 [i.9] and ISO/IEC Guide 51 [i.10].

A.3.2 Low frequency cable and wire reference insulation colour in IEC 60304

There has been an harmonization in AC building distribution since 1970 towards conductors insulations colours and jackets of optical cables. The allowed colours suggested for standardization are proposed in IEC 60304 [i.15] defining the thermoplastic insulation for low-frequency cables and wires and the colours to be used as follows:

- **Light blue:** neutral.
- **Red or brown:** phase.
- **Bicolour Yellow and green:** earth.

In addition, some use of colours are preferred but not required:

- **Orange:** phase at the output of a receiver, e.g. phase in red or brown is connected to a lighting bulb and the other wire is connected to the interrupter with an orange wire (and not red).
- For « shuttle » line between 2 inverters of a forth and back circuit: all colours excepted the previous one and earth colour are allowed (white, grey).

A.3.3 New (IEC 60445)

A.3.3.0 General information om IEC 60445

The standard IEC 60445 [3] is providing basic and safety principles for man-machine interface, marking and identification of equipment terminals, conductor terminations and conductors.

The old colours used in Europe are reminded.

A.3.3.1 Old Cable Colour Code reminder

Power cable insulation is normally colour coded so that phase, neutral and earth conductors can be easily identified. These colour codes vary with region and/or country as can be found in IEC 60445 [3].

A.3.3.2 Harmonized Cable colours

Identification colours of cores in cables have been subject to developments that results in the harmonization document HD 308 S2 [i.5].

These rules do not apply to conductors used in the materials and sets assembled at the factory although compliance is strongly recommended. A short extract of HD 324 S2 [i.6] is showing the colour choices for AC wires in cables.

A.3.3.3 Marking and alteration for cohabitation of harmonized and old Cable colours

This clause is useful to understand how to manage the cohabitation of old and new colour and marking in installation.

For information, old national habits are reminded. These cables are still widely present in existing installations.

The requirements of BS 7671 [i.4] were harmonized with CENELEC Standards HD 384.5.514 [i.7] now withdrawn and an Amendment No 2: 2004 (AMD 14905) to BS 7671 [i.4] was implemented for the harmonized cable core colours and the alphanumeric marking of the following standards based on HD 308 S2 [i.5], IEC 60445 [3] and IEC 60446 [i.19].

A guidance is provided on marking at the interface between old and harmonized colours and marking general guidance on the colours to be used for conductors.

BS 7671 [i.4] has also been modified to allow suitable methods of marking connections by colour (tapes, sleeves or discs), or by alphanumerics (letters and/or numbers). Methods may be mixed within an installation.

An addition or an alteration made to a single-phase installation need not be marked at the interface. The old cables correctly identified by the colour red for line and black for neutral, can be interconnected to the new cables correctly identified by the colour brown for line and blue for neutral.

Where an addition or alteration is made to a two- or three-phase installation wired in the old core colours with cable to the new core colours, unambiguous identification is required at the interface. Cores should be marked as follows:

- Neutral conductors: Old and new conductors: N.
- Line conductors: - Old and new conductors: L1, L2, L3.

BS 7671 [i.4], table 7A is giving an example of conductor marking at the interface for additions and alterations to an AC installation identified with the old cable colours.

A.3.4 DC coding evolution

A.3.4.1 BS 7671 case

New colour and alteration are proposed in DC cabling and unambiguous identification is required at the interface as for AC.

BS 7671 [i.4], table 7E gives an example of conductor marking at the interface for additions and alterations to a DC installation identified with the old cable colours.

A.3.4.2 Wire colours in China industry and standards

China has also defined colour coding for DC cable:

- 1) -48VDC system marking:

For China Telecom and Unicom:

L+ Red

L- Blue

For China mobile:

L+ Red

L- Light Blue

- 2) Up to 400VDC system marking:

For China Telecom and China mobile and in CCSA standard YD/T 2378 [i.20]:

L+ Brown

L- Blue

AC wire colours in China:

Blue (N line)

Red, Yellow, Green (Live lines)

- 3) Ground wire for all:

For all operators in China:

Yellow and green

A.3.4.3 Wire Colours in up to 400VDC DC Solutions

For some server, the hardwired cords that connect to the PDU are code coloured yellow, blue, and brown. Their functions are:

- Yellow: earth-ground
- Blue: negative DC voltage wire
- Brown: positive DC voltage wire

NOTE: This is compliant with the present document if blue.

A.3.4.4 Colours and marking of DC cables in Republic of Korea

Different DC voltage cables do not share the same power distribution panel. Power distribution panels are identified by marking, the voltage level, on the external cover.

DC + (positive) cable is identified with red colour and DC - (negative) with blue colour.

1) -48VDC:

- DC + (positive) Red
- DC - (negative) Blue

2) up to 400VDC:

- DC + (positive) Red
- DC - (negative) Blue

Annex B (informative): Justification of the identification wire colour choices

The choice of colour put in table 1 of the present document has been carefully made considering information of this annex and colour codes for quality manufacturing.

Some optimization reasons are provided:

Only single colour of list of IEC 60757 [4] and not bicolour solution to ensure lower cost due to mass market.

- Black and red are massively used for L- and L+ in DC while black is standardized at international level for AC live conductor and red is used also in some countries (see annex 1). Dark blue is defined as negative conductor inside mechanical tool machine using DC. Black or blue and red are used in some countries for Telecom site cabling from source to interface A. As a consequence it was decided better to discriminate higher DC voltage of interface A3 from interface A and other uses which means using dark blue for up to 400VDC L- line.
- Orange and violet are almost diametrically opposed on the colour wheel (figure B.1). Both are made in combination with the red colour that can give a kind of high voltage warning for live or hot conductor L+ and L-, while the neutral or cold conductor is ice light blue (commonly close to cyan, a mix of blue and green). While being more subjective, Red or Orange are very live colours as they are pure red or mix of red and yellow, adapted to the wish of a positive colour for positive line, dark blue or blue-violet combining red and dark blue are dark colour adapted for a negative colour for negative line.
- Considering multiwire cable: AC cables are usually compliant with DC voltage and have standard colours of IEC 60757 [4] and so industry has considered to reuse as they are widely produced. In these cables brown and blue could be used for DC according BS 7671 [i.4]. Brown can be considered close to orange or red as seen in figure B.1.

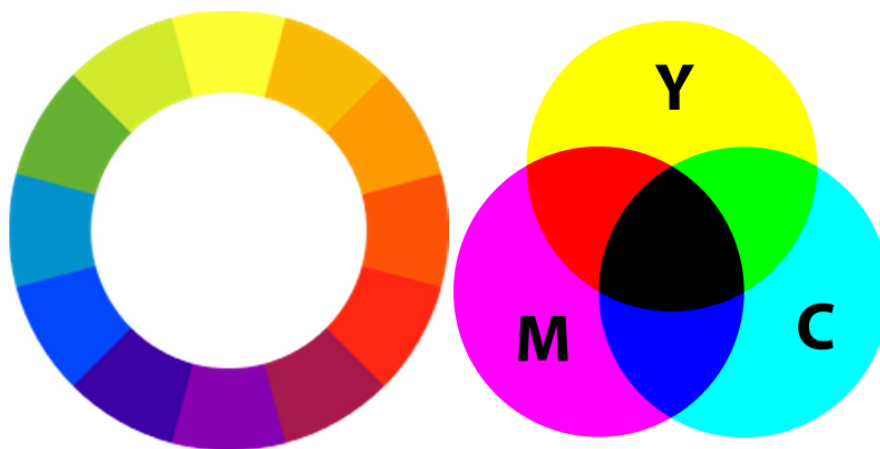


Figure B.1: colour wheel RYB (Red Yellow Blue), used in artistic painting before CMYK (cyan, magenta, yellow, and key-black) set of 3 subtractive primary colours + black used in modern printing in subtractive colour

Annex C (informative):

Wire colour choice in colour range industrial specification

For industry quality reason, RAL colour range code is proposed.

For industry quality reason, a repeatable and unambiguous colour scheme is necessary. The present document proposes using the RAL colour system [i.16] including colours range code. The RAL² 840 (RAL classic) colour ranges are listed in table C.1. A main criterion for colours in the RAL Classic collection is to be of "paramount interest". Therefore most of the colours in it are used on warning signs or are dedicated to government agencies and public services such as for security signals and safety marking. Some wire manufacturers are engaged in carefully respecting the insulation colour defined with RAL colours reference and ensuring stability with time and exposition to light or chemical agents.

Table C.1: RAL 840 (RAL classic) colours range

Range	Range Name	First	Last	Quantity
RAL 1xxx	Yellow	RAL 1000 Green Beige	RAL 1037 Sun Yellow	40
RAL 2xxx	Orange	RAL 2000 Yellow Orange	RAL 2013 Pearl Orange	14
RAL 3xxx	Red	RAL 3000 Fire Red	RAL 3033 Pearl Pink	34
RAL 4xxx	Violet	RAL 4001 Red Purple	RAL 4012 Pearl Black Berry	12
RAL 5xxx	Blue	RAL 5000 Violet Blue	RAL 5026 Pearl Night Blue	25
RAL 6xxx	Green	RAL 6000 Patina Green	RAL 6038 Luminous Green	36
RAL 7xxx	Grey	RAL 7000 Squirrel Grey	RAL 7048 Pearl Mouse Grey	38
RAL 8xxx	Brown	RAL 8000 Green Brown	RAL 8029 Pearl Copper	20
RAL 9xxx	White/Black	RAL 9001 Cream	RAL 9023 Pearl Dark Grey	14

RAL colours could be seen in RAL [i.16] with RGB decimal and hexadecimal coding.

For better application of the present document each insulation colour is associated with a set of referenced colours. The main one are indicated first, other RAL are indicated as possible. Correspondence with other colour specification can be done (see at the end of this annex).

L+

 **Red**

RAL 3031 (red)

Other RAL: 3000 (flame red), 3001 (signal red), 3002 (carmine red), 3020 (traffic red), 3024 (luminous red), 3028 (pure red)

 **Orange**

RAL 2010 (signal Orange)

Other RAL: 2001 (red orange), 2002 (vermillion), 2003, 2004 (pure orange), 2005 (luminous orange), 2008 (bright red orange), 2009 (traffic Orange), 2011 (deep orange)

 **Brown**

RAL 8002 (signal brown)

Other RAL: 8003 (clay brown), 8004 (copper brown), 8012 (red brown), 8023 (orange brown), 8029 (pearl copper)

L- non connected to PE (IT network)**Dark blue or marine****RAL 5002 (ultramarine blue), 5003 (night blue), 5010 (dark blue), RAL 4005 (blue lilac)**

Other RAL: 5000 (violet blue), 5005 (signal blue), 5015 (mid blue), 5022 (night blue), 5026 (pearl night blue)

Return line connected to PE (IT network)**L-, neutral and +0V of (-48V) in some cases****Light blue/Cyan****RAL 5012 (light blue), 5015 (sky blue), 5024 (pastel or very light blue)**

Other RAL: 5018 (turquoise blue), 5023 (distant blue), 6027 (cyan-light green)

Other colour reference standards or specification

Some other colour standards or reference specifications exist:

- Federal Standard 595C (FS) referred in USA Federal Standard colour system [i.17]
- Pantone references for paints and plastic powders referred in Pantone colour system [i.18]

A correspondence tool between colour references (RAL, Pantone, RYB, RGB, CMYK, etc.) and accurate colour measurement can be found in colour correspondence available at <http://rgb.to/>.

The conversions are based on both Hunter and CIElab 3-D colour dimensional systems and measurement equipment where L or L* represents lightness/darkness, a or a* represents red/green and b or b* represents yellow/blue. When comparing various samples, or a sample to a reference standard, Δ (delta or difference) values are reported, then the distance to the reference is calculated in RMS value (root square of the sum $\Delta L^2 + \Delta a^2 + \Delta b^2$). A 3-D graph is sometimes proposed to show the relationship of these values.

Annex D (informative): Bibliography

ISO/IEC 81346-1 (2009): "Industrial systems, installations and equipment and industrial products structuring principles and reference designations -- Part 1: Basic rules".

History

Document history		
V1.0.2	October 2016	Membership Approval Procedure MV 20161212: 2016-10-13 to 2016-12-12
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