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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems

Recommendation ITU-T L.1203

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ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.1203

Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems

Summary

Recommendation ITU-T L.1203 defines the requirements and guidelines for DC power distribution identification by colour and marking in Telecom/ICT installations (wire, cables, electric distribution boards, interconnections, etc.). It avoids confusion and errors between the different AC and DC power interfaces and distributions used in buildings and inside Telecom/ICT systems, as 400 VDC power feeding interfaces standardized in Recommendation ITU-T L.1200 is used more, increasing power density of ICT equipment, energy efficiency, simplified reliable power feeding architecture, costs optimisation, etc. Recommendation ITU-T L.1203 supports the progressive introduction of up to 400 VDC installations in cohabitation with the existing −48 V and AC distribution.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1203	2016-02-02	5	11.1002/1000/12659

Keywords

Colour, direct current (DC), identification, installation, marking, power cable.

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Introduction

This Recommendation 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 [b-EN 300 132-2]).

This document was developed jointly by ETSI TC EE and ITU-T Study Group 5 and published as Recommendation ITU-T L.1203 and ETSI Standard ES 203 408, which are equivalent in technical content. DC has been the main source of power of the 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 ITU-T Recommendation and ETSI Standard. It is also recognized that further standardization activities on LVDC is now starting in other standardization organizations such as IEC. Thus ITU-T and 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 centres, and customer sites. The legacy interface for billions of equipment is the SELV voltage range so called −48 V, where the plus pole is grounded as defined for example for interface "A" in [b-ETSI EN 300 132-2]. Other complementary ETSI standards define a whole DC distribution including earthing and bonding such as [b-ETSI EN 300 253].

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 [b-ETSI EN 302 099].

Higher power density of ICT equipment and overall site power in MW for data centres, have led to the use of higher voltage firstly in AC single or 3 phases up to 400 VAC at the input of servers. The need for resilience, energy efficiency and cost optimization has pushed the introduction of the up to 400 VDC power feeding interface standardized in [b-ETSI EN 300 132-3-1] and in [ITU-T L.1200]. 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 [b-ETSI EN 301 605] was 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 centre 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 the use of DC by the telecom sector, this Recommendation aligns with the safety principles laid down in [b-IEC Guide 104] and [b-ISO/IEC Guide 51]. It accelerates and encourages the preparation of international standards of cable identification intended for use by manufacturers, users or certification bodies. This Recommendation makes reference to existing IEC standards such as [IEC 60445] and [b-IEC 60050-195].

Considering that DC is widely used in all electronic equipment, e.g., the electric circuit in cars and trucks, solar PV power plants, etc., Appendix I provides useful information on colours of cables inside equipment.

Recommendation ITU-T L.1203

Colour and marking identification of up to 400 VDC power distribution for information and communication technology systems

1 Scope

The scope of this Recommendation is to define common practice for identification of cabling or parts of the DC electric distribution inside buildings and rooms and inside telecom, ICT and facilities equipment (power plant, cooling, building access, monitoring, etc.).

This applies to 400 VDC cabling for telecom, ICT equipment and environment equipment using interface defined in [b-EN 300 132-3-1] or [ITU-T L.1200] and avoids confusion between the DC colour and marking of up to 400 VDC distribution and the other power interfaces identification: −48 VDC 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 sub-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 this Recommendation.

2 Reference

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1200] Recommendation ITU-T L.1200 (2012), *Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment.*

[IEC 60417] IEC 60417DB (2002), *Graphical symbols for use on equipment.*

[IEC 60445] IEC 60445 Ed 5.0 (2010), *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors.*

[IEC 60617] IEC 60617DB (2012), *Graphical symbols for diagrams.*

[IEC 60757] IEC 60757 (1983), *Code for designation of colours.*

NOTE – IEC DB documents refer to database of graphical symbol. Some are joint with ISO e.g., IEC 60417 and ISO7000.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 electrical equipment [b-IEC 60050-826]: Item used for such purposes as generation, conversion, distribution or utilization of electric energy, such as electrical machines, transformers, switch gear and control gear, measuring instruments, protective devices, wiring systems, current-using equipment.

3.1.2 line conductor [b-IEC 60050-195]: 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 or mid-point conductor.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

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

3.2.2 48 VDC: Defines the −48 Volt Direct Current voltage range as standardized in [b-EN 300 132-2].

3.2.3 400 VDC: It defined up to 400 Volt Direct Current voltage range as standardized in [ITU-T L.1200].

3.2.4 IT: IT Isolation Terra is the two letter coding of one of the 3 families of earthing arrangements as defined in [b-IEC 60364-1], in which the electrical distribution is connected to earth through high resistance or impedance device i.e., HRMG in [b-EN 301 605].

3.2.5 RAL: Name of RAL colour coding for industry use.

4 Abbreviations and Acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
CMYK	Cyan, Magenta, Yellow, Key black
DC	Direct Current
HTML	Hypertext Mark-up Language
HRMG	High Resistance Middle point Grounding
PE	Protected Earthing conductor
PEL	Protective Earthing conductor and Line conductor
PEN	Protective Earthing conductor and Neutral conductor
RGB	Red Green Blue
RYB	Red Yellow Blue
3-D	3-Dimensional

5 Conventions

A (interface) Name of ICT/telecom equipment −48 VDC power interface in [b-EN 300 132-2]

A3 (interface) Name of ICT/telecom equipment up to 400 VDC power interface in ETSI [b-EN 300 132-3-1]

P Name of ICT equipment up to 400 VDC power feeding interface in [ITU-T L.1200]

6 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 or (−48 V) interface, with AC power from AC grid, or AC inverter outputs and with up to 400 VDC A3 or P interface. Figure 1 illustrates such building DC distribution and earthing-PE bonding in compliance with [b-EN 301 605] and [b-EN 300 253];

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

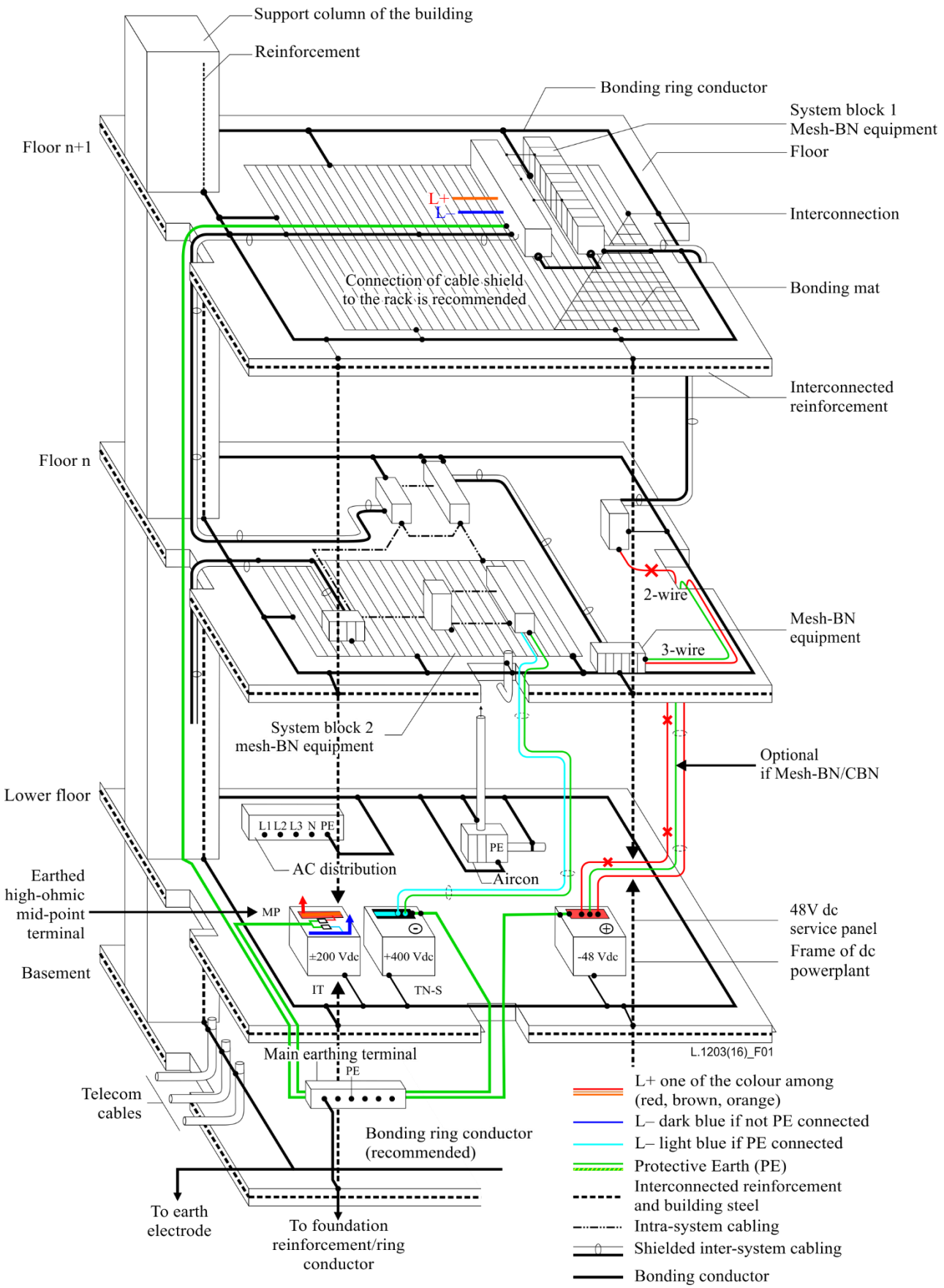

Figure 1 – DC distribution at building level from DC source to ICT/telecom systems

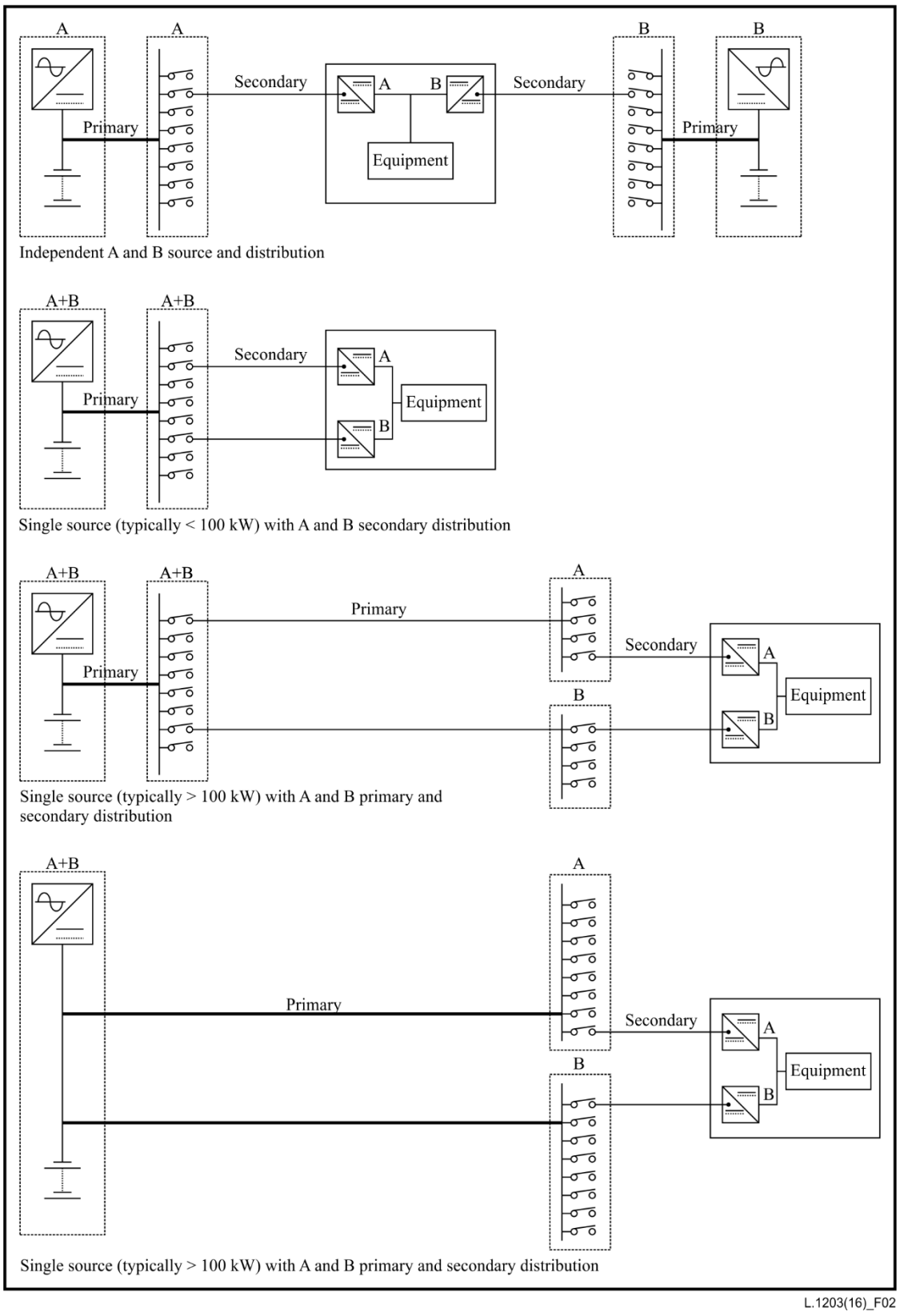

Figure 2 – Example of different DC architectures and distributions at building or technical room level from DC source to ICT/telecom equipment

7 Identification principle

7.1 General rules

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] shall be used (see Appendix I).

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 shall use the same marking and colour as defined in the power feeding distribution.

It is acceptable to have different identification marking solution along an end to end distribution (insulation colour, markers, sleeves, symbol and text…) provided they are compliant to this standard. 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 the level of room or building and on new equipment. It may be partially applied or not applied at all on an existing electrical installation. When partially applied the alteration of existing installation must be fully documented to avoid confusions in colour and marking.

7.2 Colour and marking of up to 400 VDC 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 the integral colour of the insulation of the conductor when possible. Colour markers can be added by using coloured sleeves or attachable rings at short enough distance to avoid confusion (e.g., in cable paths filled with many wires).

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

The single wire of a 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, marking shall be added 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 does not have the colour defined in Table 1 (see possible reason in clause 3.1), marking colour shall be added respecting Table 1, 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 1 – Clause 4 defines how the multiwire cable itself is labelled to identify the voltage type and level (e.g., DC 400 V) in coherence with other distribution elements.

The colour and marking requirements does 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, alphanumerical and colour marking are allowed provided they do not introduce any ambiguous understanding for users.

NOTE 2 – 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 are required to use colours and marking of existing IEC standard. In compliance with [IEC 60 445], 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 [b-EN 301 605].

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 400 VDC 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 (sleeve, ring, …) 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	**One of the colour among options: Red, Brown or Orange** (Notes 1 and 3)	**L+** and voltage level e.g., **380 VDC**	+	**[IEC 60617]** **[IEC 60417]** **[IEC 60757]** **[b-RAL]**
Negative line HRMG	**Blue** (Notes 1 and 2)	**L-** and voltage level e.g., **380 VDC**	-	**[IEC 60617]** **[IEC 60417]** **[IEC 60757]** **[b-RAL]**
Negative line connected to PE	**Light blue** (Notes 1 and 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 that of Table 1, identifiers of clause 3.1 should be used (e.g., sleeves).				

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

DC lines	Colour marking	Text marking	Optional graphic symbol marking	Standard bases
NOTE 2 – The blue colour of L- of HRMG type (IT network) should be different from the turquoise or light blue (blue + green) usually chosen for conductor connected to PE. It should be a blue of dark, marine or night blue type. Refer to Appendix II for colour range and Appendix III for choice of RAL colour. NOTE 3 – The colour of L+ conductor is chosen in a set of colour (red, brown or orange) – Refer to Appendix II for colour range and Appendix III for choice of RAL colour.				

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

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

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

Table 2 – Recommendation for −48 VDC 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, …) 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+ (−48 V)**	**+**	**[IEC 60617] [IEC 60417] [IEC 60757]**
Negative Line	Not defined (Note)	**L- (−48 V)**	**-**	**[IEC 60617] [IEC 60417] [IEC 60757]**
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.				

8 DC distribution devices additional colour and marking

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

Table 3 – Requirements for colours and marking of 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] [IEC 60417] [IEC 60757]
A (-48VDC)	Different from A3 and AC	(Note 2)	DC −48 V L+ to earth	[IEC 60617] [IEC 60417] [IEC 60757]
AC	Different from A3 and A	(Note 2)	AC (nominal voltage) Voltage level e.g., 230 V IT, TNS, …	[IEC 60617] [IEC 60417] [IEC 60757]
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 a new installation. NOTE 2 – Symbols for DC and AC of [IEC 60417]. The chosen colour should be very readable on the chosen background colour.				

8.1 General requirements

In general the distribution cables in a building 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 centres 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 be no mixed distribution of 48 VDC, AC and 400 VDC 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 between −48 VDC, 400 VDC, and AC outputs at level of cabinets, racks or shelf and sub-blocks or modules inside.

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

8.2 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 be no mixed distribution of 48 VDC, 400 VDC, AC in the same mechanical module without proper insulation separator.

8.3 DC sub-distribution boards (with protective devices)

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

There shall be no mixed distribution of 48 VDC, 400 VDC, AC in the same mechanical module without proper insulation separator.

8.4 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 the respective colours of Table 3 for the respective voltage type could be used rather than full plastic colour.

9 Durability of marking and reading errors limitation

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

Appendix I

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

(This appendix does not form an integral part of this Recommendation.)

I.1 Recommended colours for wires in [IEC 60757] and [IEC 60445]

The recommended colours of wires are given in Annex B of [IEC 60757] in Table B.1.

Table B.1 – Recommended colours and code

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]).

More colours and codes are in national standard such as DIN transposition of [IEC 60757]: Grey GY, Pink PK, Gold GD, Turquoise TQ, Silver SR.

The [IEC 60445] standard 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 must not be used for any other type of conductor.

I.2 Other norms or specifications

Other activity sectors have standardized cabling and marking for their specific sector: The International Standard [b-ISO 6722] 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 ranges 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.

I.2.1 Single and bicolour cables used in cars

Figure I.1 gives an idea of variety of colours used in cars.

This colour coding exists in some manufacturers association standards to specific use in the vehicle, e.g., for motor sensors or auxiliary circuits

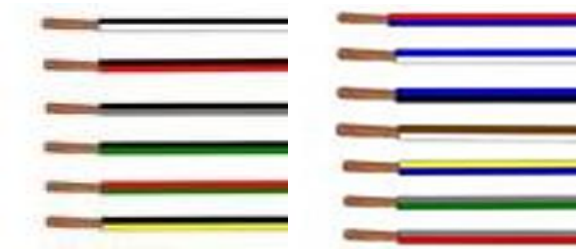

Figure I.1 – Example of some bicolour wires used in road vehicles

I.2.2 Cables used in aircraft, ground works machines and boats

Standard [b-ISO 2574] provides specifications for aircraft electrical cables identification marking and the standard [b-ISO 9247] provides specifications for earth-moving machinery, electrical wires and cables identification and marking principles.

NOTE – The ship and boat sector also have specifications.

I.2.3 Colour of personal computer power cables

There is a common practice for colour cabling mostly used in "ATX" design of personal computer tower.

Table I.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

I.2.4 Machine cabling

[b-EN 60204-1], the standard on electrical machine cabling, stated that the colour light blue should be used for a neutral conductor if the equipment has a DC circuit, and that dark blue should be used for the negative pole in order to clearly differentiate between AC and DC circuits.

I.2.5 Family of cables coding

This chapter gives an indication of cable type codification and shows that transparent insulation can also be a solution. Each type of wire or cable has a coding for a wide variety of use as seen in the following examples:

Fixed installations and electric board cabling

H07VU ou VR, H07VK cable

– H::: harmonised
  - 07::: max voltage 700 volt
    - V::: polychlorure de vinyle (PVC)
    - U::: single core copper
    - R::: hard multicore conductor
    - K::: flexible multiwire

U1000R2V cable

2V::: double insolation PVC

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

– Example::: U1000R2V 3G 1.5 mm^2

– U1000R2V 3 × 1.5 mm^2 means 3 wires, without ground yellow/green

H03VVF/H05VVF

– VV::: insolation with PVC material.
  - 03::: <1 mm^2 (2 wires)
  - 05::: > 1 mm^2 (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 cinemas

– blue, red, black, white and **transparent**

– Section: 0.75 to 6 mm^2

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

I.3 Building distribution cable colour and marking standards

I.3.1 Introduction

The standard on colour cable has changed with time and are stipulated in new [IEC 60445] as [b-IEC 60446] has been withdrawn.

NOTE – The IEC 60446 standard Third edition 1999-02 of [b-IEC 60446] has been withdrawn but gave 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 [b-IEC Guide 104] and [b-ISO Guide 51].

I.3.2 Low frequency cable and wire reference insulation colour in [b-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 [b-IEC 60304] 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 except the previous one and earth colour are allowed (white, grey).

I.3.3 New IEC 60445

Standard [IEC 60445] provides basic and safety principles for man-machine interface, marking and identification of equipment terminals, conductor terminations and conductors.

Reference was made to the old colours used in Europe.

I.3.3.1 Old cable colour code

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

I.3.3.2 Harmonized cable colours

Identification of colours of cores in cables have been subjected to developments that resulted in the harmonization document [b-HD 308 S2].

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 [b-HD 324 S2] shows the colour choices for AC wires in cables.

I.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 colours and markings in installations.

For information, reference is made to the old national habits as far as the use of colours are concerned.. These cables are still widely present in existing installations.

The requirements of [b-BS 7671] were harmonized with CENELEC Standards [b-HD 384.5.514] now withdrawn and Amendment No 2: 2004 (AMD 14905) to [b-BS 7671] was implemented for the harmonized cable core colours and the alphanumeric marking of the following standards based on [b-HD 308 S2], [EN 60445] [b-EN 60446]. In the appendix of these documents, guidance is given on the harmonized colours to be used for conductors and marking at the interface between old and harmonized colours.

[b-BS 7671] was also 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.

A table (labelled 7A in [b-BS 7671] gives an example of conductor marking at the interface for additions and alterations to an a.c. installation identified with the old cable colours.

I.3.4 DC coding evolution

I.3.4.1 [b-BS 7671] case

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

The table (labelled 7E in [b-BS 7671] gives an example of conductor marking at the interface for additions and alterations to a d.c. installation identified with the old cable colours.

I.3.4.2 Wire colours in China industry and standards

China has also defined colour coding for DC cable

1) −48V DC system marking
   - For China Telecom and Unicom
     - L+ Red
     - L- Blue
   - For China mobile
     - L+ Red
     - L- Light Blue
2) Up to 400 VDC system marking
   - For China Telecom and China mobile and in CCSA standard [b-YD/T 2378]
     - 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

I.3.4.3 Wire colours in Lenovo flex system higher voltage DC solutions (Lenovo press)

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 this standard if blue.

I.3.4.4 Colours and marking of DC cables in the 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) −48V DC
   - DC + (positive) Red
   - DC – (negative) Blue

2) Up to 400 VDC

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

Appendix II

Justification of the identification wire colour choices

(This appendix does not form an integral part of this Recommendation.)

The choice of colour outlined in Table 1 was carefully documented taking into account the information of this appendix and colour codes for quality manufacturing.

Some optimization reasons are provided:

– Only single colour of list of [IEC 60757] 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 to differentiate higher DC voltage of interface A3 from interface A and other uses which means using dark blue for up to 400 VDC L- line.

– Orange and violet are almost diametraly opposed on the colour wheel (Figure II.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 colour as they are pure red or mix of red and yellow, adapted to the need 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] and so industry has considered its reuse as they are widely produced. In these cables brown and blue could be used for DC according to [b-BS 7671]. Brown can be considered close to orange or red as seen in Figure II.1.

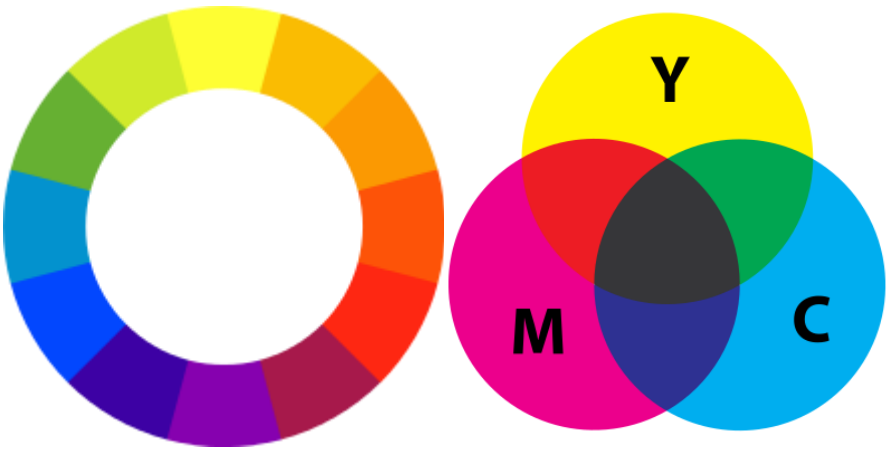

Figure II.1 – Colour wheel RYB (Red Yellow Blue), used in artistic painting before CMYK (cyan, magenta, yellow, and key-black) set of 3 substractive primary colours + black used in modern printing in substractive colours

Appendix III

Wire colour choice in colour range industrial specification

(This appendix does not form an integral part of this Recommendation.)

For industry quality reason, RAL colour range code is proposed. The RAL 840 (RAL classic) colour ranges are listed in Table III.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 and traffic signs or are dedicated to government agencies and public services such as for security signals and safety marking. Some wire manufacturers such as [b-Nexans] or Topflex are engaged in carefully respecting the insulation colour defined with RAL colours reference and ensuring stability with time and exposure to light or chemical agents.

Table III.1 – RAL 840 (RAL classic) industry 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 [b-RAL] with RGB decimal and hexadecimal coding.

For better application of this standard each insulation colour is associated with a set of referenced colours. The main ones are indicated first, other RAL are indicated as possible. Correspondence with other colour specification can be done (see end of this appendix).

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 +0 V of (−48 V) 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 [b-Federal Standard];

– Pantone references for paints and plastic powders referred in [b-Pantone].

A correspondence tool between colour references (RAL, Pantone, RYB, RGB, CMYK, etc.) and accurate colour measurement can be found in [b-colour correspondence].

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 $\Delta L^2+\Delta a^2+\Delta b^2$). An attached 3-D graph may show the relationship of these values.

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