EUROPEAN WORK ON LV ABC ACCESSORIES STANDARD

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I. INTRODUCTION

When the first insulated conductors appeared in the 1950's, the insulation layer was rubber (neoprene) and the conductor was copper (for example in France). The connectors were not reinsulated and mechanical bolted connectors were the most common items. Soon utilities discovered that conductors with insulation were safe for linemen and customers, however, the insulation material was not resistant enough to climatic conditions (neoprene deteriorated) and failures appeared due to the poor quality of the insulation. In the 1960's, Utilities (EdF Electricité de France), changed to PVC insulation and aluminium conductors. Although the insulation problems seemed to be solved, connector failures appeared due to the aluminium oxide layer formed from exposure to the air and the knife stripping process. This operation damaged the strands and started the wire necking process and was amplified by the vibration of the conductor. During this time, crimped connectors were used with heat shrinkable cable accessories but it became apparent that PVC was not resistant to the temperature variations and cracked due to the tensile load on the neutral messenger.

In order to eliminate the inconveniences above, Utilities, in association with Aluminium & Cable producers and connector manufacturers, investigated three main issues:

1) Find a more resistant insulation layer

2) Improve contact and installation reliability

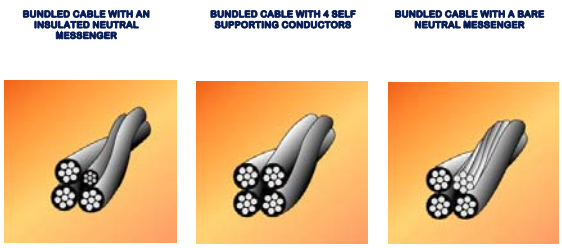
3) Connect customers under voltage and in safe conditions.

II. CABLE DESIGN

1 – XLPE cross linked polyethylene was chosen in the 70's (France in 1977) and is now the most well known insulation material used in LV insulated overhead lines due to its high environmental and mechanical resistance.

2 – Three main techniques for low voltage insulated overhead distribution lines were identified in Europe as LV ABC (Low Voltage Aerial Bundled Conductors) systems:

- Insulated Neutral messenger
- Bare Neutral Messenger
- Self supporting



3 – In addition to the above, several utilities' specifications and standards appeared. In the 90's, Cenelec TC 20 consolidated all existing ABC under an Harmonization Document reference HD 626 and requested to create a working group for ABC Accessories.
TC20/WG11 SG ABC Accessories was born in September 1996.

III. SUCCESSIVE WORKING STEPS

The elaboration of an European standard for ABC accessories has been defined according to the following steps:

Scope of the work

This standard applies to overhead line fittings for anchoring, supporting and connecting Aerial Bundled Cables (ABC) of rated voltage $U_0/U(U_m)$: 0,6/1(1,2) kV.
The objective is to provide a method of testing the suitability of accessories when used under normal operating conditions with low voltage aerial bundled cables (ABC) complying with HD626**.** .

This scope was based on Vilamoura notifications.

Main objectives

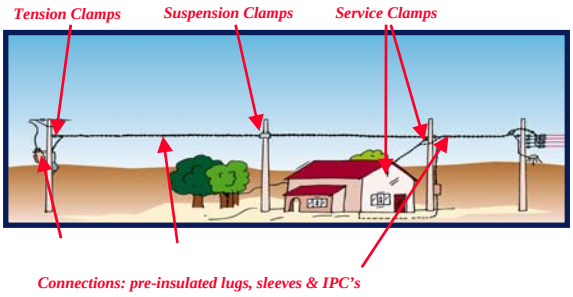
- Define the product applications on which the group will focus
- Collect existing standards/ specification
- Compare all of them and discuss the structure of the draft
- Focus on the performance requirements of the products rather than on the product design.

Product applications

According to the scope of work above, the group decided to define the product performances of the main applications:

- Tension & Suspension clamps. Fixture hooks and brackets were not included having too many kind of items on the European market place.
- Connection: only connections to transformers (lugs), jointing of ABC cables (splices) and tap off connectors (Insulation Piercing Connectors) were considered. All transition connections like ABC to bare lines or ABC to underground lines were not selected due to different possibilities depending of the countries.

However, the electrical performances as well as the environmental behaviour may be applicable to the products which will be linked to the LV ABC environment.



Existing European Standards

An impressive list of standards/specifications has been elaborated with the help of National Committees and members of the Working Group.
The most popular have been identified in the attached table. Based on the existing standards, the Working group elaborated different comparative charts to highlight the main tests requested in different countries and learn about the choice of the countries as well as understand their LV network.

UK	**EATS 43-14 for all ABC Accessories**
SWEDEN	**SS424 12 20/21/22/23 for hooks** **SEN 24 15 10 for connectors** **SS424 14 28 for tension & suspension**
NORWAY	**NEK87 for tension & suspension** **EFI for connectors**
FINLAND	**SFS2454 for suspension** **SFS2663 for tension clamps & connectors**
PORTUGAL	**EDP DMA C3386(0)/N for connectors** **EDP DMA C33864/N for tension & suspension** **EDP DMA C33872/N for sleeves**
IRELAND	**ESB 16142 for all LV ABC accessories**
FRANCE	**NF C 33 020 for IPC'** **NF C 33 021 for pre-insulated connectors** **NF C 33 040 for suspension clamps** **NF C 33 041 for tension clamps** **NF C 33 042 for service clamps**
AUSTRIA	**ÖVE-L1: General for O/H lines** **ÖVE-L40 for testing for O/H lines** **ÖVE-L41 for testing fitting for LV O/H lines**
ITALY	**DM 6810/6812 for tension clamps** **DM 6814 for suspension clamps** **DM 6860 for pre-insulated connectors** **DM 6850 for Insulation Piercing Connectors**
GERMANY	**VDE 0211 for tension & suspension clamps** **VDE 0220 for IPC tests**

Standard comparison

Having collected the above information from the different National Committees, the Working Group built several charts in order to identify the main criteria and collect the needs of each country. Many discussions arose on the reason of the selected standard requirements. It is obvious that having three different technologies associated to different country regulations and climatic environment, it has been hard to combine the requests with the reality and issue a draft which answers the majority of the represented countries. We agreed on the following test families:

- Mechanical tests
- Electrical ageing tests
- Environmental tests

Recommendations about sample test, quality control and test report content have been given on request of customer representatives attending the WG11 SG ABC Accessories meetings.
We finally agreed that:

- There is variation between the different ABC specifications provided by HD 626 and tests carried out on one of the ABC types may not be completely

applicable to ABC of different specification. Therefore, the purchasers, of accessories tested to this standard, must ensure that all their requirements are met. In order to gain approval, if necessary, with agreement between the customer and the manufacturer, some or all of the tests carried out to this standard may have to be repeated on a cable specified by the customer.

- Climate differs across Europe and in order to meet the differing geographic climatic conditions it is necessary to provide a range of tests to meet these variations. A range of optional, additional tests are provided to meet the varying climatic needs and these should be agreed between the customer and the supplier (see Annex C in pr EN 50483-6).

The purpose of this standard is to define the common aspects of the products included in the above scope.

- Previous type approvals:

Formerly, approvals for such products have been achieved of the basis of national standards and specifications and/or the demonstration of satisfactory service performances. The publication of this standard does not invalidate existing approvals. However products approved to current National standards or specifications, shall be subject to agreement between customer and manufacturer to define if the tests comply with the new European standard or if additional tests must be carried out.

After they have been made, these tests do not need to be repeated unless changes are made to the accessory's material, design or manufacturing process which might affect the performance characteristics.

Performance requirements

Based on the main test families above, the group worked on anchoring & suspension clamps for each three technologies, and then on connections which are applicable for all. The structure adopted has been based on the existing standards or specifications and on test definition already included in existing EN or IEC standards.

IV. DRAFT CONTENT

The draft is composed of 6 parts:

- Part 1: Generalities

In this part, all information on the test method, conditions are included as well as the information concerning marking, quality and sample tests.
Recommendation for test report are given, tables for selection of samples by test are shown in the Annexes.

- Part 2: Test Requirements for LV Aerial Bundled Cable Accessories - Tension & Suspension clamps for self supporting system

In this part are identified all tests which must be carried out for accessories being used in ABC self supporting system.

- Part 3: Test Requirements for LV Aerial Bundled Cable Accessories - Tension & Suspension clamps for neutral messenger system.

In this part are identified all tests which must be carried out for accessories being used in ABC neutral messenger system, bare or insulated neutral.

- Part 4: Test Requirements for LV Aerial Bundled Cable Accessories - Connections.

In this part are identified all tests which must be carried out for connectors (lugs, splices and tap off) being used in any ABC systems.

- Part 5: Requirements for LV Aerial Bundled Cable Accessories – Electrical aging test.

In this part is defined the electrical ageing test which must be used for qualifying connectors as Part 4 and or other connectors link to the ABC environment (e.g.; transition connectors from ABC to LV bare lines or LVABC to LV underground cables)

- Part 6: Test Requirements for LV Aerial Bundled Cable Accessories – Environmental test.

In this part are defined the corrosion and climatic ageing tests which must be applied to all above products with an Annex which recommends where the above tests could be applicable.

In the following paragraphs, we will highlight the key issues for each part. More detailed information is available in the mentioned parts.

Part1: prEN 50483-1

This part defines the marking, traceability, routine & sample tests to check the compliance of the supplied products with the standard. A test is defined to check the permanent marking.
In addition, all test conditions to apply during the type testing are identified: frequency, ambient temperature, applied load tolerances, speed for load application; leakage current for dielectric voltage test, water resistivity, speed for voltage application, tightening torque application, humidity conditions. Connector classes are defined as follows:

- A for connectors subjected to heat cycles & short circuit tests
- B for connectors subjected to heat cycles only
- 1 for connectors subjected to dielectric test in water
- 2 for connectors subjected to dielectric test in air.

Part 2: prEN 50483-2

This part defines the tests to be performed on tension & suspension clamps designed for LV ABC self supporting system.

Tension clamps:
- tensile test at ambient temperature: 60% or 80% of MBL with respectively dielectric behaviour of clamp and bundled cables.
- mechanical failure load test: 100% of MBL during 1 minute
- tensile test at high temperature: 20% of MBL – 100 cycles at operating cable temperature with respectively dielectric behaviour of clamp and bundled cables.
- tensile test at low temperature: 25% or 40% of MBL at -10°C during 1 hour.

Suspension clamps:
- tensile test at ambient temperature: 20% or 40% of MBL
- mechanical failure load test: 100% of MBL during 1 minute.
- slip test at ambient temperature: 500 to 1000 N with respectively dielectric behaviour of clamp and bundled cables.
- slip test at high temperature (optional): 250 cycles of 90 minutes
- thermal test: 100 cycles at maximum normal cable temperature with respectively dielectric behaviour of clamp and bundled cables.

For both clamp types:
- dielectric voltage test (clamp + cable): 4kV/1 minute.
- clamp bolt tightening: 10 times 110% of specified torque.
- environmental test with corrosion ageing and climatic ageing.

Part 3: prEN 50483-3

This part defines the tests to be performed on tension & suspension clamps designed for LV ABC self supporting system.

Tension clamps:
- tensile test at ambient temperature: 90% of MBL
- tensile test at high temperature: 500 cycles at a cable temperature of 60°C with dielectric behaviour of clamp and bundled cables.
- tensile test at low temperature: 45% of MBL at -10°C with dielectric behaviour of clamp and bundled cables.

Suspension clamps:
- clamp bolt tightening test: specified torque +10%, 10 times
- tensile test of the clamp 75-90% of MBL
- slip test of the neutral
  - insulated neutral: ≥ 300N
  - bare neutral: 45 N/mm²
- swing test (optional): at 2,5 Hz with a load equal to 1300 N
- slip test at high temperature (optional): 250 cycles

For both clamp types:
- dielectric voltage test: 4kV : 1 minute
- environmental test with corrosion ageing and climatic ageing.

Part 4: prEN 50483-4

Insulation Piercing connectors (IPC's)
- mechanical damage test on main conductors > 25 mm²:
  - 80% of MBL for self supporting ABC
  - 90% of MBL for neutral messenger
  - 60 % of MBL for phases
- branch pull out test: 1000 N or 10% of MBL the greater

- connector bolt tightening test: max torque x 1,2
- shear head function at -10 and +50°C
- low temperature impact test at -10°C
- low temperature assembly test at -10°C: contact established at 70% of minimum torque

Pre-insulated sleeves:
- mechanical test:
  - 20% of MBL for 4 to 16 mm² copper
  - 1200N or 40% of MBL the greater for 16 to 25 mm² Alu
  - 85% for 35 to 150 mm² Alu self supporting system
  - 60% of MBL for 16 to 150 mm² Alu Phase
  - 95 % of MBL for Alu alloy neutral messenger
- endurance test under tensile: 500 cycles at normal operating cable temperature
- low temperature test at -10°C.

Pre-insulated lugs:
- mechanical test:
  - 1200 N from 16 to 25 mm²
  - 2500 N from 35 to 150 mm²
- water tight test: 24 hours in immersion

For all connectors:
- dielectric voltage test class 1 or 2
- electrical ageing test class A or B
- environmental test:
  - corrosion test
  - climatic ageing test
- low temperature test at -10°C

Part 5: prEN 50483-5

This part relates to the electrical ageing test method for connections. It defines the test cycles, loop installation, preparation of cables, samples as well as the acceptance criteria.
- Test is made on 6 connectors:

- Class A: 1000 cycles with 6 short circuit applied after 200 cycles
- Class B: 1000 cycles without short circuit

- Main requirements:
  - resistance factor ratio λ: ≤ 2
  - assessment of resistance stability: ≤ 15%
  - temperature stability: ± 10° C
  - T°C of each connector ≤ T°C of reference cable

Part 6: pr EN 50483-6

This part defines the corrosion and climatic tests to be performed for all products above.

- Corrosion test:
  - salt mist test: according to EN 60068-2-11
  - gas atmosphere test: method 1 (SO_2) or method 2 (0.05% of NaCl+ 0.35% of $(NH_4)_2(SO_4)$
  - immersion test in salt solution (optional)
- Climatic ageing test:
  - Method 1: as the cable in HD 626
  - Method 2: according to EN 60068-2-5

V. CONCLUSION

This new standard must provide a better support to the Utilities in order to elaborate their own specification and rationalise the test requirements and acceptance criteria requested for all manufacturers. It has been based on the field experience of both utilities & manufacturers as well as the expertise /guidance of LV ABC engineers. Therefore, the information in this paper is subject to further changes and improvements.
This European draft will be circulated for vote by the end of 2007.

VI. BIOGRAPHY

Gilles Porcheray received his degree in mechanics in 1971 from IUT (Technology Institute) in Dijon, France. His area of expertise includes electric field analysis and design of connectors. He joined SIMEL in 1974 as Project Manager and is currently Product Manager for LV insulated overhead product line in Tyco Electronics/Energy Division. From 1974 to 1985, he worked as a Product Development Engineer, mainly focused on piercing connectors. For 10 years, he leads the WG11 Sub Group ABC Accessories.

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