Base Load Power Hub (BLPH)

INSTRUMENT CABLES

FAT PROCEDURE - INSTRUMENT CABLES

Document Number: 1725000275 -QC-PRO-00005

Document Class: 2

01	14/03/2025	Accepted for Construction (AFC)	Fumagalli	Cucinotta	Messa
00	03/03/2025	Issue for review (IFR)	Fumagalli	Cucinotta	Messa
Rev.	Date	Description	Prepared	Reviewed	Approved

FLEI S.r.l.

This document undergoes an issuance cycle within EDMS "Fusionlive".
Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

Table of Contents

SH.	DESCRIPTION	REVISIONS							
		00	01						
1	Cover	X	X						
2	Table of Contents	X	X						
3	Revision / Change Log / Hold List	X	X						
4	References	X	X						
5	FAT	X	X						

This document undergoes an issuance cycle within EDMS "Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

Revision / Change Log

Rev.	Description
00	Issue for Review (IFR)
01	Accepted for Construction (AFC)

HOLDS LIST

No.	Description
1.	
2.	
3.	
4.	

This document undergoes an issuance cycle within EDMS "Fusionlive". Its distribution is electronically controlled. Once printed shall be considered as "NOT CONTROLLED" copy

FACTORY TEST PROCEDURES

Low Voltage Instrument Cables

CONTENTS	TITLE N.
Test procedure for High Voltage Test	1
Test procedure for Conductor Resistance	2
Test procedure for Insulation Resistance	3
Test procedure for Mutual Capacitance (pairs/triples)	4
Test procedure for Inductance (pairs/triples)	5
Determination Value of L/R ratio adiacent cores	6
Test procedure for Conductor Examination	7
Test procedure for Measurement of Thickness of Insulation and Sheaths	8
Test procedure for Armour Wire / Tape Measurement	9
Test Procedure of diameter under armour and overall	10
Test procedure for Hot Set Test	11
Fire Resistant & Flame Retardant	12

1 . Test Procedure for High Voltage test

1 SCOPE OF THE TEST

This test procedure details the test methods to verify the dielectric strength of the insulation of the finished instrumentation cables

2 NORMATIVE REFERENCES

IEC 60092-376

3 TEST EQUIPMENT

a. I05 - HV transformer 15Kv ac/100KVA Manuf. VNZ SIF MODEL 001/2011

b. Timer Chronometer Manuf. GEONAUTE SERIAL N° 13101

4 METHOD OF TESTING

4.1Method of Testing

The testing shall be carried out at ambient temperature.

Remove sufficient length of the outer jacket, armour and inner sheath from both end of the cable.

Connect the high voltage source to the conductor.

Connect amour, metallic screen to the ground.

Test voltage shall be applied between each conductor and the metallic sheath & the armour, if any.

4.2 Low Voltage cables

4.2.1 High voltage Test

Apply the 1.5 kV a.c. between each conductor and metallic screen & armour for 1 minutes.

4.2.1.1 Requirements

No breakdown of the insulation shall occur during the testing period.

(POINT 4 of the STANDARD IEC 60092-376)

4 Rated voltage

The standard rated voltage U_o/U (U_m) is as follows:

$$U_o/U\ (U_m) = 150\ V/250\ V\ (300\ V)\ a.c.$$

In the voltage designation of cables

U_o is the rated power-frequency voltage between the conductor and the earth or metallic covering for which the cable is designed;

U is the rated power-frequency voltage between conductors for which the cable is designed.

U_m is the maximum value of the highest system voltage for which the equipment may be used.

A d.c. voltage up to a maximum of 1,5 times the a.c. voltage may be used, provided that the voltage to earth does not exceed 250 V.

2. Test Procedure for Conductor Resistance

1 SCOPE OF THE TEST

This test procedure details the test methods to determine the DC resistance characteristics of the conductors and screens of the finished instrumentation cables

2 NORMATIVE REFERENCES

IEC 60092-376

3 TEST EQUIPMENT

I02 - Resistance measuring - Manufacturer FLUKE Model 8840A Serial 5256028.
Cert. Calibration N. RT05424 MTA

4 METHOD OF TESTING

Remove sufficient length of the outer jacket, armour and inner sheath from both end of the cable.

The insulation of the conductor has to be removed about 30mm from the end of the cable.

Connect the testing clamp of the resistomat to the both ends of the conductor.

Adjust suitable range for the same required value.

Adjust the cable temperature on the resistance-measuring unit for compensation at 20°C for manual measurement or connect the temperature sensor to the measuring unit for auto compensation.

Calculate the observed resistance value per kilometers by using the following formula:

$$R = \frac{R_1 \times 1000}{L} \text{ (ohm/Km)}$$

Where : R = Resistance per kilometers
R_1 = Measured Resistance
L = Length of the cable

5 REQUIREMENTS

As per relevant specifications.

Table 6 – Electrical resistance of conductors

	Class 2 Stranding		Class 5 Stranding	
Nominal cross-section	DC resistance of plain copper conductors	DC resistance of tinned copper conductors	DC resistance of plain copper conductors	DC resistance of tinned copper conductors
mm^2	Ω/km at 20°C	Ω/km at 20°C	Ω/km at 20°C	Ω/km at 20°C
0,50	40,4	41,6	41,4	42,5
0,75	26,0	26,3	27,6	28,3
1,00	19,2	19,3	20,7	21,2
1,50	12,8	12,9	14,1	14,5
2,50	7,86	8,02	8,47	8,71

3. Test Procedure for Insulation Resistance

1. TEST EQUIPMENT

1 . M E G A O H M E T R O
I03 - Manufacturer CHAUVIN ARNOUX Model CA6543 Serial 235837CMH
Cert. Calibration N. RT03807 MTA

2. METHOD OF TESTING

→ Connect the ' + ' lead of the megger to core and ' - ' lead to all other cores, metallic screen & armour.
→ Apply 500 V DC for 1 minute and measure the reading.

→ Calculate the observed insulation resistance value per kilometers by using the Following formula:

Ri = R1x L (MohmxKm)

Where Ri : Insulation resistance x kilometers
R1: Measured resistance Megaohm
L : Length of the cable kilometers

3. REQUIREMENT

→ Insulation resistance as per data sheet

Note: In the case of manual measurement, to calculate resistance at 20 deg.C, measured insulation resistance at ambient temperature shall be multiplied by the temperature correction factor of insulation material

Table 3 – Electrical requirements of insulation compounds

Designation of the insulating compound	EPR	HEPR	XLPE	HF90	S 95
Insulation resistance constant Ki (MΩ.km) (see 7.2 of IEC 60092-350:—)					
– at 20 °C, minimum,	3 670	3 670	3 670	550	1 850
– at maximum operating temperature, minimum.	3,67	3,67	3,67	0,55	1,85
Volume resistivity ρ(Ω.cm) (see 7.2 of IEC 60092-350:—)					
– at 20 °C, minimum,	$1,0 \times 10^{15}$	$1,0 \times 10^{15}$	$1,0 \times 10^{15}$	$1,5 \times 10^{14}$	$5,0 \times 10^{13}$
– at maximum operating temperature, minimum.	$1,0 \times 10^{12}$	$1,0 \times 10^{12}$	$1,0 \times 10^{12}$	$1,5 \times 10^{11}$	$5,0 \times 10^{10}$

4. Test procedure for mutual capacitance (Pairs/Triples)

1 SCOPE OF THE TEST

This test procedure details the test methods to determine the mutual capacitance characteristics of the finished instrumentation cables.

2 NORMATIVE REFERENCES

BS EN 50288.7
BS EN 50288.1
BS EN 50289.1.5 par. 4.3.2.1

3 TEST EQUIPMENT

I12 - Capacitance measuring equipment – LCR METER 1KHZ Manufact. HIOKI Model IM3523

serial number 230710207 Cert. Calibration N° RTR342597 ARO

4 METHOD OF TESTING

Remove sufficient length of the outer sheath, armour and inner sheath from both the end of the cable

The insulation of the conductors of the pairs/triples have to be removed about 30mm from the end of the cable

Connecting testing clamp at one pair/triple to one end of the cable, all others conductors and screen, if any, connected to earth .

Adjust suitable range for the same required value

Calculate the observed mutual capacitance value per kilometers by using the following

Formula:

$$C = \frac{Cmx1000}{L} \quad (\mu F/Km)$$

Where

C= mutual capacitance

Cm= measured capacitance in µF

L= Length of the cable in meters

5 REQUIREMENTS As per relevant specifications (APPROVED SPECIFICATION TO BE AVAILABLE DURING FAT)

Data Sheets approved available during FAT.

Note The value of mutual capacitance measured at ambient temperature shall be multiplied by the temperature correction factor

5. Test Procedure for Inductance (Pairs/Triples)

1 SCOPE OF THE TEST

This test procedure details the test methods to determine the inductance characteristics of the finished instrumentation cables.

2 NORMATIVE REFERENCES

BS EN 50288.7
BS EN 50288.1
BS EN 50289.1.12

3 TEST EQUIPMENT

I12 - Inductance measuring equipment – LCR METER 1KHZ Manufact. HIOKI Model IM3523

serial number 230710207 Cert. Calibration N° RTR342597 ARO

4 METHOD OF TESTING

Remove sufficient length of the outer sheath, armour and inner sheath from both the end of the cable.

The insulation of the conductors of the pairs/triples has to be removed about 30mm from both ends of the conductor.

Connecting testing clamp at one pair/triple to one end of the cable, on the other end the conductor are placed in short circuit .

Adjust suitable range for the same required value

Calculate the observed inductance value per kilometers by using the following Formula

$$L = \frac{Lm \times 1000}{Le} \quad (\text{Mh/Km})$$

Where L = Inductance

Lm= measured inductance in Mh

Le= Length of the cable in meters

5 REQUIREMENTS (APPROVED SPECIFICATION TO BE AVAILABLE DURING FAT)
Data Sheets approved available during FAT.

(POINT 7.6 of the standard IEC 60092-350)

7.6 Inductance to resistance ratio (control and instrumentation cables only)

The inductance-to-resistance ratio (L/R ratio) shall be calculated from measurements of inductance (L) made at 1 kHz on a total of at least two pairs, triples or quads that have been selected at random from the inner and outer layers and the d.c. resistance measured at 20 °C. The values obtained shall be recorded in the cable type-test report.

6. Determination Value of L/R Ratio Adjacent Cores

1 SCOPE OF THE TEST

This test procedure details the test methods to determine the value of the inductance to resistance ratio of adiacent cores (pais/triple) of the finished instrumentation cables.

2 NORMATIVE REFERENCES

IEC 60092-350

3 TEST EQUIPMENT

I12 - Inductance and resistance measuring equipment – LCR METER 1KHZ Manufact. HIOKI Model IM3523 serial number 230710207 Cert. Calibration N° RTR342597 ARO

4 METHOD OF TESTING

As per inductance and conductor resistance (Loop) of the pairs/triple

* Calculate the observed L/R ratio value

Formula $L/R = \frac{Lm \times 1000}{R1X2}$ (µH/ohm)

5 REQUIREMENTS (APPROVED SPECIFICATION TO BE AVAILABLE DURING FAT)

Data Sheets approved available during FAT. (POINT 7.6 of the standard IEC 60092-350)

7.6 Inductance to resistance ratio (control and instrumentation cables only)

The inductance-to-resistance ratio (L/R ratio) shall be calculated from measurements of inductance (L) made at 1 kHz on a total of at least two pairs, triples or quads that have been selected at random from the inner and outer layers and the d.c. resistance measured at 20 °C. The values obtained shall be recorded in the cable type-test report.

7. Test Procedure for Conductor examination

1. SCOPE OF THE TEST

This test procedure details the test methods to determine the diameter and number of copper wire in the conductors

2. NORMATIVE REFERENCE

IEC 60228

3 TEST EQUIPMENT

Vernier Caliper-> (digital 0÷150) Man. MARCALL Model 16ER Serial number 7101056465
Cert. Calibration N° II11
Calibrated with primary sample I13: Mitutoyo Type 611506-0,2/0,5 mm Serial number 960307
Cert. Calibration N°35069 LAT187

4 METHOD OF TESTING

Take a sample have length of 30 cm approximately.
The average of two measurements taken at right angles shall be taken as the diameter.
Average of three measurements at different places shall be considered as the diameter.
Measurement must be taken up to two decimal places to avoid any over usage of material
Count the number of wires / strands in the conductor

5 REQUIREMENTS

As per IEC 60092-350 (SEE POINT 4.2.3)

4.2.3 Class and form

The conductors considered in this standard are intended only for fixed installations and shall comply with class 2 or class 5 of IEC 60228. The minimum nominal conductor size depends on the voltage rating of the cable and shall be in accordance with Table 1.

Stranded copper class 2 conductors are recommended for general fixed-installation systems.

To aid installation, a conductor of class 5 may be used. Cables using class 5 conductors should not be regarded as suitable for repeated flexing in service.

Stranded circular non-compacted or compacted conductors are permitted for all cross-sections. Sector-shaped conductors are permitted for cross-sections of 10 mm^2 and above.

Table 1 – Minimum size of conductors

U	**Nominal cross-sectional area (Minimum)** mm^2
250 V	0,5
1 000 V	1,0
3 kV	10
6 kV	10
10 kV	16
15 kV	25
20 kV	35
30 kV	50

8. Test Procedure for Measurement of Thickness of Insulation and Sheaths

1 SCOPE OF THE TEST

This test procedure details the test methods to determine the insulation and the sheath thickness.

2. NORMATIVE REFERENCE

IEC 60811-201

3. TEST EQUIPMENT

3. Profile Projector –>II56 Optical Englander (20x) manuf. JVC Alpa TK-C700 E N° 1553454
Digital micrometers 0÷25 DIGITRIX N°399968-399978
Cert. Calibration N° II56
Calibrated with primary sample:I22 Mitutoyo Type Nominal accuracy : 7.983 mm
Cert. Calibration N°RTD26895

Vernier Caliper-> (digital 0÷150) Man. MARCALL Model 16ER Serial number 7101056465
Cert. Calibration N° II11
Calibrated with primary sample:I13 Mitutoyo Type 611506-0,2/0,5 mm Serial number 960307
Cert. Calibration N°35069 LAT187

4 METHOD OF TESTING

Prepare each test piece of insulation and sheaths in the form of a thin slice along a place perpendicular to the axis of the conductor or cable.
Place the test piece under the measuring equipment with the plane of the cut, perpendicular to the optical axis.
Make six measurements at 60° to each other.
If the inner profile of the sample is irregular or uneven take six readings radically at a position where the thickness is thinnest.
Take the reading in millimeter to two decimal places if the thickness is greater than 0.50 mm and to three decimal places if the thickness is less than 0.50 mm.
For the sheath direct over the insulation cores the number of readings shall be the same number of cores but limited to six measurements points.

5 REQUIREMENTS

As per IEC 60092-350(SEE POINT 4.3.3)

4.3.3 Insulation thickness

The thickness of insulation is specified for each size and type of cable in the applicable product standard.

For single core or multi-core cables, the thickness at any point may be less than the specified value, provided the difference does not exceed 0,1mm + 10 % of the specified value.

For single-unit or multi-unit cables, the thickness at any point may be less than the specified value, provided the difference does not exceed 0,1mm + 20 % of the specified value.

The thickness of any separator, screen or inorganic tape(s) applied over the conductor or over the insulation shall not be included in the thickness of insulation.

9. Test Procedure for Armour Wire / Tape Measurement

1. SCOPE OF THE TEST

This test procedure details the test methods to determine the diameter of galvanized steel wire for armour and thickness of aluminum/polyester tape.

2. NORMATIVE REFERENCE

BS EN 608111-1-1
BS EN 50288.7
BS EN 50288.1

3 TEST EQUIPMENT

Y Micrometer digital 0÷25 Man. Mytutoyo Model 293.265 Serial 6099146 ID 120
Cert. Calibration N° II08
Calibrated with primary sample I13: Mitutoyo Type 611506-0,2/0,5 mm Serial number 960307
Cert. Calibration N°35069 LAT187

4 METHOD OF TESTING

Take a sample have length of 30 cm approximately.
The average of two measurements taken at right angles shall be taken as the diameter of wire / width & thickness of tape.
Average of three measurements at different places shall be considered as the diameter of wire / width & thickness of tape.
Measurement must be taken up to two decimal places to avoid any over usage of material

5 REQUIREMENTS

As per relevant specifications (APPROVED SPECIFICATION TO BE AVAILABLE DURING FAT)
Data Sheets approved available during FAT.

10 – Title: Test Procedure of diameter under armour and overall

1. TEST EQUIPMENT

1. Vernier caliper

2. METHOD OF TESTING

→ Take a sample have length of 30 cm approximately.
→ The average of two measurements taken at right angles shall be taken as the diameter
→ Average of three measurements at different places shall be considered as the diameter
→ Measurement must be taken up to two decimal places to avoid any overusage of material

3. REQUIREMENT

→ As per relevant specification and data sheet.
Data Sheets approved available during FAT.(SEE BELOW POINTS of THE STANDARD IEC 60092-350

4.9 Outer sheath

4.9.1 Material

The sheath shall be selected from one of those listed in IEC 60092-360. The sheathing compound selected shall be compatible with the cable components with which it is in contact and compatible with the operating temperature of the cable.

4.9.2 Application

The outer sheath shall be extruded in one or more closely adherent layers. The outer sheath shall form a compact and homogeneous body and shall be so applied that it fits closely onto the underlying components.

It shall be possible to remove the outer sheath without damaging the underlying insulation and/or screen(s).

4.9.3 Thickness of outer sheath

The thickness of sheath for each size and type of cable shall be as specified in the applicable product standard.

Unless specified in the applicable product standard, the thickness at any point may be less than the specified value if any, providing the difference does not exceed 0,1 mm + 15 % of the specified value for sheaths applied on a smooth cylindrical surface, or 0,2 mm + 20 % of the specified value for sheaths applied on an irregular cylindrical surface.

11. Test Procedure for Hot Set Test

1. SCOPE OF THE TEST

This test procedure details the test methods to determine the max elongation under load and max permanent elongation after cooling of XLPE insulation.

2. NORMATIVE REFERENCE

IEC 60811-507

IEC 60092-360

IEC 60092-350

3 TEST EQUIPMENT

a. Heating Oven. 30°C ÷300°C Manuf. GALLI Model 2100 Serial N°2123
b. Calibrated weights Manuf. CIBE Serial N° B5608÷B5612 – Cert. Calibration N°041/10÷045/10
c. Sample holding fixture
d. Vernier Calliper (digital 0÷150) Man. Mytutoyo Model 500-181U Serial 206522 ID 123 Cert. Calibration N° RT07640 –e. Timer Chronometer Manuf. GEONAUTE SERIAL N° 13101
Cert. Calibration N° RT07564 MTA –
f. Temperature thermometer 0÷300°c – manuf. KAYE model Pt 50.4 Serial N°910908
Certificate Calibration LAT123 20-ST-2283

4 METHOD OF TESTING

Prepare dumbbell test pieces from XLPE insulation with thickness 0.8 to 2.00 mm.
Mark 20 mm gauge length in the center of the dumbbell. (L_1)
Suspend the sample in the oven with a weight of 20 N/cm2 at 200^0C for 15 minutes.
After the test duration of 15 minutes measure the length between the marks. (L_2)
Calculate the elongation, in percentage, under load as follows

$$\frac{L_2 - L_1}{L_1} \times 100$$

Remove the load from the test piece and keep in oven at same temperature for 5 minutes.
After 5 minutes, remove the sample from oven and allow to cool to room temperature.
After the sample attained to room temperature measure the lengths between the marks. (L3)
Calculate the elongation, in percentage, without load as follows

$$\frac{L_3 - L_1}{L_1} \times 100$$

5 REQUIREMENTS

The elongation under load shall not be more than 175%
The elongation without load shall not be more than 15%

12. Test Procedure for Flame Retardant & Fire Resistant

1 SCOPE OF TEST

This test procedure details the test methods to check if cable will pass test for Flame retardant & or Fire Resistant

2. NORMATIVE REFERENCE

IEC 60332.1.2 **-** IEC 60332.3.22 Flame retardant
IEC 60331.21 Fire Resistant

3. TEST EQUIPMENT

According to IEC 60332.1.2 for Flame Retardant

TEST EQUIPMENT

- A suitable three-sided metallic screen, with open front and closed top and bottom. The base shall be non-metallic
- A clamp suitable to fix the test sample of cables
- One gas burner

TEST SAMPLE

The test sample shall be a piece of the finished cable of cable 600 + - 25 mm long

FLAME CONDITION

When propane is used, the burner being regulated to give a flame approximately 175 mm Long with an inner blue cone approximately 55 mm long

TEST PROCEDURE

The sample shall be clamped at each end to position it vertically in the middle of a three-sided metallic screen and shall be adjusted so that the bottom of sample is approximately 50 mm from the base of the metallic screen.
The axis of the burner shall be at an angle of 45° to the axis of the sample.
The flame is applied for a continuos period of T seconds derived from Table 1:

Table 1 – Time for flame application

Overall diameter of test piece [a] mm	Time for flame application [b] s
$D \leq 25$	60 ± 2
$25 < D \leq 50$	120 ± 2
$50 < D \leq 75$	240 ± 2
$D > 75$	480 ± 2

[a] Where non-circular cables (for example, flat-form constructions) are to be tested, the circumference shall be measured and used to calculate an equivalent diameter, as if the cable were circular.

[b] For flat cables having a ratio of major to minor axis greater than 17:1, the flame application time remains under consideration.

TEST EVALUATION CRITERIA

After the burning has ceased, the surface of sample shall be wiped clean and the charred of affected portion shall not have reached 50 mm of the lower edge of the top clamp.

According to IEC 60331.21 For Fire Resistant

TEST EQUIPMENT

- A suitable chamber, of minimum volume 10 m^3
- A source of heat comprising a horizontally mounted ribbon burner
- A sample supporting systems
- A test wall equipped with thermocouples for verification of the source of heat
- A continuity checking arrangement
- Fuses

TEST SAMPLE

A cable sample at least 4.5m long shall be available from the cable length for test. Each individual test specimen to be tested shall be a piece of cable, taken from the cable sample,
not less than 1200 mm long shall have approximately 100 mm of sheath or outer coverings removed at each end.
At each end of the cable, each conductor shall be suitably prepared for electrical connections, and the exposed conductors shall be spread apart to avoid contact with each other.

TEST CONDITIONS

- Flow rate (at reference conditions of 1 bar and 20°C)
- Propane: (5,0 ± 0,25) litres/minute
- Air: (80 ± 5) litres/minute
- Test temperature: 750 °C
- Voltage applied between the cores: 250 (300) V a.c.

TEST PROCEDURE

The test specimen shall be held horizontally by means of suitable supports at each end and securely clamped to prevent movement.
The middle portion of the test specimen shall be supported by two metal rings placed approximately 300 mm; these, as well as any other metal parts of the supporting systems, shall be earthed.
At the transformer end of the test sample, ground the neutral conductor and any protective conductors. Any metal screens, drain wire or metallic layer shall be interconnected and grounded. Where a metallic sheath, armour or screen acts as a neutral or protective conductor, it shall be connected as for a neutral or protective conductor.
Each phase conductor is connected to a separate phase of the transformer output by a 2A fuse.
For multicores ≥4, multipairs, and multitriads cables, the conductors have to be divided in groups and each group has to be connected to a separate phase of the transformer output with a 2 A fuse or circuit-breaker with equivalent characteristics in each phase.

Ignite the burner and adjust the propane and air flow rates to those obtained during the verification procedure (see IEC 60331-11).
Switch on the electricity supply and adjust the voltage to the rated voltage of the cable (subject to a minimum voltage of 100 V a.c.), i.e. the test voltage between conductors shall equal the rated voltage between conductors and the test voltage from conductors to earth shall equal the rated voltage from conductor to earth. In the case of single-core cables the voltage shall be applied between the conductor and the earthed supporting apparatus and earthed metallic covering, if present.
The test shall continue for the flame application for 3 hours, if not otherwise specified. After that the flame shall be extinguished but the cable sample shall remain energized for a further 15 min. The total test duration shall be the flame application time together with the 15 min cooling period.

TEST EVALUATION CRITERIA

The criteria for determining the point of failure shall be as follows:

. the voltage is not maintained during the test duration, as indicated by fuse failure
. a conductor rupture during the test duration, as indicated by the lamp extinguishing