

IEEE Guide for Energy Efficiency Technology Evaluation of Electric Power Fittings

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

IEEE Std 2747™-2020

IEEE Guide for Energy Efficiency Technology Evaluation of Electric Power Fittings

Developed by the

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

Approved 24 September 2020

IEEE SA Standards Board

Abstract: This guide describes the energy efficiency technology evaluation of electric power fittings. It is applicable to electric power fittings in direct contact with electric power conductors.

Keywords: electric power fittings, energy efficiency technology evaluation, IEEE 2747™

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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PDF: ISBN 978-1-5044-7074-2 STD24417
Print: ISBN 978-1-5044-7075-9 STDPD24417

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Introduction

This introduction is not part of IEEE Std 2747-2020, IEEE Guide for Energy Efficiency Technology Evaluation of Electric Power Fittings.

This guide was prepared by the Fittings Energy Consumption Working Group to establish standard specifications for electric power fittings that are in direct contact with electric power conductors.

The purpose of this guide is to provide the requirements and testing procedures for the energy loss test and energy efficiency technology evaluation of electric power fittings.

Caution is advised to avoid misuse of the results of energy loss measurements. For example, non-ferrous current-carrying connectors are required by existing standards to have lower resistance, and therefore lower energy loss, than the same length of conductor. It could be assumed that energy loss is reduced by using more connectors. However, connectors are a point of failure, and their use should be minimized in the interest of reliability.

Connector energy loss and connector reliability are not correlated. For example, large compression connectors have a resistance of approximately 40% of the free-span conductor of length equal to the connector length. Large compression connectors are widely used, and their failure rate has a dominant impact on the reliability of overhead lines. Newer connector designs, including radial-swage connectors and implosion connectors, by contrast, exhibit significantly lower failure rates in both field and laboratory testing. The connector resistance for newer designs is approximately 80% of the resistance of a free-span conductor of equal length. This means the energy loss is greater for the compression connectors, though it is of note that the loss is still lower than the loss from the same length of free-span conductors. Connector selection should therefore be based on reliability, with energy loss considered only if reliability is equal or better.

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IEEE Guide for Energy Efficiency Technology Evaluation of Electric Power Fittings

1. Overview

1.1 Scope

This guide describes the energy efficiency technology evaluation of electric power fittings. It is applicable to electric power fittings that are in direct contact with electric power conductors.

1.2 Purpose

The purpose of this guide is to provide the basis for energy loss test and energy efficiency technology evaluation of electric power fittings. This guide provides technical support for the reduction of power grid loss and the expansion of power grid capacity. It promotes the technical progress of production enterprises for energy efficiency fittings.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{1,2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 61284, Overhead lines—Requirements and tests for fittings.³

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁴

branch connector: Device for connecting a branch conductor to a main conductor.

current-carrying electric fitting: The fitting that is designed for carrying electric current; mainly includes parallel groove clamp, insulation piercing connector, compression-type tension clamps, compression-type splicing sleeves, etc.

energy loss of fitting: The loss of electric energy caused by a fitting or its assembly with conductors when current passes through.

in-line connector: Device for connecting two conductors to extend the length.

non-current-carrying electric fitting: The fitting that is not designed for carrying electric current; mainly includes suspension clamps, bolt-type tension clamps, wedge-type tension clamps, vibration dampers, spacers, etc.

reference conductor: The conductor with a certain length in the test circuit, which is used as a reference for measuring the energy loss of fittings in order to measure the temperature and energy loss and select the current value for the test.

steady state: The state of which the temperature variation of a reference conductor does not exceed 2 °C within 15 min, when the test loop passes through a certain constant current at required test conditions.

4. General requirements

The fitting sample for testing should comply with the requirements in accordance with IEC 61284.⁵

A fitting under test may be complete with all components. Test equipment should be calibrated or verified as qualified in the validity period.

The following technical details should be recorded in a test report:

- Ambient temperature and humidity
- Test current

³IEC publications are available from the Sales Department of the International Electrotechnical Commission, 3 rue de Varembe, PO Box 131, CH-1211, Geneva 20, Switzerland (<https://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<https://www.ansi.org>).

⁴*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

⁵Information on references can be found in [Clause 2](#).

- Test voltage
- Test power
- Conductor temperature
- Energy loss of reference conductors and energy loss of fittings, etc.

5. Test equipment

Test equipment should include a current generator, horizontal tensile tester, and measuring devices of temperature, humidity, current, voltage, and power (or power factor).

The current generator and measuring devices of temperature, humidity, current, voltage, and power (power factor) can be integrated or separated.

The accuracy level of the tension measurement of horizontal tensile tester should be no lower than class 1.0.

The temperature measure meter should employ thermal resistance or other suitable sensor, with a maximum permissible error not exceeding 0.5 °C.

Humidity should be measured by the use of moisture sensitive resistance, moisture sensitive capacitor, or other suitable sensors whose maximum permissible error does not exceed $\pm 5\%$ relative humidity (RH).

AC can be measured by the current transformer and ammeter with an accuracy level no lower than class 0.5.

Voltage can be measured by voltmeters with an accuracy level no lower than class 0.5.

Power factor can be measured by the power factor meter with an accuracy level no lower than class 0.5.

Power can be measured by the power meter with an accuracy level no lower than class 1.0.

6. Test and evaluation for energy efficiency of current-carrying electric fittings

6.1 Sample number

The number of fitting samples may be four.

6.2 Test conductor selection

Select a test conductor for which the fitting is designed.

Branch connector: For a fitting connecting conductors of the same size, the test conductor size should be in the fitting application range that the supplier declared, as shown in [Figure 1](#).

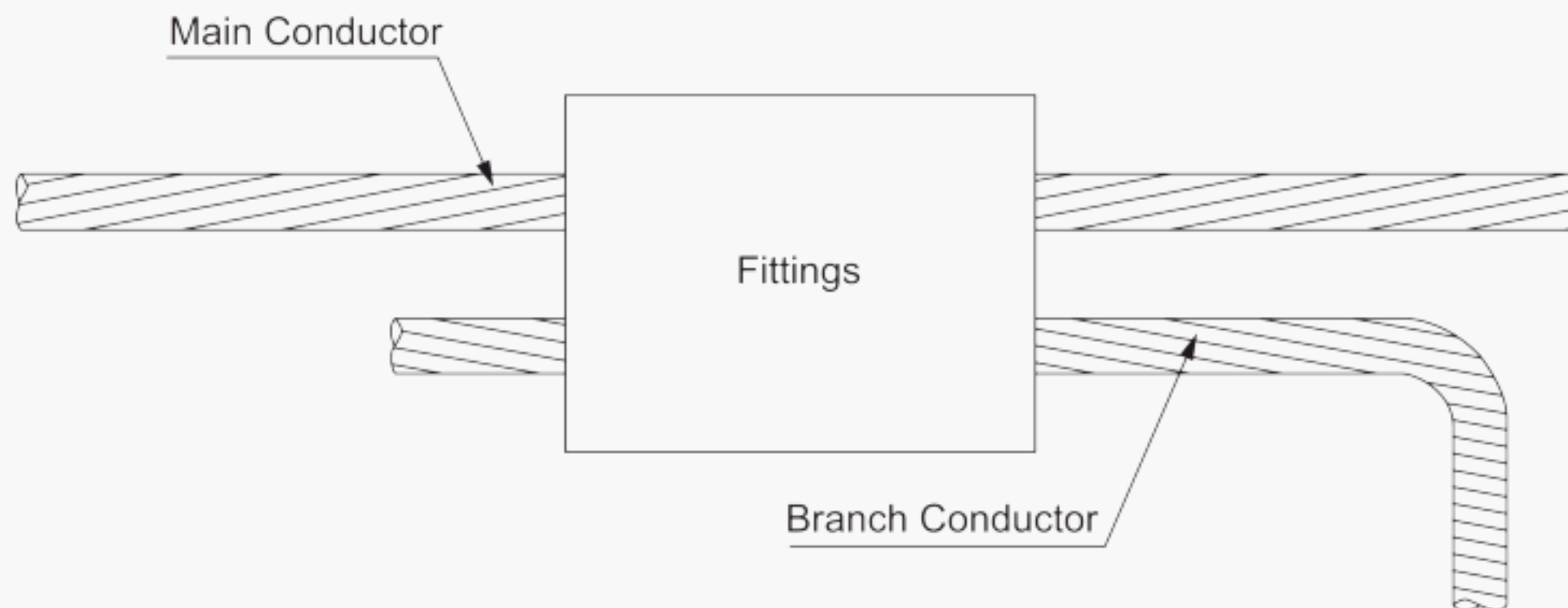


Figure 1—Fittings connecting conductors of the same size

For a fitting connecting two conductors of different sizes, at least two different sets of testing conductors should be selected.

- Set 1: The main conductor should be the maximum size in the application range of the fitting, and the branch conductor should be the maximum size in the application range of the fitting.
- Set 2: The main conductor should be the minimum size in the application range of the fitting, and the branch conductor should be the minimum size in the application range of the fitting.

If a fitting has a wide application range of conductor size, an additional set of test conductors should be selected as agreed between purchaser and supplier. The main conductor should be the maximum size in the application range of the fitting, and the branch conductor should be the minimum size in the application range of the fitting, as shown in [Figure 2](#).

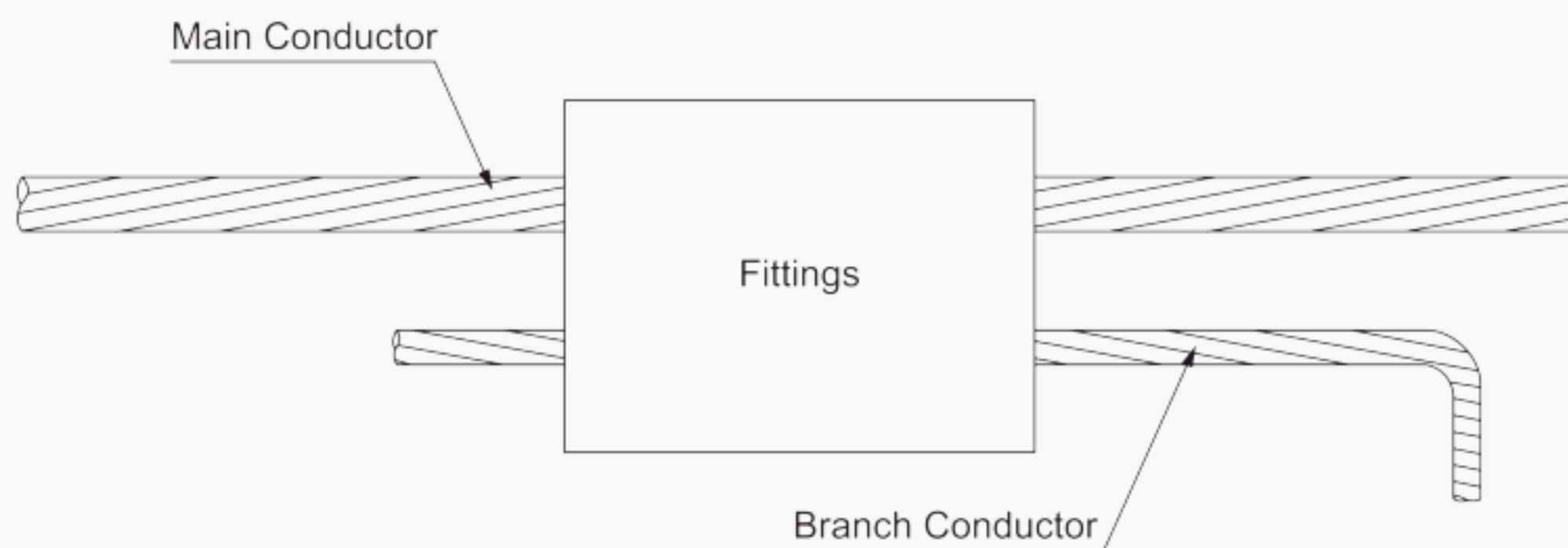


Figure 2—Fittings connecting conductors of different sizes

In-line connector: For a fitting connecting conductors of the same size, the test conductor's size should be in the fitting application range that the supplier declared as shown in [Figure 3](#).

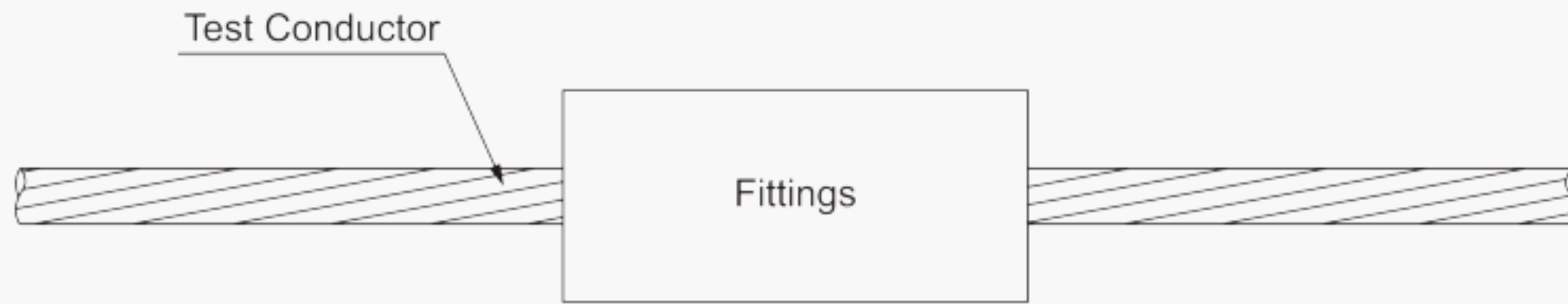


Figure 3—Fittings connecting conductors of the same size

For a fitting connecting two or more sizes of conductor, the maximum size of the conductor should be selected for testing, as shown in [Figure 4](#).

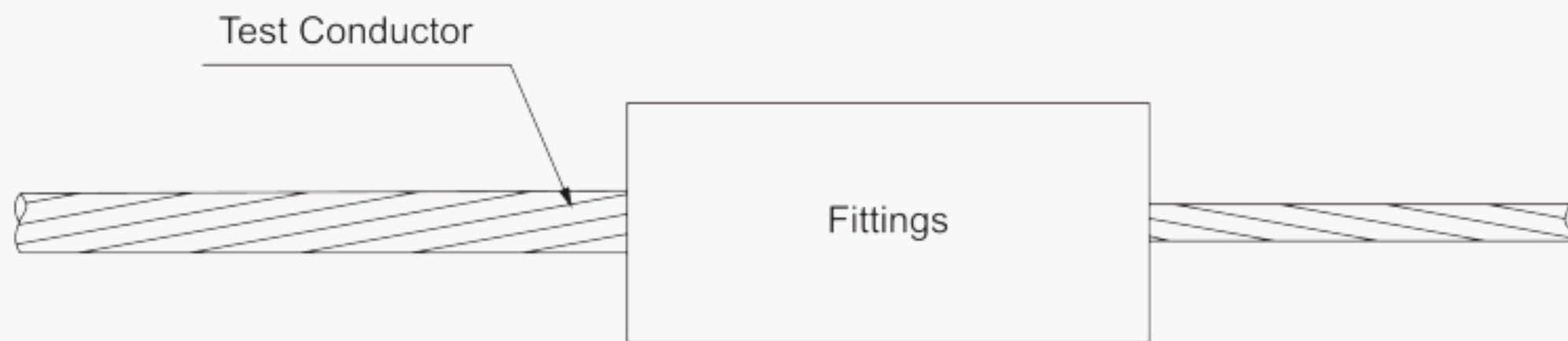


Figure 4—Fittings connecting conductors of different sizes

The tests should be carried out using new conductors. The length of each test conductor may not be less than 100 times the diameter of the conductor.

6.3 Test conditions

The test should be carried out in reasonably draft-free conditions at an ambient temperature between 15 °C and 30 °C, with an ambient humidity no greater than 80%.

6.4 Test methods

6.4.1 Reference conductor selection

For the test circuit of branch connectors, the reference conductor should be a branch conductor located in the center part, as shown in [Figure 5](#).

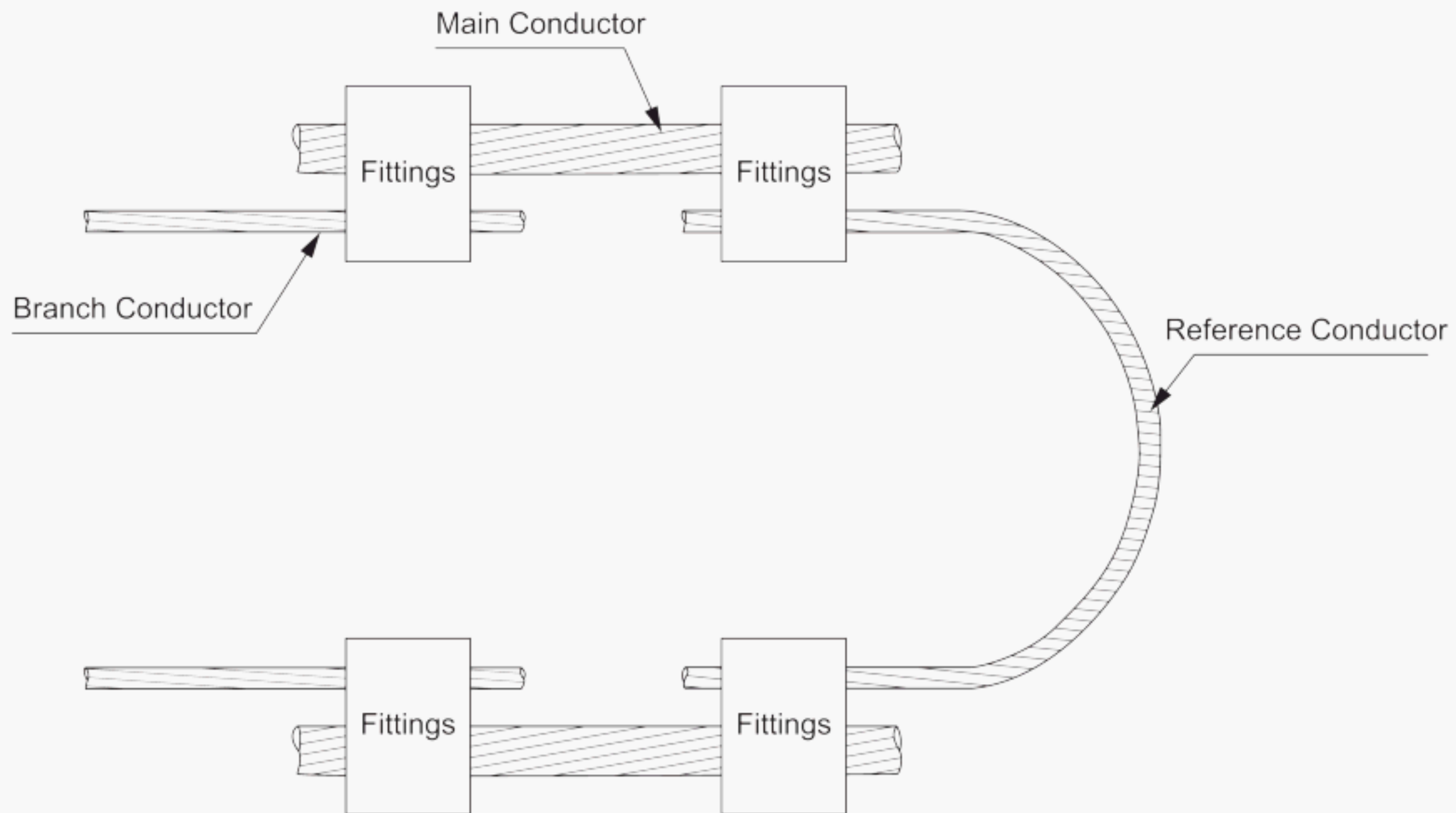


Figure 5—Layout of branch connector test circuit

For the test circuit of in-line connectors, the reference conductor should be located in the center part as shown in [Figure 6](#).

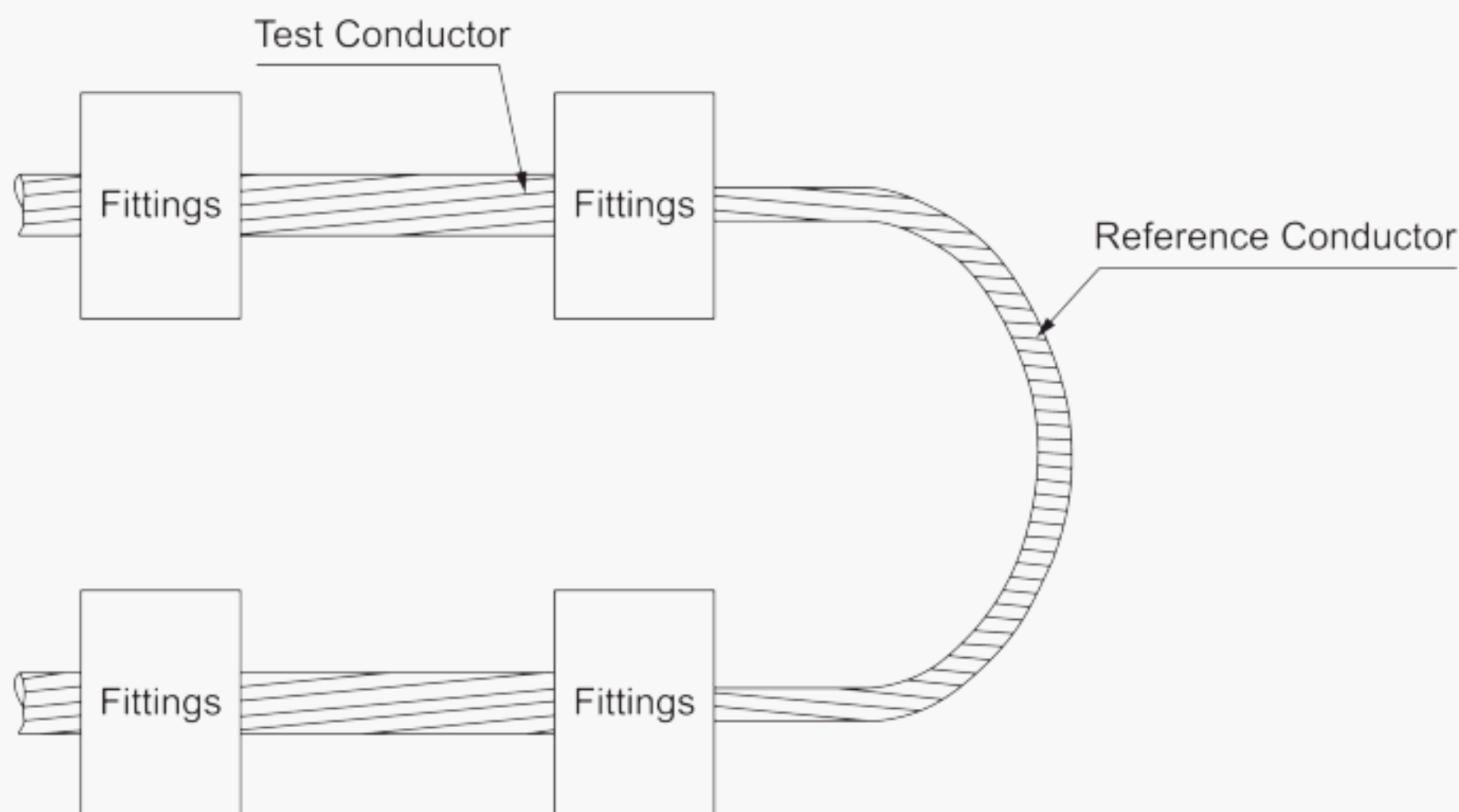


Figure 6—Layout of in-line connector circuit

6.4.2 Temperature measurement

The temperature probe should be securely fastened to the surface of the conductor.

For testing of insulation piercing connectors, the insulation layer of a cable should be stripped off at the position where the temperature probe is to be placed. The stripping length should not be greater than 30 mm,

and the width should be approximately 10 mm, as shown in Figure 7. After installing the temperature probe, the insulation should be restored to avoid uneven heat dissipation of the conductor.

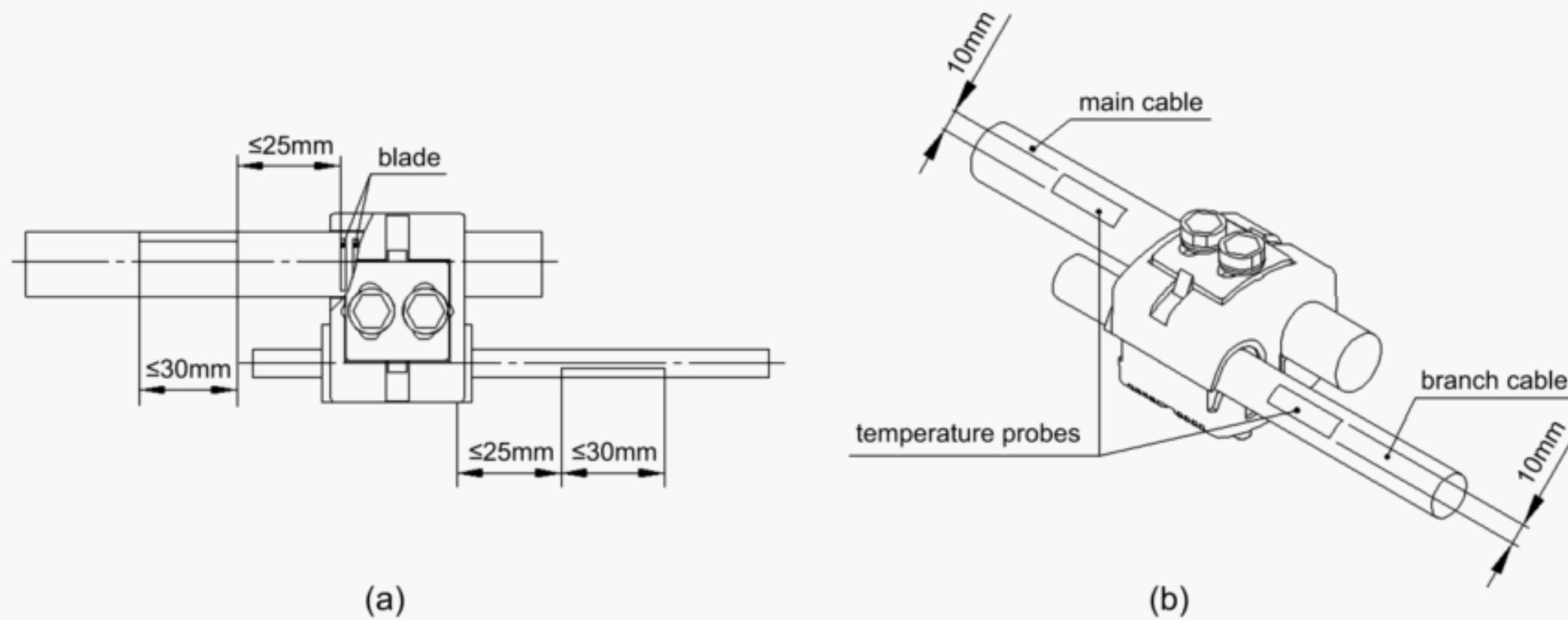


Figure 7—Layout of temperature probe for insulated cable

6.4.3 Current measurement

Pass the test conductor through the straight-through current transformer, and connect the current transformer secondary side to the current ammeter. The current of the test circuit is obtained by the ammeter reading and the transformer ratio.

6.4.4 Voltage measurement

Use a copper wire with a diameter of $0.8 \text{ mm} \pm 0.2 \text{ mm}$ to tie three to four turns at the voltage measuring point in order to create tight contact with the out strands of the conductor. If insulated cable is employed, the cable insulation layer at the position of the voltage measuring point may be removed. The stripping size is shown in Figure 7.

The layout of the voltage measuring point for the branch connector should be as depicted in Figure 8.

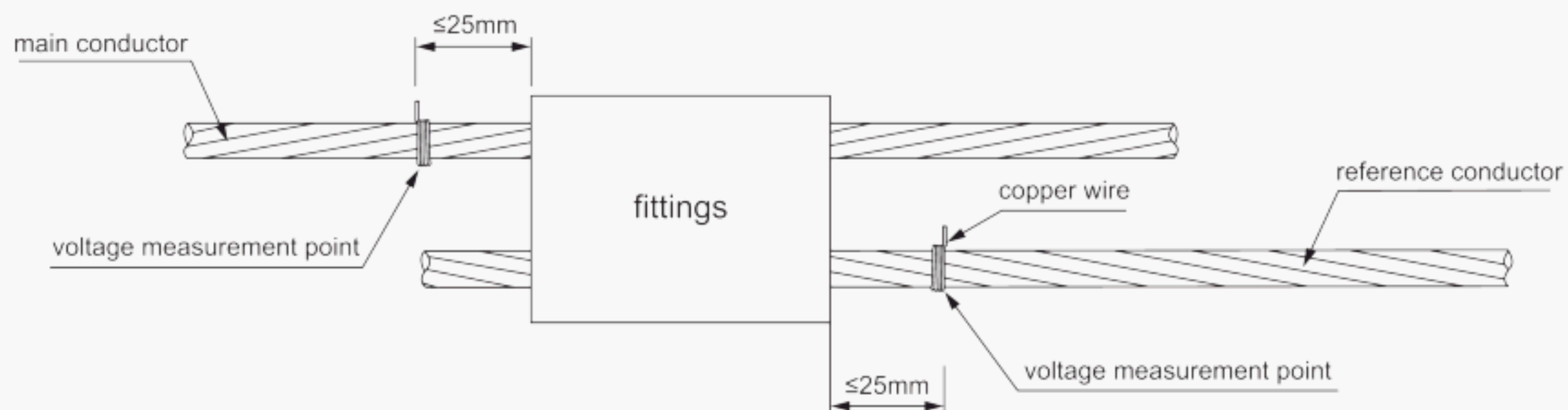


Figure 8—Voltage measurement point of branch connector

If the insulation piercing connector is tested, the voltage measurement point should be installed on the conductor 30 mm from the edge of the outer blade, as shown in Figure 9.

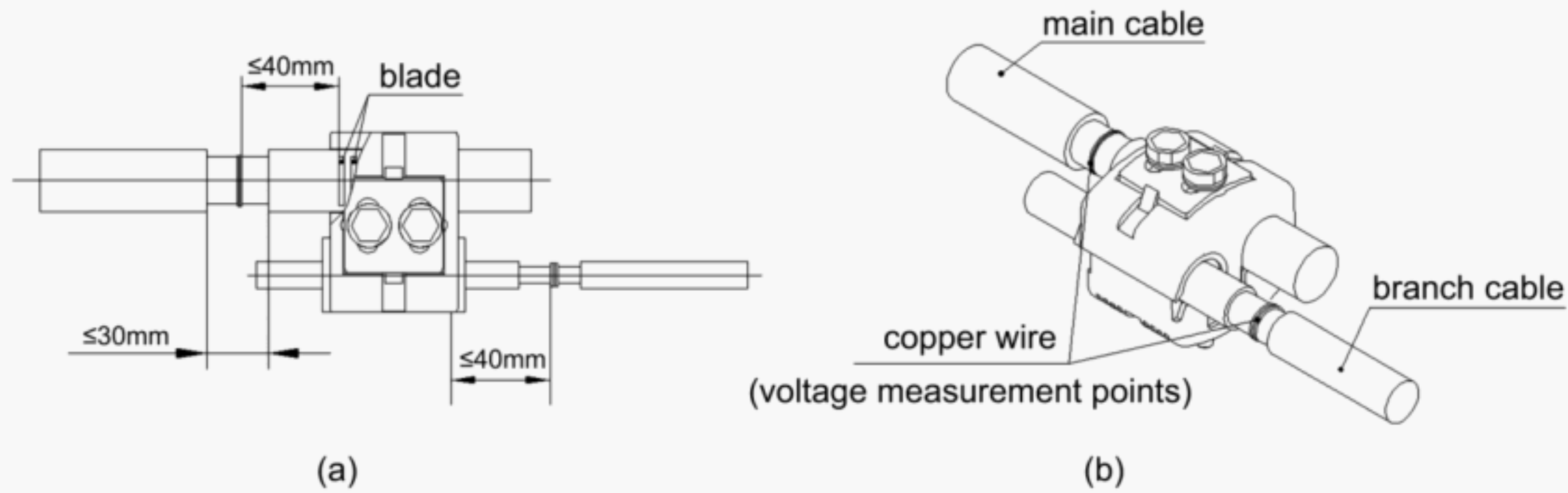


Figure 9—Voltage measurement point of insulation piercing connector

The layout of the voltage measuring point for an in-line connector should be as depicted in [Figure 10](#).

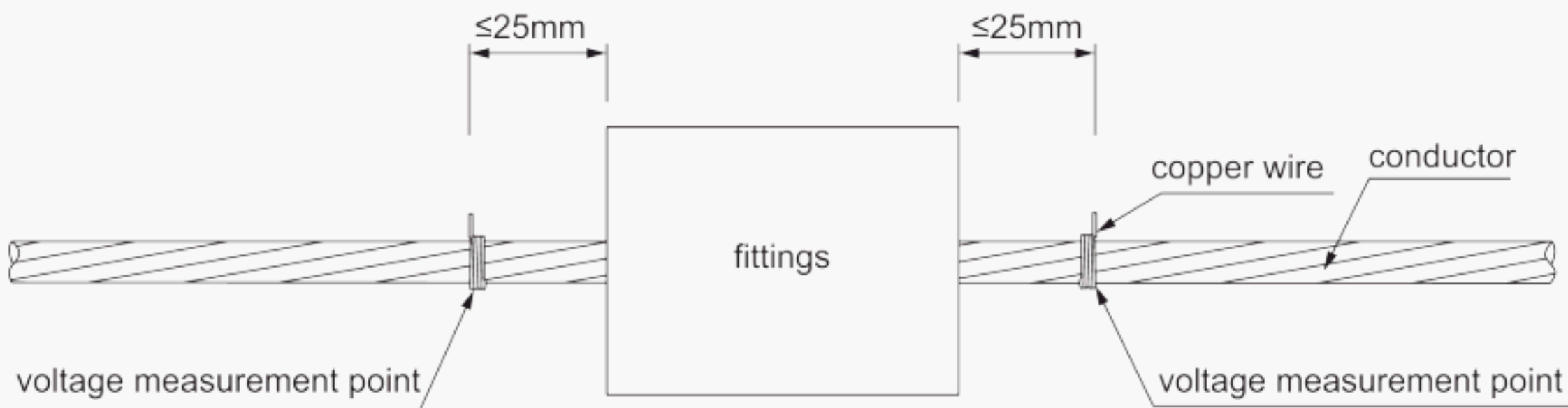


Figure 10—Voltage measurement point of in-line connector

6.4.5 Power measurement

Direct measurement: A power meter is employed to measure current, voltage, and power simultaneously.

Indirect measurement: A power factor meter is employed to measure the power factor of the test circuit. The measured current, voltage, and power factor are multiplied to be the power value by means of following [Equation \(1\)](#):

$$P = UI \cos \phi \quad (1)$$

where

U is the measured voltage
 I is the measured current
 $\cos \phi$ is the measured power factor

6.5 Test circuit layout

The fittings should be installed according to the product instructions.

The test circuit layouts of branch connectors are as illustrated in [Figure 11](#), [Figure 12](#), [Figure 13](#), and [Figure 14](#).

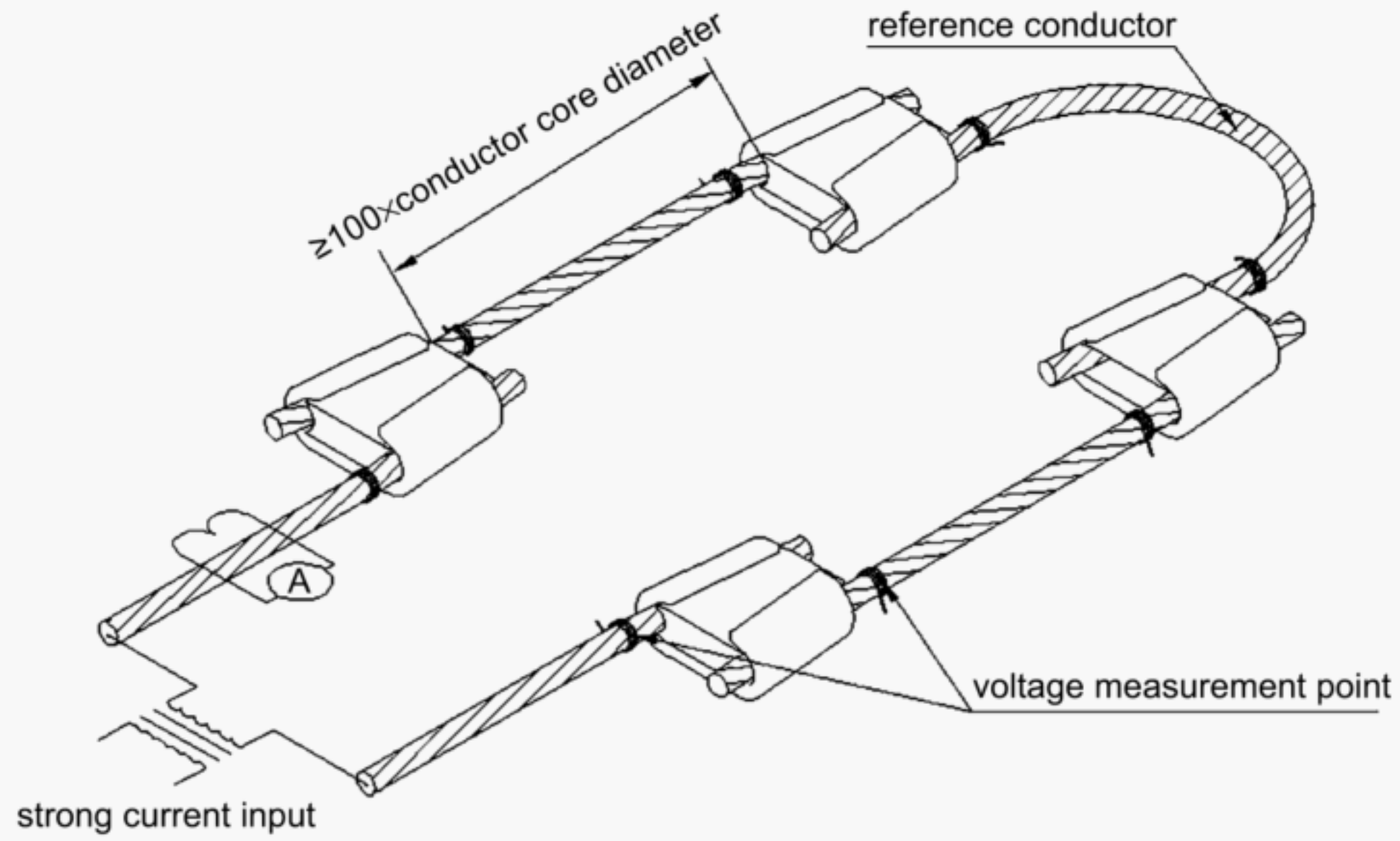


Figure 11—Layout of wedge groove clamp test

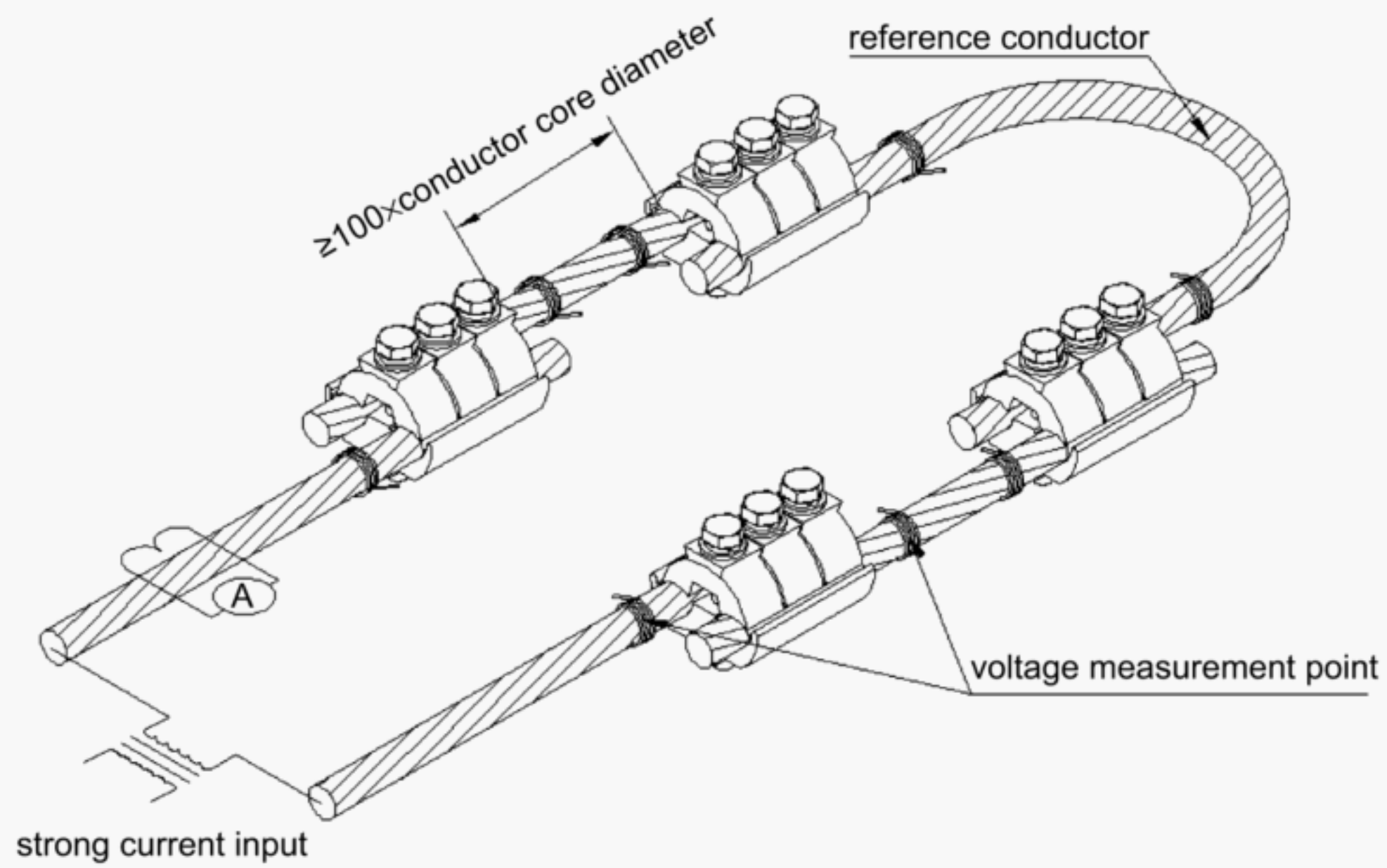


Figure 12—Layout of parallel groove clamp test

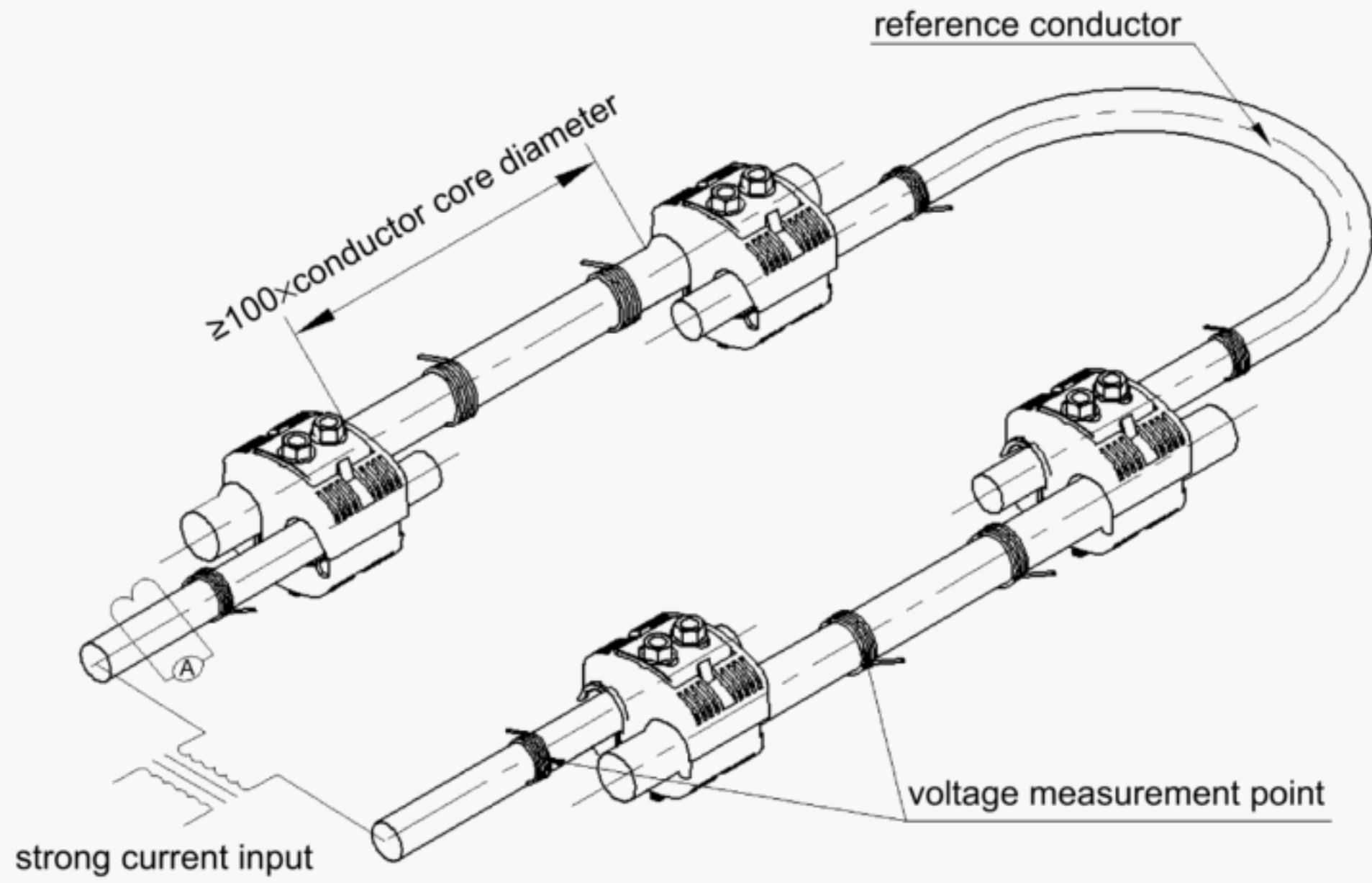


Figure 13—Layout of insulation piercing connector test

The test circuit layout of in-line connectors is as illustrated in [Figure 14](#).

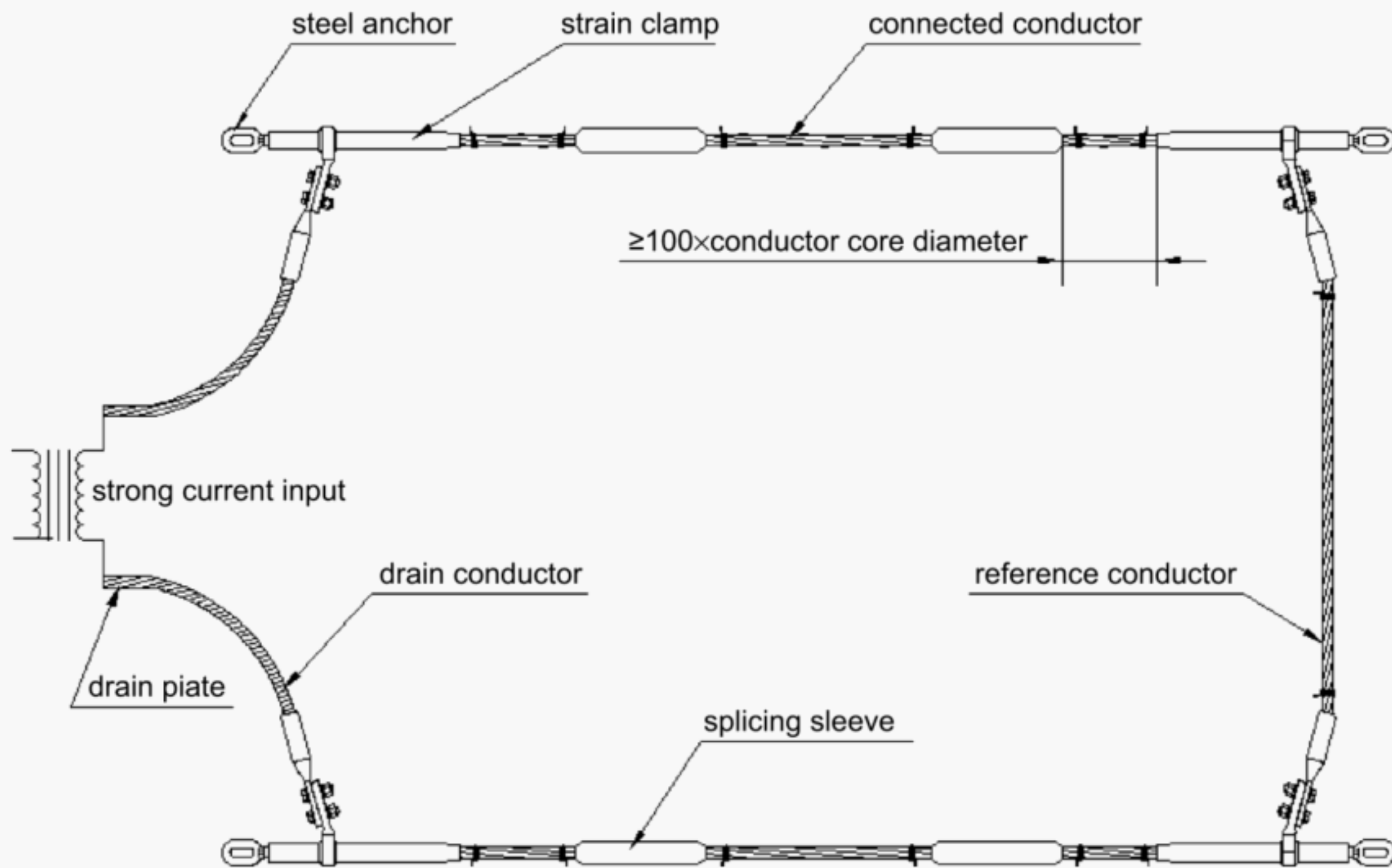


Figure 14—Layout of in-line connector test circuit

Magnetic materials should be avoided within the sphere of 0.5 m from the test area to ensure negligible magnetic interference. For a typical test sphere layout, take the insulation piercing connector shown in [Figure 15](#) as an example.

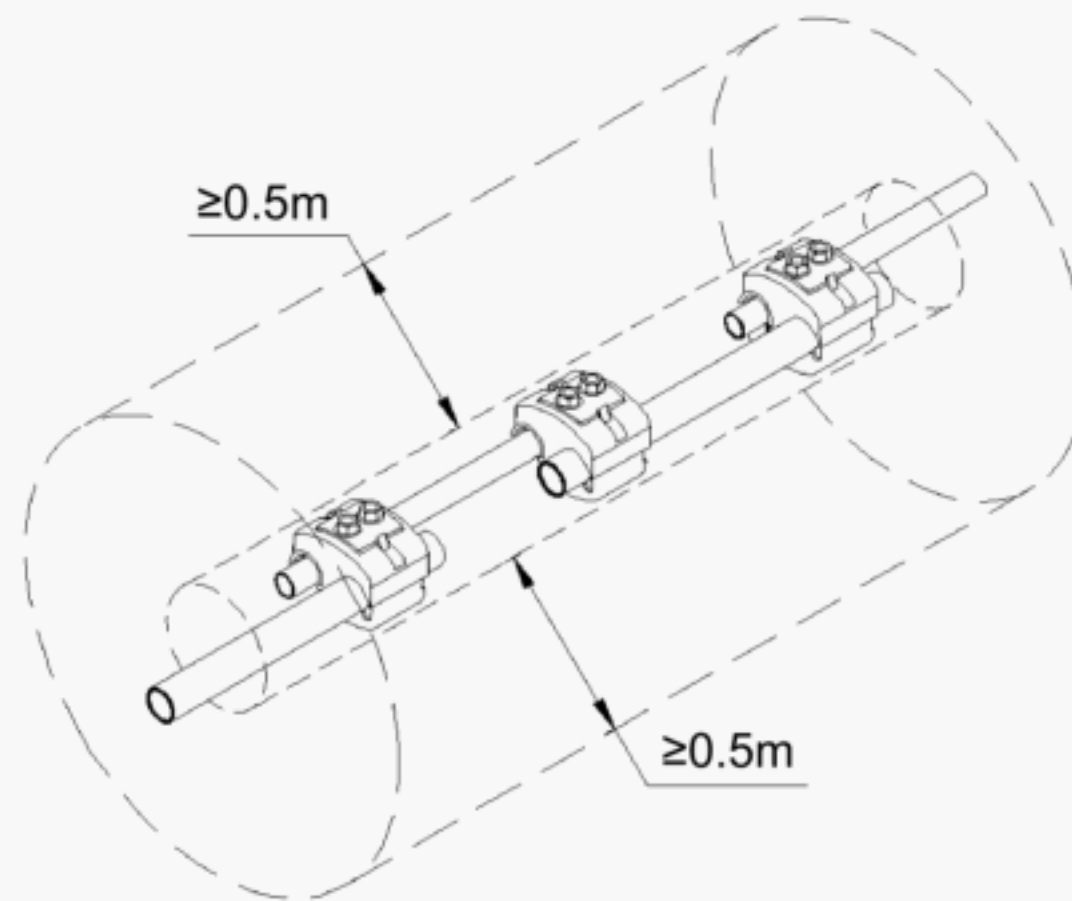


Figure 15—Sphere layout of the test area

The distance between the current output point and its fitting should be no less than 50 times the diameter of the test conductor.

6.6 Test procedures

6.6.1 Test steps

- The layout of the test circuit should be set up according to 6.4.
- A test current should then be passed through the test circuit. Consult [Annex B](#) for the value of the test current. Another method is to select a certain test temperature in advance. The value and duration of the test current should be such as to raise the reference conductor temperature to the test temperature. When the conductor temperature reaches a steady state, keep constant for 30 min. Use an initial current value not greater than 1.5 times of the test current to provide accelerated heating to reduce testing time.
- Measure and record data every five min in the last 10 min of steady state, and obtain the results by means of average values of three times measurement. When the energy loss of the fittings is too small to be measured directly, the total energy loss of the fittings and one of its connecting conductors can be measured first before the energy loss of the connecting conductors can be measured. Subtract them to obtain energy loss P_f between the voltage measuring points at the two ends of the fitting.
- Cut off the current and perform the next cycle after the conductor temperature cools to within 5 °C above ambient. In order to reduce the cooling time, forced cooling is permitted. However, uniform cooling rate should be maintained in all parts of the test circuit.
- After the three test cycles, the energy loss of each fitting P_f and the energy loss of the reference conductor P_l (P_f and P_l are both the average of all three cycles) are calculated. The calculation method of the energy loss of fittings P_f is shown in [Annex A](#). The relative deviation of each test data from its average may not exceed 5%. Otherwise, the whole process should be resampled and retested.

The energy loss test of fittings should be carried out for three cycles. The test sequence diagrammatic form is shown in [Figure 16](#).

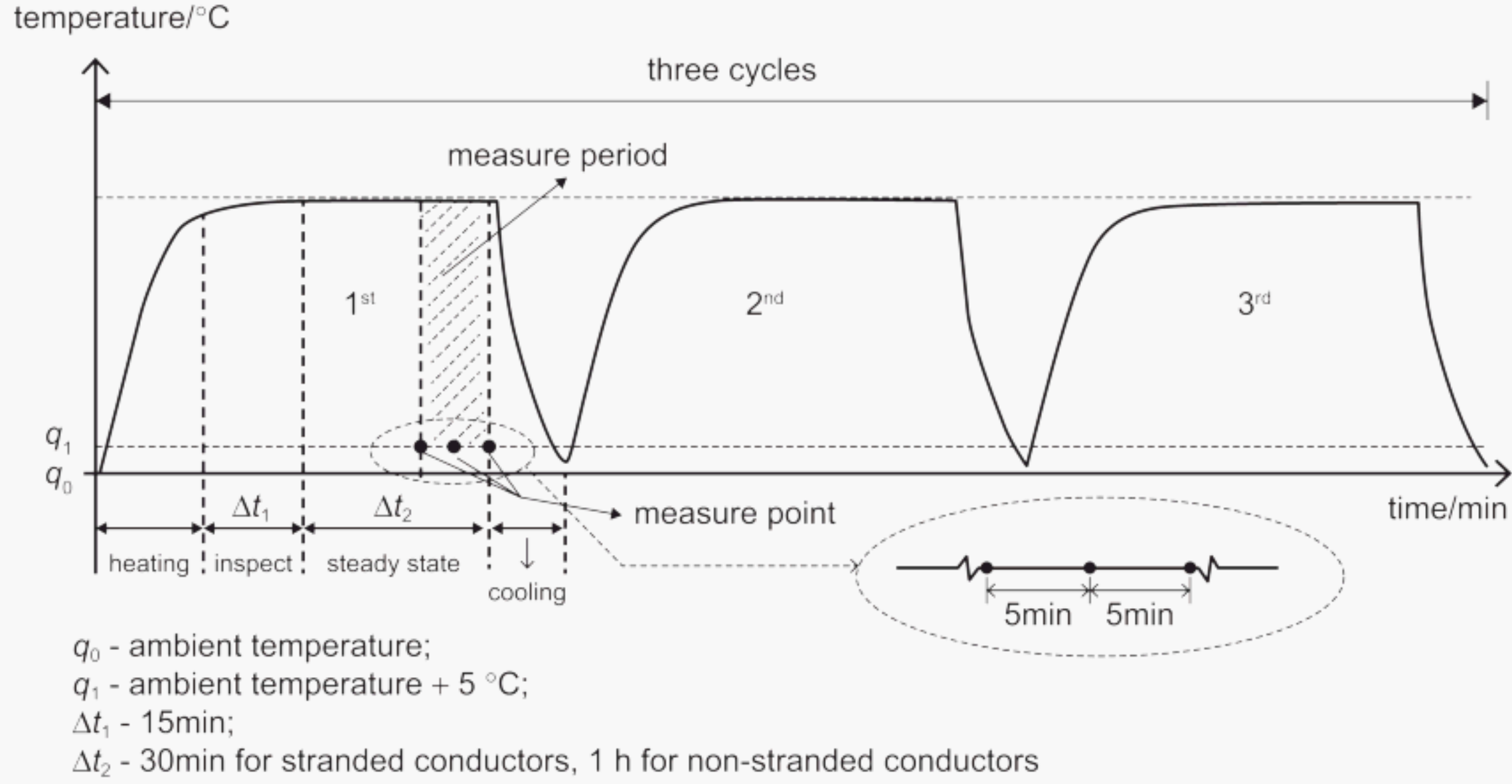


Figure 16—Cycling test sequence diagrammatic form of fitting energy loss

6.6.2 Evaluation criteria

The condition corresponds to the relation. If the test results meet the requirements of Equation 2, the fitting can be regarded as an energy-efficient type.

$$\frac{P_f}{L_f} \leq \frac{P_r}{L_r} \quad (2)$$

where

- P_f is the energy loss of fittings, in W
- P_r is the energy loss of reference conductor, in W
- L_f is the length of fittings connection, in m
- L_r is the length of reference conductor, in m

For the fitting (e.g., insulation piercing connectors with insulated cover), if the test results meet the requirements of Equation 3, the fitting can be regarded as an energy-efficient type. The adjustment coefficient α is agreed upon between the supplier and purchaser, and the recommended value is no less than 1.0.

$$\frac{P_f}{L_f} \leq \alpha \frac{P_r}{L_r} \quad (3)$$

where

- P_f is the energy loss of fittings, in W
- P_r is the energy loss of reference conductor, in W
- L_f is the length of fittings connection, in m
- L_r is the length of reference conductor, in m
- α is the adjustment coefficient

7. Test and evaluation for energy efficiency of non-current-carrying electric fittings

7.1 Sample number

The number of fitting samples should not be less than five.

7.2 Test conductor selection

The conductor used in the test should be the one for which the fitting is intended, or use annealed copper strand conductors that are agreed upon between both the supplier and purchaser. Copper rods with high purity (no less than 99.8%) can be used for the spacer test.

Test conductor should comply with the requirements as follows:

- If a fitting is designed for a single size conductor, the test conductor size should be the one for which the fitting is intended.
- If a fitting is designed for two or more sizes of conductor, the test conductor size should be the maximum one for which the fitting is intended.

7.3 Test conditions

Test conditions are as specified in [6.3](#).

7.4 Test methods

7.4.1 Temperature measurement

Temperature measurement methods are as specified in [6.4.2](#).

7.4.2 Current measurement

Current measurement methods are as specified in [6.4.3](#).

7.4.3 Voltage measurement

Voltage measurement methods are as specified in [6.4.4](#).

If the test sample is the spacer, the voltage measurement points should be located at current output terminals at both sides of the test assembly. Use a copper wire with a diameter of $0.8\text{ mm} \pm 0.2\text{ mm}$ to tie three to four turns at the voltage measuring points. Other methods can be used as agreed upon by both the supplier and purchaser.

Power measurement methods are as specified in [6.4.5](#).

7.5 Test circuit layout

For layout of the test circuit, see [Figure 17](#), [Figure 18](#), [Figure 19](#), [Figure 20](#), and [Figure 21](#). From [Figure 17](#) to [Figure 20](#), auxiliary test wires should be the same size as that of the test conductor, and a mechanical tension should be applied to the assembly of both fittings and test conductors to ensure it is in a horizontal state.

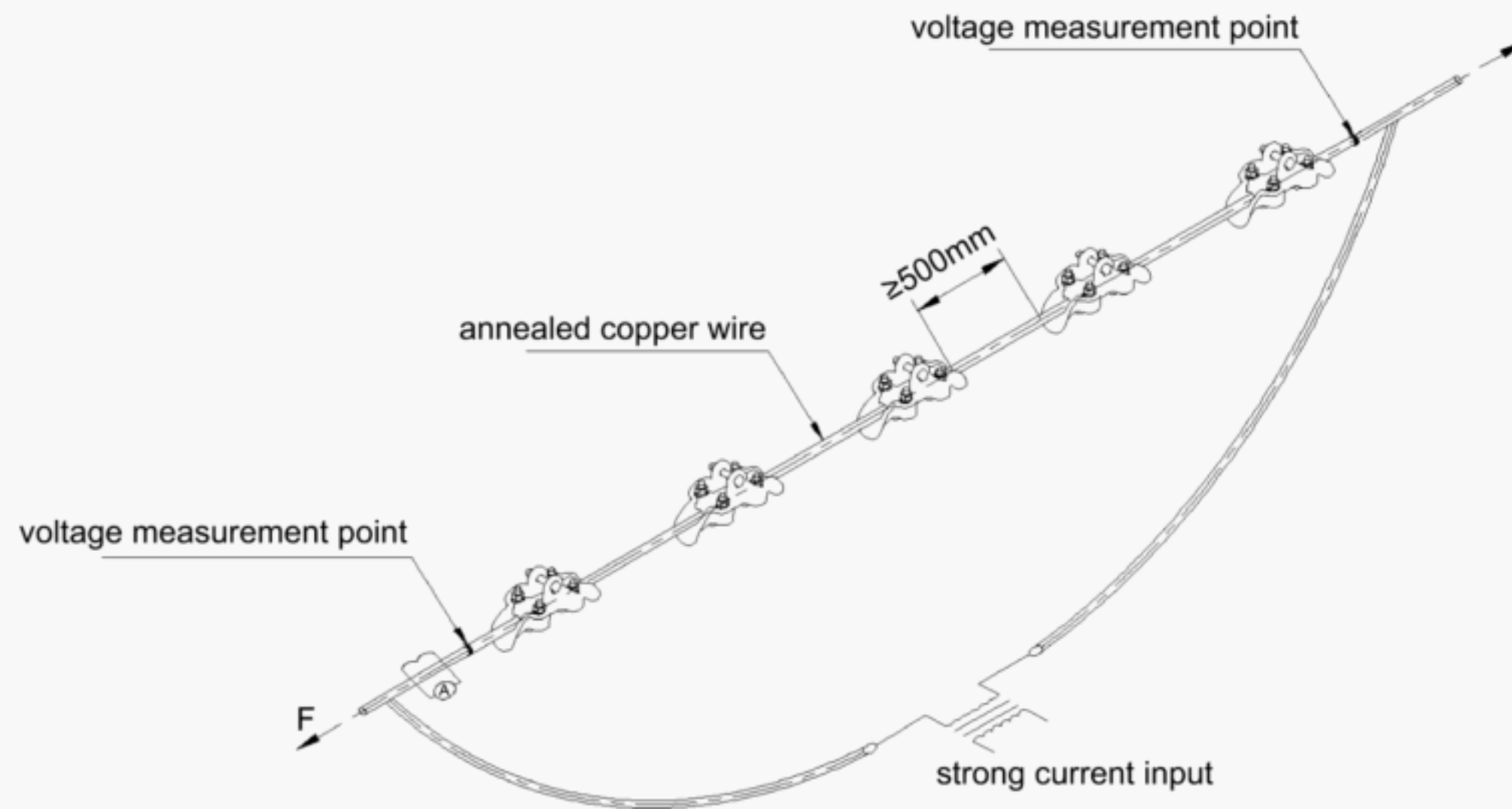


Figure 17—Layout of aluminum suspension clamp test circuit

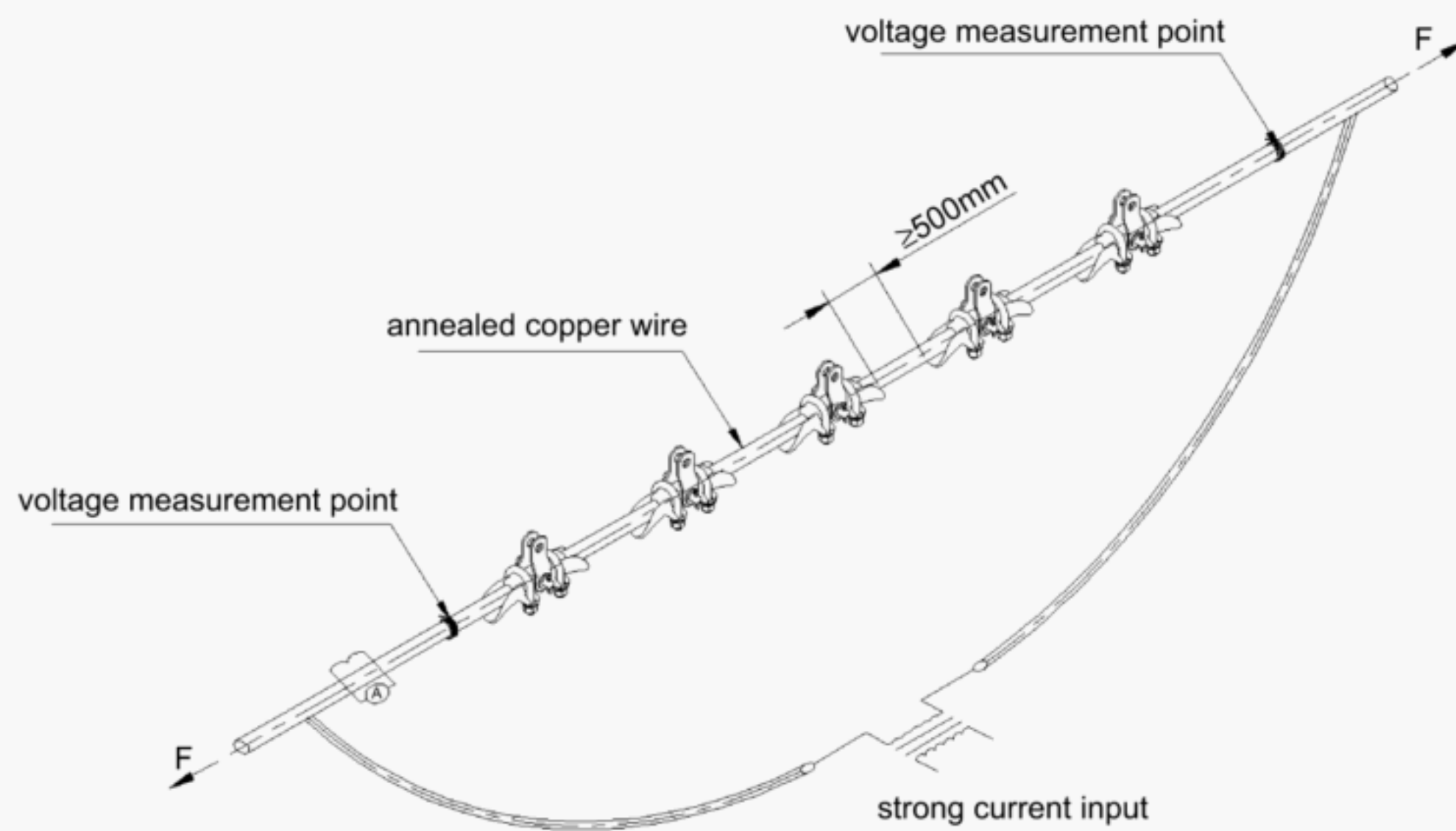


Figure 18—Layout of steel suspension clamp test circuit

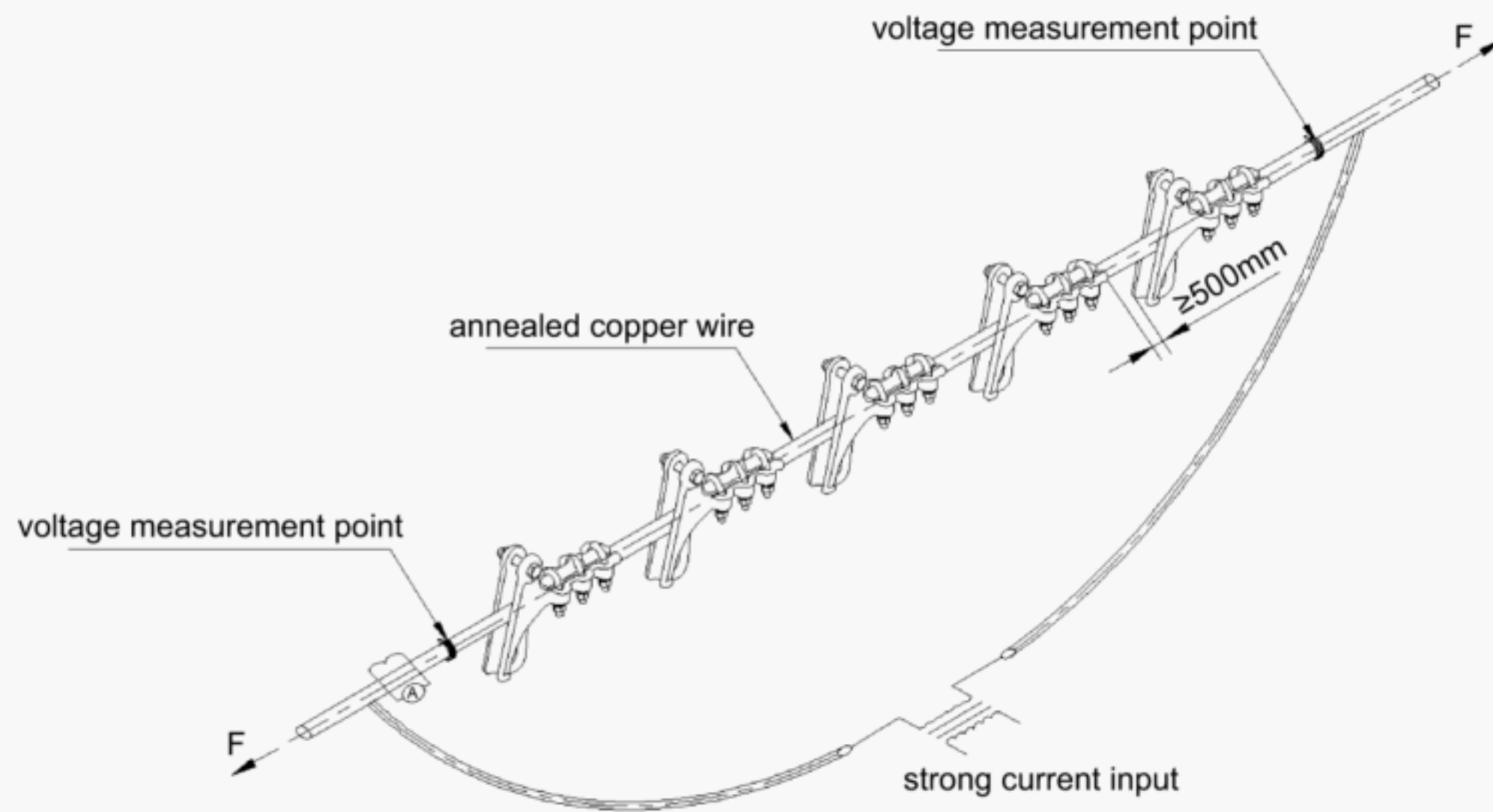


Figure 19—Layout of tension clamp test circuit

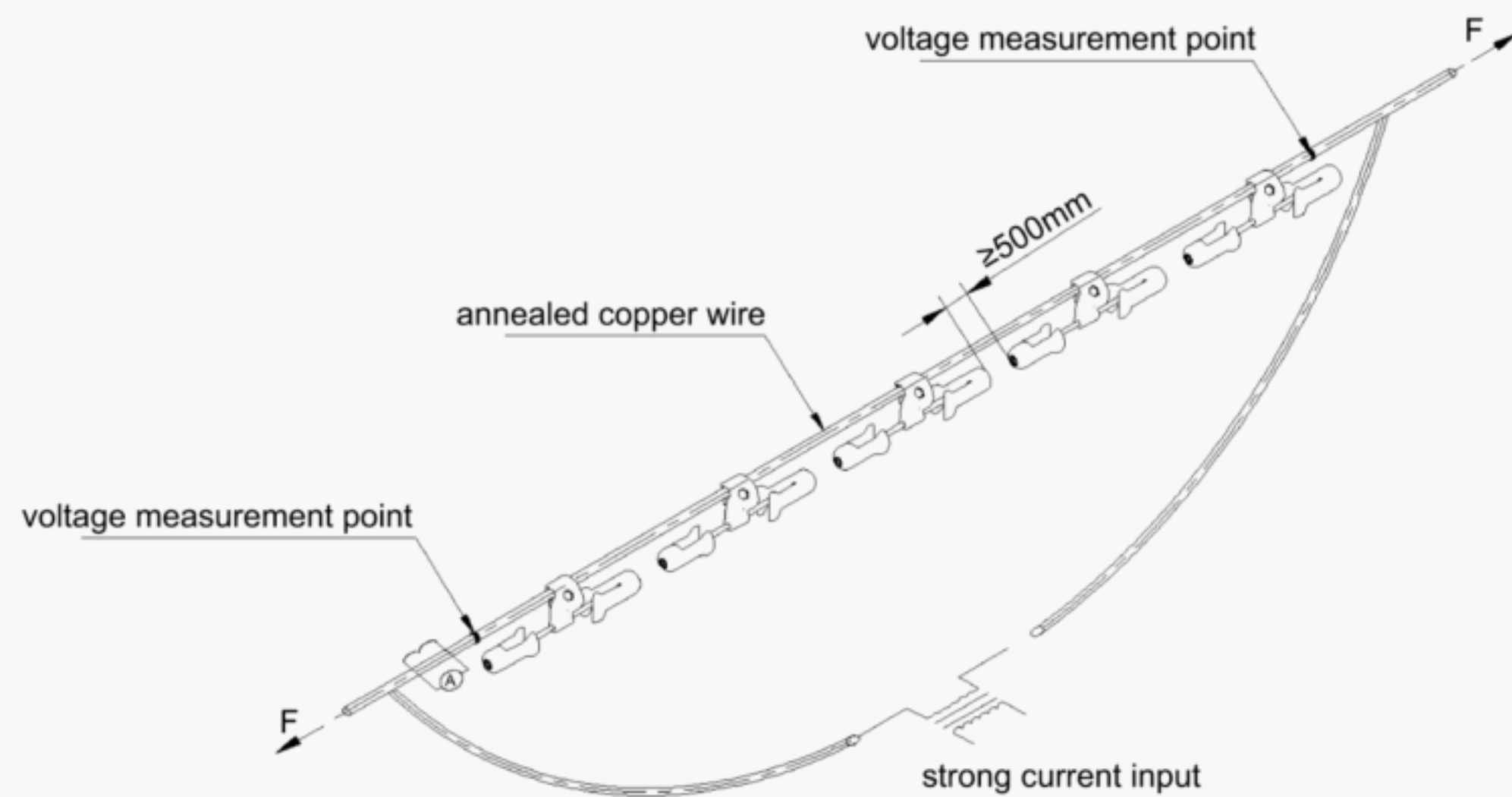


Figure 20—Layout of damper test circuit

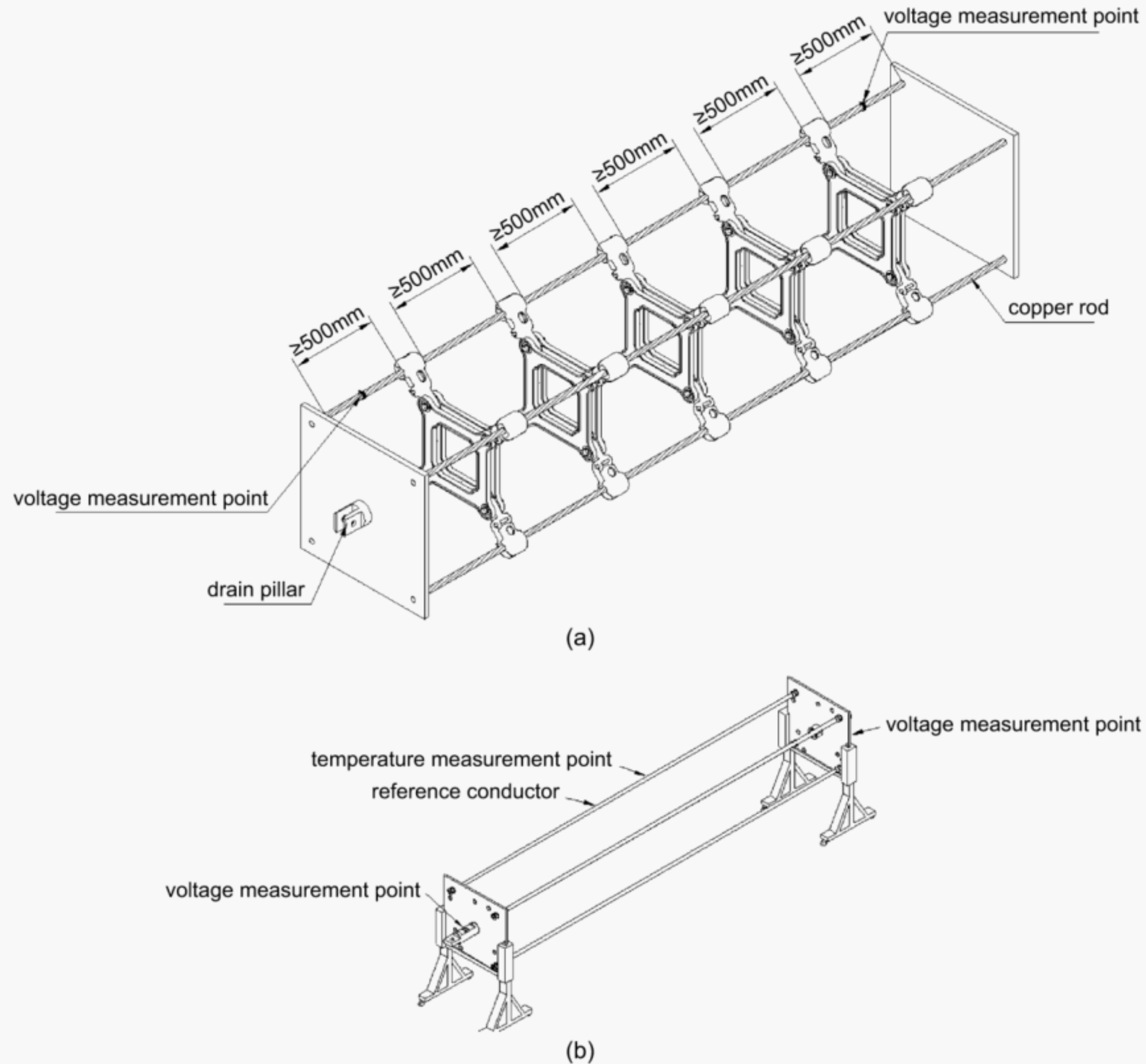


Figure 21—Layout of spacer test circuit

Magnetic materials should be avoided within the sphere of 0.5 m from the test area to ensure negligible magnetic interference.

The distance between the current output point and its fitting should be no less than 50 times the diameter of the test conductor.

A fitting under test should be complete with all components. The slot of the fitting should be in close contact with the test conductor after installation.

7.6 Test procedure

7.6.1 Test steps

- The layout of test circuits should be according to 7.5.

- b) Run the test current through the test circuit. The value of the test current should be according to [Annex B](#). Another means is to select a certain test temperature in advance. The value and duration of the test current should be sufficient enough to raise the reference conductor temperature to the test temperature. When the conductor temperature reaches steady state, keep for 30 min. The use of an initial current value not greater than 1.5 times the test current is to provide accelerated heating to reduce testing time.
- c) Measure and record the test current, conductor temperature, and the total energy loss of conductors and fittings every five min in the last 10 min of steady state, and determine test results by averaging the values of three consecutive tests.
- d) Cut off the current and cool the conductor temperature to 5 °C above ambient before performing the next cycle. In order to reduce the cooling time, forced cooling is permitted. However, a uniform cooling rate should be maintained in all parts of the test circuit.
- e) Repeat steps b) through d) and cycle three times.
- f) Remove the fittings on the test conductors, then repeat steps b) through d) and cycle three times. Measure and record the energy loss of the conductor and calculate the energy loss of each fitting according to [Equation 4](#).
- g) Calculate the average value of P_f and P_c of three cycles. The relative deviation of each test data from its average should not exceed 5%, otherwise the whole process should be resampled and retested.

$$P_f = \frac{P_{fc} - P_c}{N} \quad (4)$$

where

- P_f energy loss of fittings, in W
- P_{fc} total energy loss of conductors and fittings, in W
- P_c energy loss of test conductors, in W
- N Number of fitting samples

The test sequence diagrammatic form is shown as [Figure 22](#).

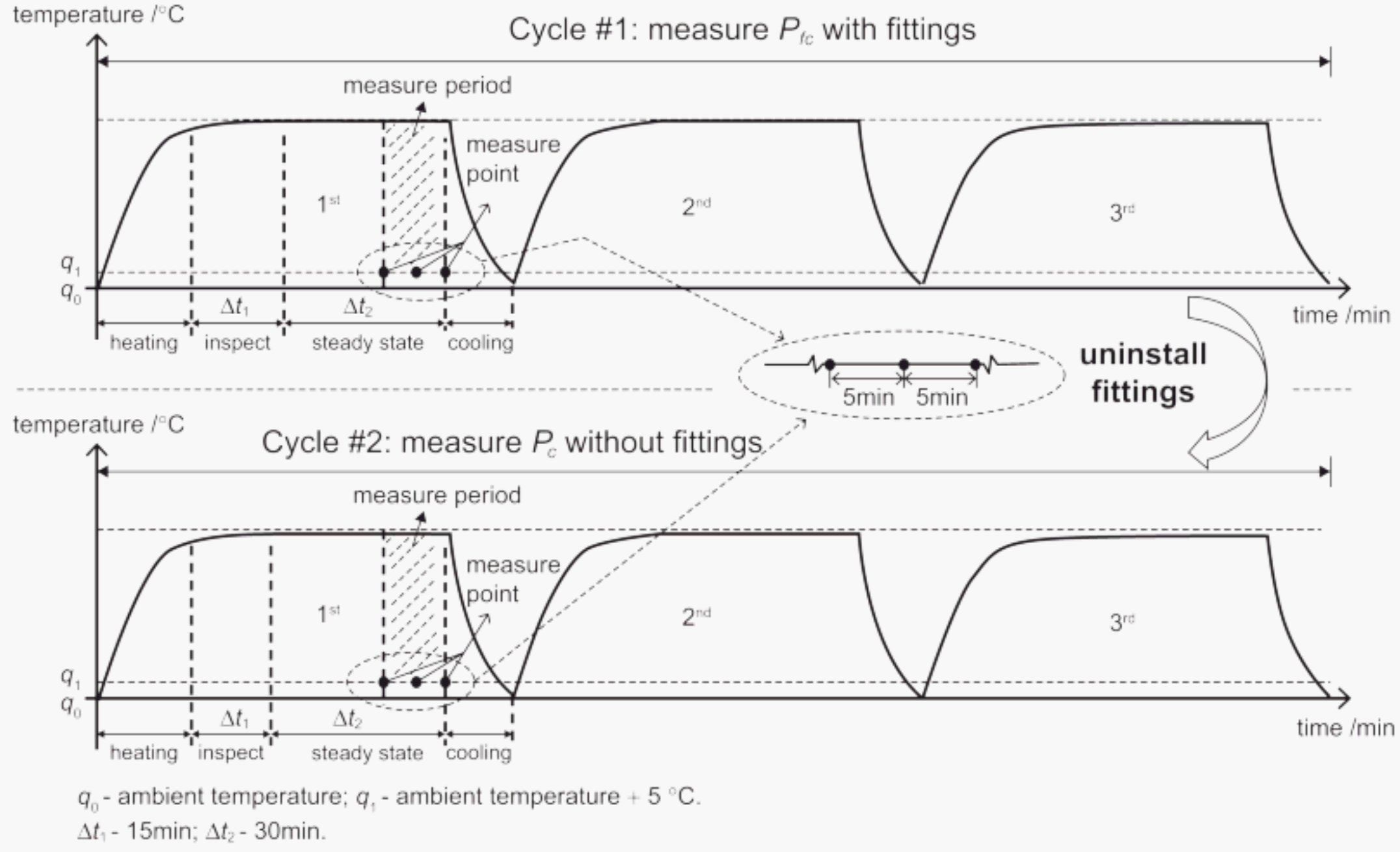


Figure 22—Cycling test sequence diagrammatic form of non-current-carrying fittings

7.6.2 Evaluation criteria

If the test results meet the requirements of Equation (5), the fittings can be regarded as an energy-efficient type.

$$P_f \leq \beta \frac{P_r}{L_r} \quad (5)$$

where

- P_f is the energy loss of fittings, in W
- P_r is the energy loss of reference conductor, in W
- L_r is the length of reference conductor, in m
- β is the adjustment coefficient, unless otherwise stated by the purchaser or supplier, it should be taken as equal to 1

Annex A

(normative)

Energy loss calculation of fittings

The schematic diagram of an energy loss test for branch connectors is shown in [Figure A.1](#):

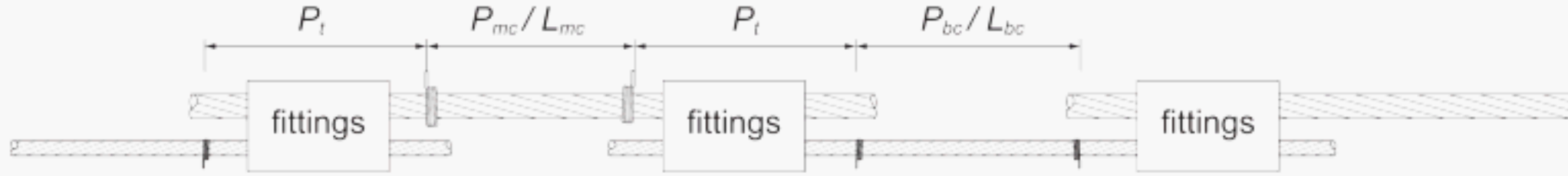


Figure A.1—Schematic diagram of energy loss test for branch connectors

The energy loss of fittings P_f is calculated in [Equation \(A.1\)](#):

$$P_f = P_t - \frac{P_{mc}}{L_{mc}} \times l - \frac{P_{bc}}{L_{bc}} \times l \quad (\text{A.1})$$

where

- P_f is the energy loss of fittings, in W
- P_t is the energy loss measured at two voltage measurement points, in W
- P_{mc} is the energy loss of the main conductor, in W
- L_{mc} is the length of the main conductor, in m
- P_{bc} is the energy loss of a branch conductor, in W
- L_{bc} is the length of a branch conductor, in m
- l is the distance between the voltage measurement point and the end of the clamp. It should be taken as equal to 25, in mm

The schematic diagram of an energy loss test for in-line connectors is shown in [Figure A.2](#).



Figure A.2—Schematic diagram of energy loss test for in-line connectors

Energy loss of fittings P_f is calculated in [Equation \(A.2\)](#):

$$P_f = P_t - \frac{P_r}{L_r} \times l \times 2 \quad (\text{A.2})$$

where

- P_f is the energy loss of fittings, in W
- P_t is the energy loss measured at two voltage measurement points, in W

P_r is the energy loss of reference conductor, in W

L_r is the length of reference conductor corresponding to P_r , in m

l is the the distance between voltage measurement point and the end of the clamp, it should be taken as equal to 25, in mm

Annex B

(normative)

Current magnitudes for test

Table B.1—A1 aluminum stranded conductor

Cross-section/mm ²	Test current/A
10	75
16	101
25	133
40	178
63	236
100	314
125	360
160	420
200	482
250	553
315	636
400	737
450	791
500	843
560	902
630	968
710	1038
800	1113
900	1191
1000	1264
1120	1346
1250	1429
1400	1515
1500	1571
NOTE 1—If the test conductor uses cables other than the metric ones specified above, use the test current corresponding to the larger, nearest equivalent metric size conductor. ⁶	
NOTE 2—The test current of the conductor is calculated according to the following conditions: an ambient temperature of 30 °C, operating temperature of 70 °C, wind speed of 0.5 m/s, sunlight intensity of 1000 W/m ² , conductor radiant cooling coefficient of 0.9, and conductor heat gain coefficient of 0.9.	

Table B.2—A2 aluminum alloy conductor

Cross-section/mm ²	Test current/A
20	104
30	136
45	182
75	242

Table continues

⁶Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

Table B.2—A2 aluminum alloy conductor (*continued*)

Cross-section/mm ²	Test current/A
120	322
145	369
185	431
230	494
300	567
360	652
465	755
520	811
580	864
650	924
720	992
825	1064
930	1141
1050	1220
1150	1295
1300	1379
1450	1464
NOTE 1—If the test conductor uses cables other than the metric ones specified above, use the test current corresponding to the larger, nearest equivalent metric size conductor.	
NOTE 2—The test current of the conductor is calculated according to the following conditions: an ambient temperature of 30 °C, operating temperature of 70 °C, wind speed of 0.5 m/s, sunlight intensity of 1000 W/m ² , conductor radiant cooling coefficient of 0.9, and conductor heat gain coefficient of 0.9.	

Table B.3—A3 aluminum alloy conductor

Cross-section/mm ²	Test current/A
20	104
30	136
45	183
75	242
120	322
145	370
185	431
230	494
300	567
360	653
465	756
520	812
580	865
650	926
720	994
825	1065
930	1142
1050	1222

Table continues

Table B.3—A3 aluminum alloy conductor (*continued*)

Cross-section/mm ²	Test current/A
1150	1297
1300	1380
NOTE 1—If the test conductor uses cables other than the metric ones specified above, use the test current corresponding to the larger, nearest equivalent metric size conductor.	
NOTE 2—The test current of the conductor is calculated according to the following conditions: an ambient temperature of 30 °C, operating temperature of 70 °C, wind speed of 0.5 m/s, sunlight intensity of 1000 W/m ² , conductor radiant cooling coefficient of 0.9, and conductor heat gain coefficient of 0.9.	

Table B.4—A1/S1A, A1/S1B, A1/S2A, A1/S2B, A1/S3A aluminum cable steel reinforced

Cross-section/mm ²	Test current/A
16/3	100
25/4	132
40/6	177
65/10	234
100/17	312
125/7	362
125/20	367
160/9	422
160/26	427
200/11	484
200/32	490
250/25	559
250/40	563
315/22	630
315/50	648
400/28	730
400/50	735
450/30	784
450/60	790
500/35	837
500/65	843
560/40	896
560/70	904
630/45	963
630/80	970
710/50	1035
710/90	1043
800/35	1122
800/65	1128
800/100	1120
900/40	1202
900/75	1210
1000/45	1277

Table continues

**Table B.4—A1/S1A, A1/S1B, A1/S2A, A1/S2B, A1/S3A
aluminum cable steel reinforced (*continued*)**

Cross-section/mm ²	Test current/A
1120/50	1361
1120/90	1373
1250/50	1447
1250/100	1458
NOTE 1—If the test conductor uses cables other than the metric ones specified above, use the test current corresponding to the larger, nearest equivalent metric size conductor.	
NOTE 2—The test current of the conductor is calculated according to the following conditions: an ambient temperature of 30 °C, operating temperature of 70 °C, wind speed of 0.5 m/s, sunlight intensity of 1000 W/m ² , conductor radiant cooling coefficient of 0.9, and conductor heat gain coefficient of 0.9.	

If not specified in [Table B.1](#) through [Table B.4](#), test current value can also be calculated as shown in [Equation \(B.1\)](#).

$$I = \sqrt{(W_R + W_F - W_S)/R_t^I} \quad (\text{B.1})$$

where

- I is the permissible ampacity, in A
- W_R is the radiant cooling power per unit length of conductor, in W/m
- W_F is the convection cooling power per unit length of conductor, in W/m
- W_S is the sunshine heat absorption power per unit length of conductor, in W/m
- R_t^I is the ac resistance of the conductor under permissible temperature, in Ω/m

W_R , radiant cooling power, is calculated as shown in [Equation \(B.2\)](#).

$$W_R = \pi D E_1 S_1 [(\theta + \theta_a + 273)^4 - (\theta_a + 273)^4] \quad (\text{B.2})$$

where

- D is the outer diameter of the conductor, in m
- E_1 is the radiant cooling coefficient of conductor surface (0.23 to 0.43 as bright new conductor, and 0.90 to 0.95 as dated conductor or black coated preservative conductor)
- S_1 is the Stefan-Boltzmann constant, $5.67 \times 10^{-8} \text{ W/m}^2$
- θ is the average temperature rise of the conductor surface, in °C
- θ_a is the ambient temperature, in °C

W_F , convection cooling power, is calculated as shown in [Equation B.3](#).

$$W_F = 0.57\pi\lambda_f\theta R_e^{0.485} \quad (\text{B.3})$$

where

- λ_f is the heat-transfer coefficient of an air layer on the conductor surface, in $\text{W/m}^2\cdot^\circ\text{C}$
- R_e is Reynolds number

λ_f , the heat-transfer coefficient of an air layer on the conductor surface, is calculated as shown in Equation B.4.

$$\lambda_f = 2.42 \times 10^{-2} + 7(\theta_a + \theta/2) \times 10^{-5} \quad (\text{B.4})$$

R_e , the Reynolds number, is calculated as shown in Equation B.5.

$$R_e = VD/\nu \quad (\text{B.5})$$

where

V is the wind speed in the radial direction of the conductor, in m/s

ν is the kinematic viscosity of the air layer on the conductor surface, in m²/s

ν , the kinematic viscosity of the air layer on the conductor surface, is calculated as shown in Equation B.6.

$$\nu = 1.32 \times 10^{-5} + 9.6(\theta_a + \theta/2) \times 10^{-8} \quad (\text{B.6})$$

W_s is the sunshine heat absorption power per unit length of conductor, which is calculated as shown in Equation B.7.

$$W_s = a_s J_s D \quad (\text{B.7})$$

where

a_s is the heat gain coefficient of the conductor surface, 0.35-0.46 as bright new conductor, 0.90-0.95 as dated conductor or black coated preservative conductor

J_s is the sunshine intensity, in W/m², 1000 W/m² when direct sunlight is applied to the conductor on a sunny day

Table B.5—Permissible ampacity of overhead insulated conductor

Rating cross-section/ mm ²	Copper conductor/A			Aluminum conductor/A			Aluminum alloy/A		
	PVC	PE	XLPE	PVC	PE	XLPE	PVC	PE	XLPE
6	55	55	70	43	43	55			
10	77	79	98	60	62	76	56	57	71
16	102	104	132	79	81	104	73	75	97
25	138	142	177	107	111	139	99	102	134
35	170	175	218	132	136	172	122	125	159
50	209	216	268	162	168	211	149	154	195
70	266	275	339	207	214	267	191	198	248
95	332	344	419	257	267	330	238	247	306
120	384	400	488	299	311	385	276	287	357
150	442	459		342	356		320	329	
185	515	536		399	416		369	384	
240	615	641		476	497		440	459	
NOTE—Ambient temperature = 30 °C.									

Annex C

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] IEC 60228-2004, Conductors of insulated cables.⁷

[B2] IEC 61089-1991, Round wire concentric lay overhead electrical stranded conductors.

[B3] IEC 61238-1-1-2018, Compression and mechanical connectors for power cables—Part 1–1: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV ($U_m = 1.2$ kV) tested on non-insulated conductors.

[B4] IEC 62219-2002, Overhead electrical conductors—Formed wire, concentric lay, stranded conductors.

⁷IEC publications are available from the Sales Department of the International Electrotechnical Commission, 3 rue de Varembé, PO Box 131, CH-1211, Geneva 20, Switzerland (<https://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<https://www.ansi.org>).

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