
**Tractors and machinery for
agriculture and forestry — Electrical
high-power interface 700 V DC / 480 V
AC —**

**Part 2:
Physical interface**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

This document is intended to be used in conjunction with ISO 23316-1, ISO 23316-3, ISO 23316-4, ISO 23316-5 and ISO/FDIS 23316-6:—.

A list of all parts in the ISO 23316 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose ISO 23316 series is to provide design and application standards covering implementation of an electrical high-power interface with a nominal voltage of 700 V DC/480 V AC for agricultural and forestry machinery.

The ISO 23316 series specifies physical and logical interface requirements that provide interoperability and cross compatibility for systems and equipment operating at nominal voltages of 700 V DC/480 V AC.

The following are not within the scope of ISO 23316:

- service, maintenance, and related diagnostics;
- functional safety;
- control strategies for high-power supplies and loads;
- application-specific strategies and operational modes;
- component design;
- energy storage systems, e.g. supercapacitors or batteries;
- multiple electrical power supplies to a common DC-link.

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Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC —

Part 2: Physical interface

1 Scope

This document specifies direction for the design of the physical interface between a supply system and a consumer system. Electrical, geometrical and test requirements are defined within this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC/IEEE 8802-3:2021, *Telecommunications and exchange between information technology systems — Requirements for local and metropolitan area networks — Part 3: Standard for Ethernet*

ISO 4892-3, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 6270-2, *Paints and varnishes — Determination of resistance to humidity — Part 2: Condensation (in-cabinet exposure with heated water reservoir)*

ISO 8092-2:2005, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 2: Definitions, test methods and general performance requirements*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 16230-1, *Agricultural machinery and tractors — Safety of higher voltage electrical and electronic components and systems — Part 1: General requirements*

ISO 16750-3:2012, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

ISO 16750-5:2010, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 5: Chemical loads*

ISO 20567-1, *Paints and varnishes — Determination of stone-chip resistance of coatings — Part 1: Multi-impact testing*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

ISO 23316-1:2022, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 1: General*

ISO 23316-4, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 4: AC operation mode*

ISO 23316-2:2023(E)

ISO/FDIS 23316-6:—¹⁾, *Tractors and machinery for agriculture and forestry — Electrical high-power interface 700 V DC / 480 V AC — Part 6: Communication signals*

IEC 60068-2-6, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing — Part 2-14: Tests — Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

IEC 60068-2-31, *Environmental testing — Part 2-31: Tests — Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-60:2015, *Environmental testing — Part 2-60: Tests — Test Ke: Flowing mixed gas corrosion test*

IEC 60068-2-78, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes — Part 1: General requirements*

IEC 60512-2-1, *Connector for electronic equipment — Tests and measurements — Parts 2-1: Electrical continuity and contact resistance — Test 2a: Contact resistance – Millivolt level method*

IEC 60512-5-1, *Connectors for electronic equipment — Tests and measurements — Part 5-1: Current – carrying capacity tests — Test 5a: Temperature rise*

IEC 60512-5-2, *Connectors for electronic equipment — Tests and measurements — Part 5-2: Current – carrying capacity tests — Test 5b: Current - temperature derating*

IEC 60512-23-7, *Connectors for electronic equipment — Tests and measurements — Part 23-7: Screening and filtering tests — Test 23g: Effective transfer impedance of connectors*

IEC 60512-25-2, *Connectors for electronic equipment — Tests and measurements — Part 25-2: Test 25g — Attenuation (insertion loss)*

IEC 60512-25-5, *Connectors for electronic equipment — Tests and measurements — Part 25-5: Test 25e — Return loss*

IEC 60512-25-7, *Connectors for electronic equipment — Tests and measurements — Part 25-7: Test 25g — Impedance, reflection coefficient, and voltage standing wave ratio (VSWR)*

IEC 60603-7-7:2010, *Connectors for electronic equipment — Part 7-7: Detail specification for 8-way, shielded, free and fixed connectors for data transmission with frequencies up to 600 MHz*

IEC 60664-1:2007, *Insulation coordination for equipment within low voltage systems*

IEC 61984, *Connectors — Safety requirements and tests*

IEC 62153-4-6, *Metallic cables and other passive components test methods — Part 4-6: Electromagnetic compatibility (EMC) — Surface transfer impedance — Line injection method*

IEC 62153-4-7, *Electromagnetic compatibility (EMC) — Test method for measuring of transfer impedance Z_T and screening attenuation ac or coupling attenuation ac of connectors and assemblies up to and above 3 GHz – Triaxle tube in tube method*

IEC 62196-1:2014, *Plugs, socket outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles — Part 1: General requirements*

1) Under development. Stage at the date of publication: ISO/FDIS 23316-6:2023.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23316-1, ISO/FDIS 23316-6:— and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

space inside the connector

area inside of the connector which is permanently closed and cannot be reached without tools

3.2

exposed connector parts and surfaces

all connector parts and space inside connector face which are accessible without using tools

3.3

comparative tracking index

CTI

numerical value of the maximum voltage at which five test specimens withstand the test period for 50 drops without tracking failure and without a persistent flame occurring and including also a statement relating to the behaviour of the material when tested using 100 drops

[SOURCE: IEC 60112:2009, 3.5]

4 Connector requirements

4.1 General function description

- a) The connector is part of the electric drive system of agricultural vehicles and implements.
- b) Its function is to provide external consumers with electric power.
- c) The connector is intended to be a part mounted to the vehicle chassis exterior.

4.2 Detailed function description

- a) The connector shall be designed such that more than one connector can be installed on vehicle.
- b) The connector shall incorporate a housing providing environmental protection, including EMC shielding.

4.3 Geometric requirements

4.3.1 General

The connector shall provide a cable strain relief.

4.3.2 Interface geometric definition

4.3.2.1 General tolerances

General tolerance applies to all unspecified dimensions on the partial drawings within this subclause. See [Table 1](#).

Table 1 — Tolerances

	Range 1	Range 2	Range 3	Angles
Length of dimension [mm]	0 - 50	50 - 100	100 >	n/a
Tolerance [mm]	±0,15	±0,2	±0,3	±0,5°

4.3.2.2 Maximum material model for the tractor side

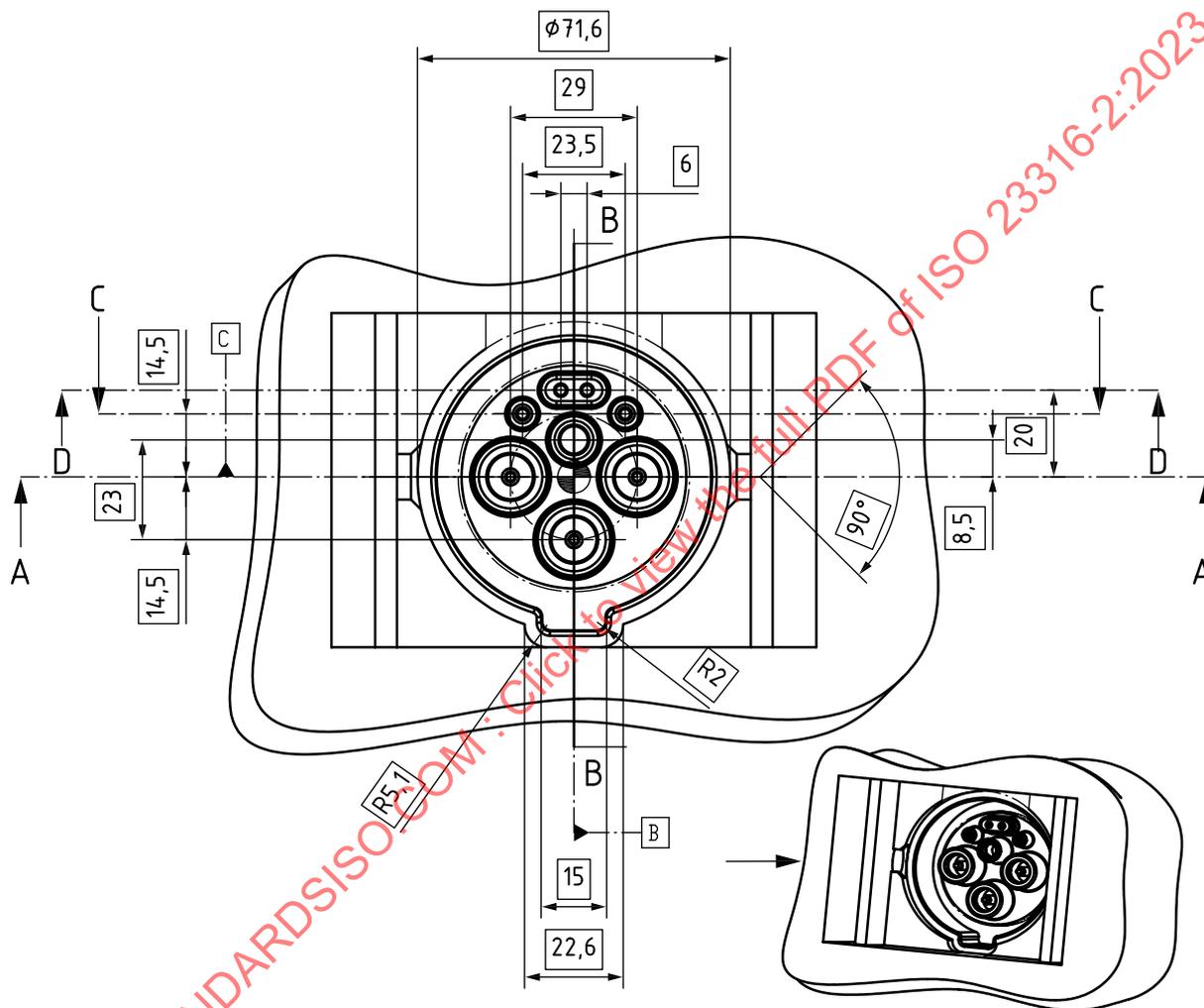
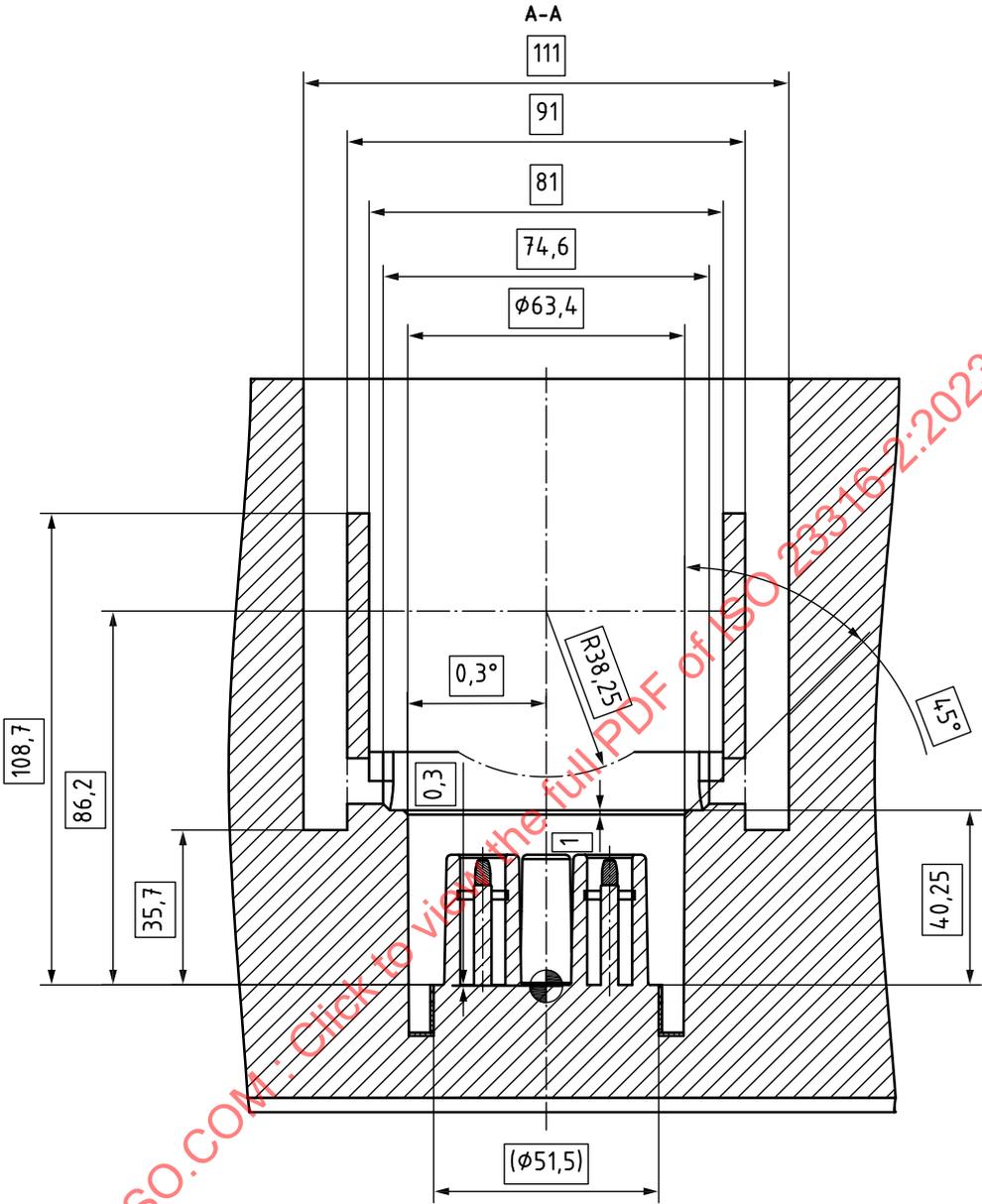


Figure 1 — Main front view of the tractor side in maximum material model



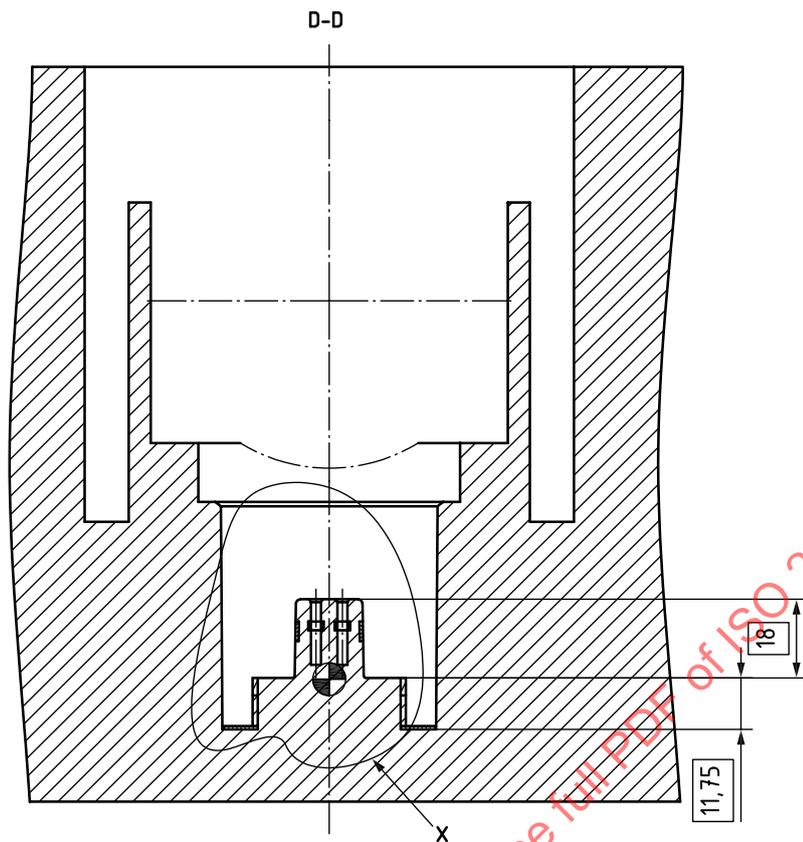
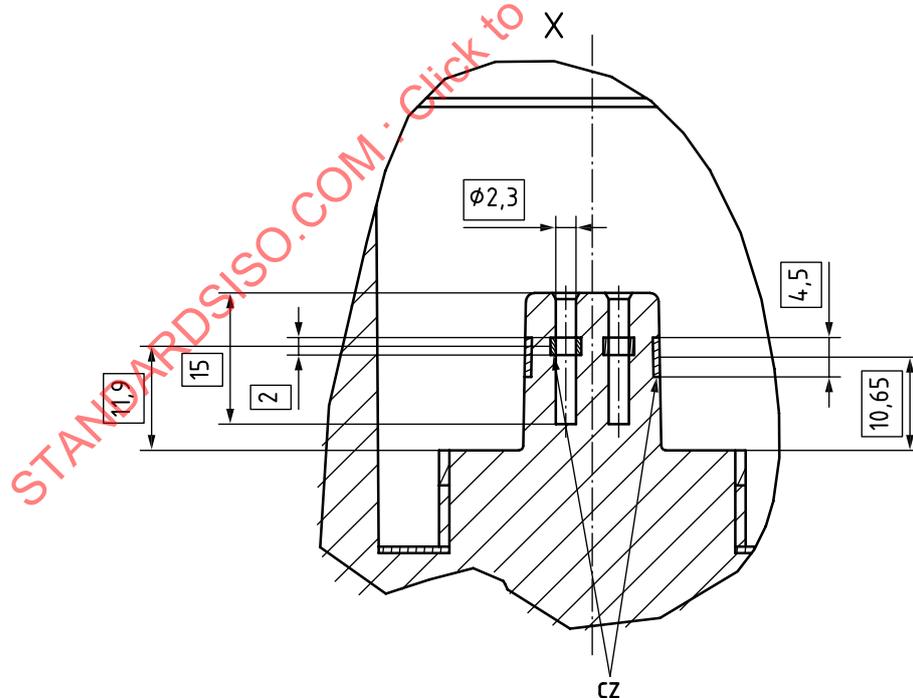


Figure 3 — Main front view, section D-D



Key

CZ contact zone

Figure 4 — Main front view, section D-D and detail X

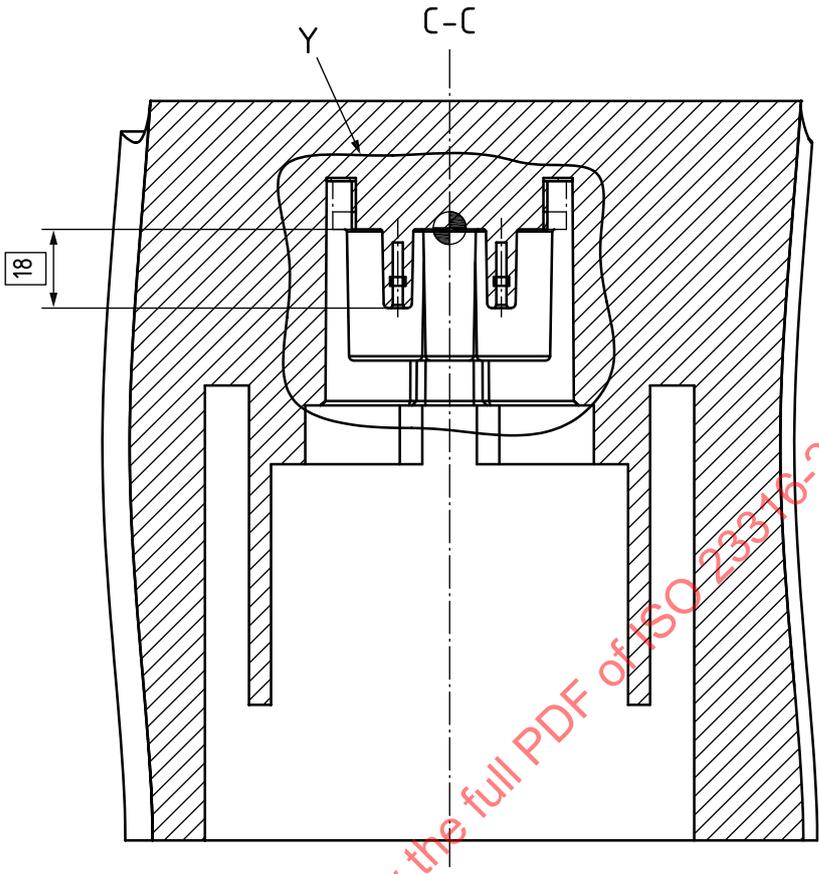


Figure 5 — Main front view, section C-C

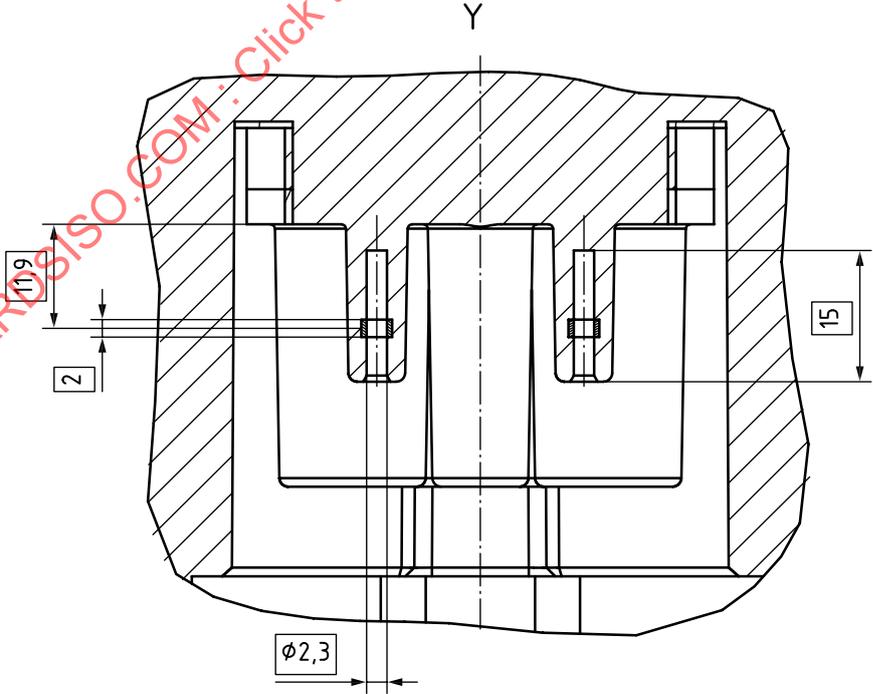


Figure 6 — Main front view, section C-C and detail Y

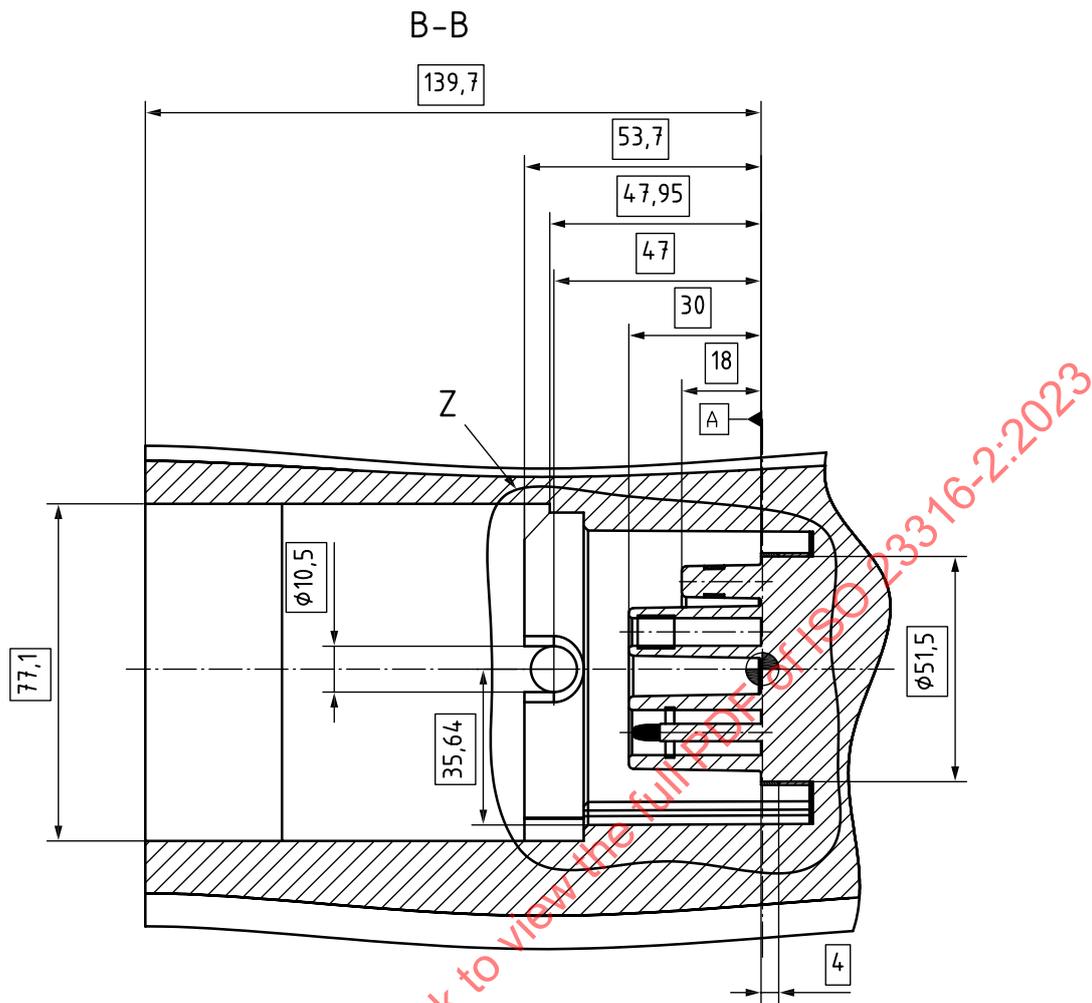
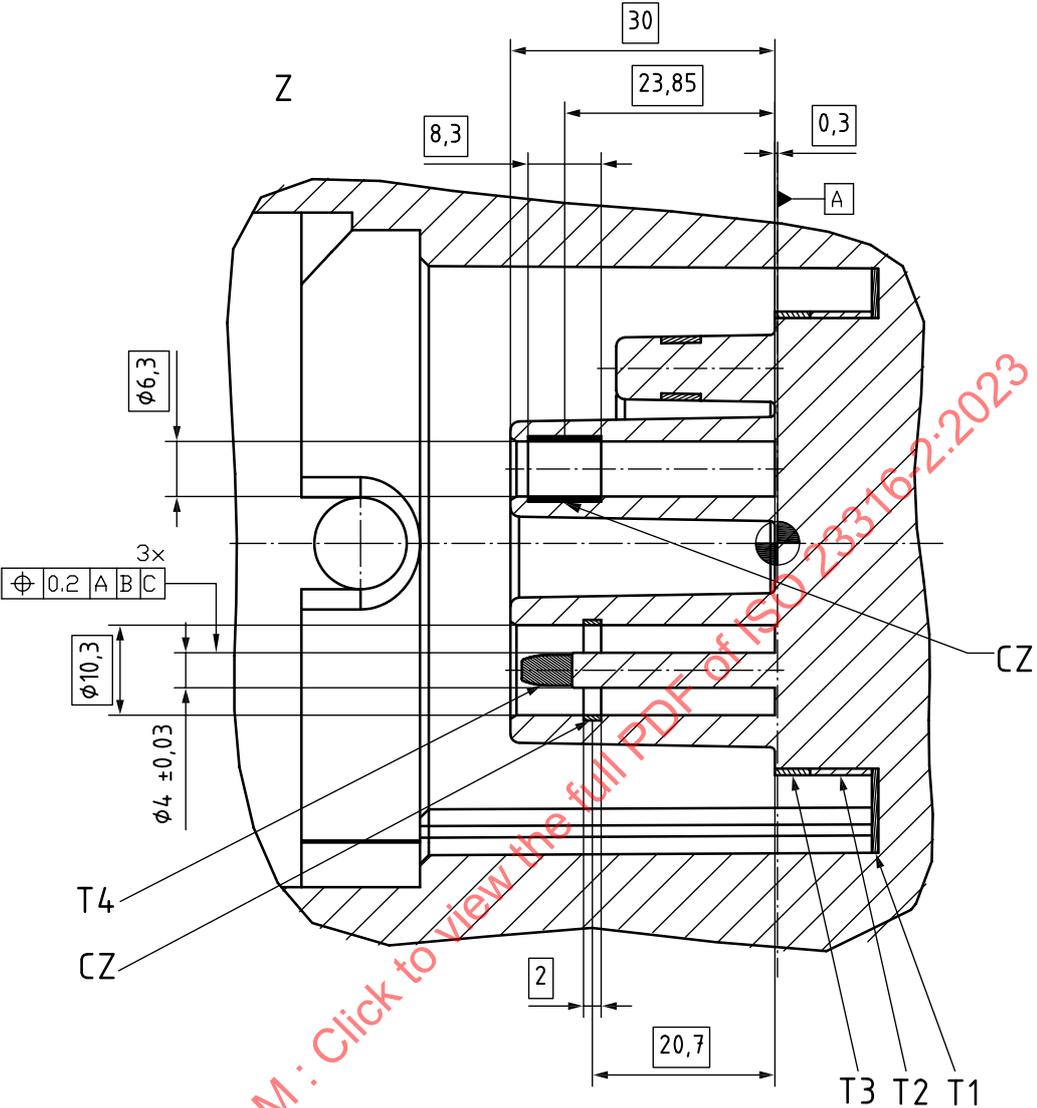


Figure 7 — Main front view, section B-B



- Key**
- CZ contact zone
 - T1 area for axial tolerance compensation
 - T2 area for sealing
 - T3 area for shield transfer
 - T4 finger protection cap

Figure 8 — Main front view, section B-B, detail Z

4.3.2.3 Minimum material model for the tractor side

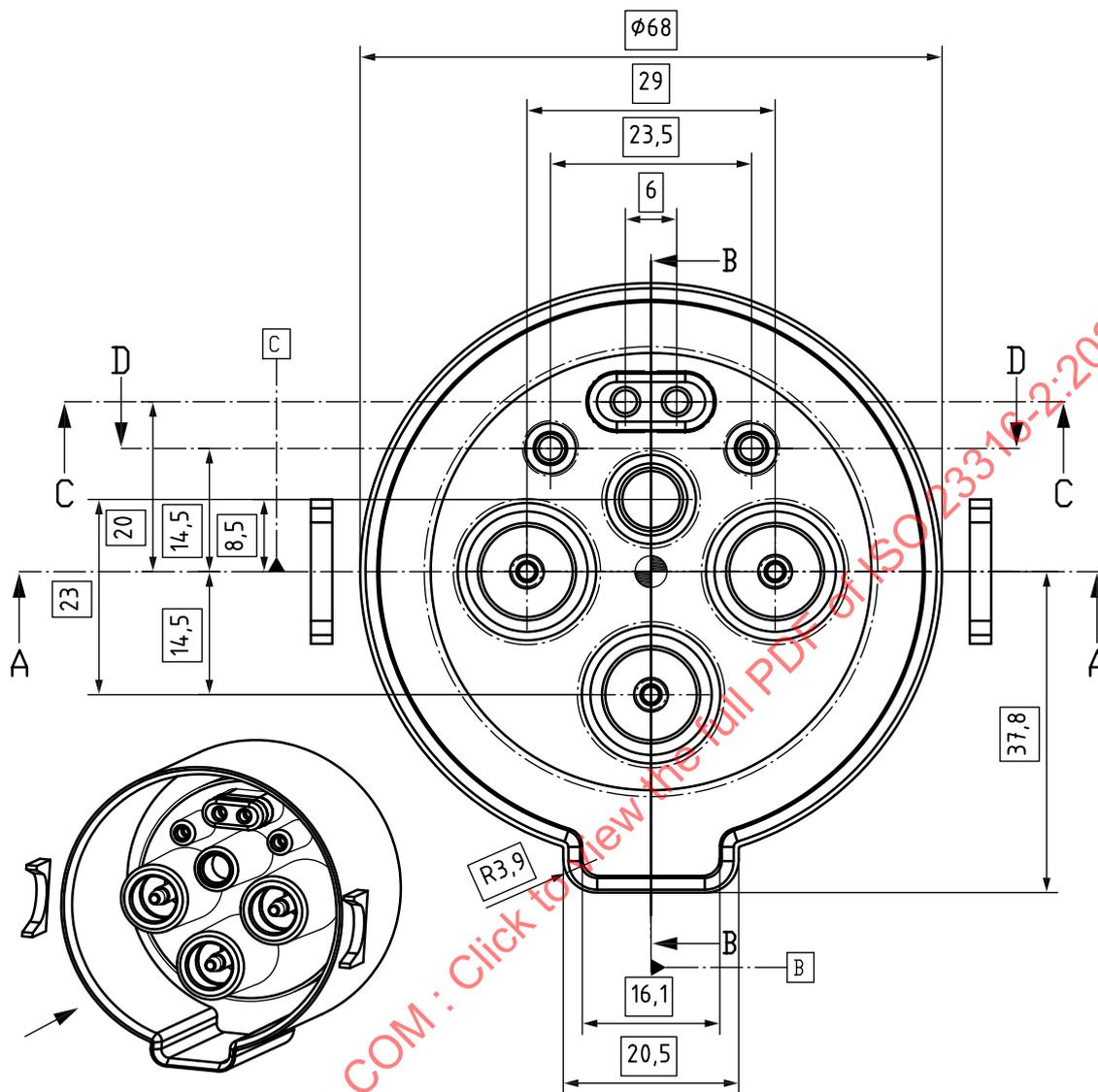


Figure 9 — Main front view of the tractor side in minimum material model

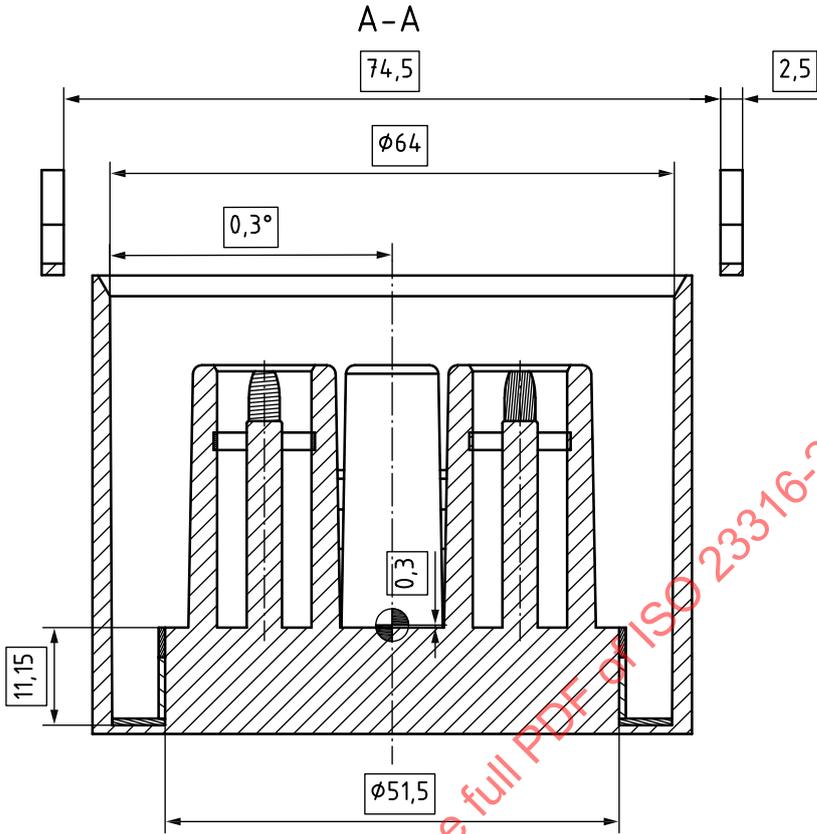


Figure 10 — Main front view, section A-A

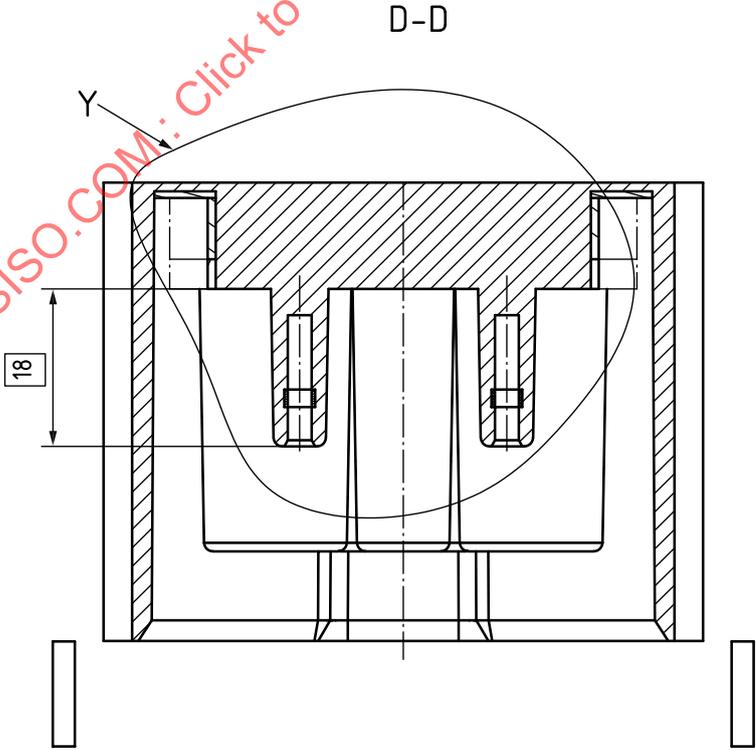
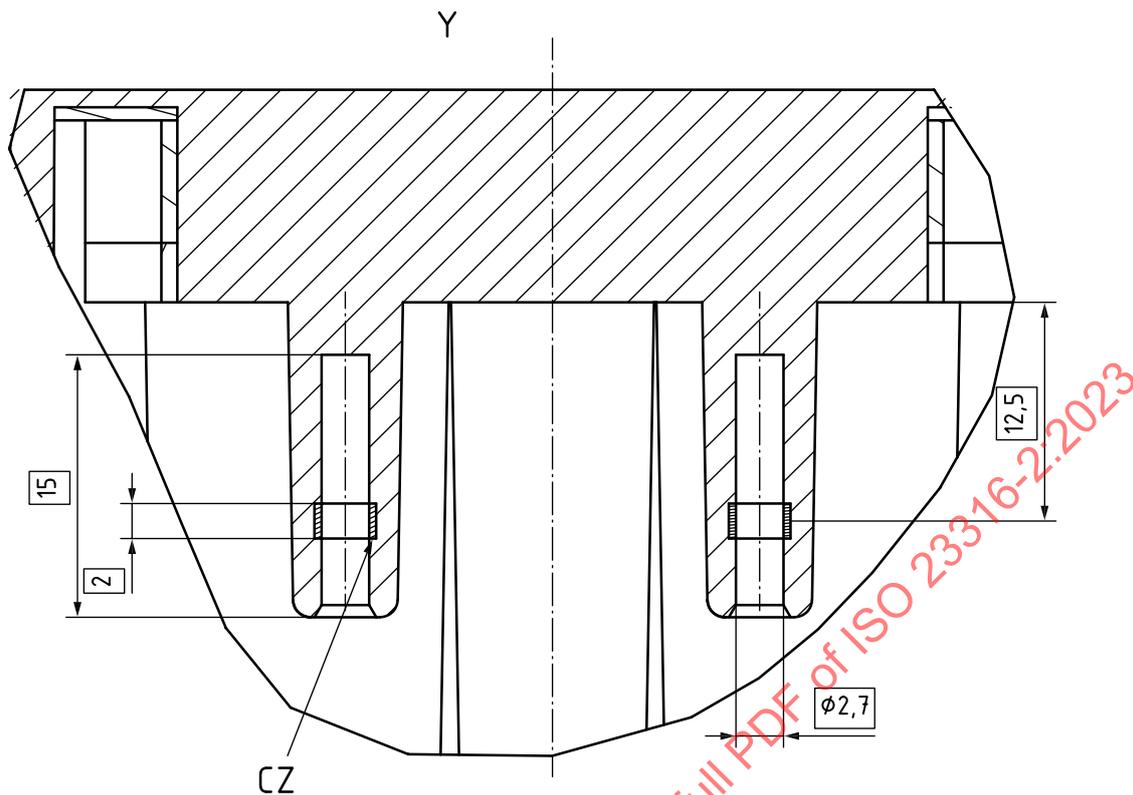


Figure 11 — Main front view, section D-D



Key

CZ contact zone

Figure 12 — Main front view, section D-D, detail Y

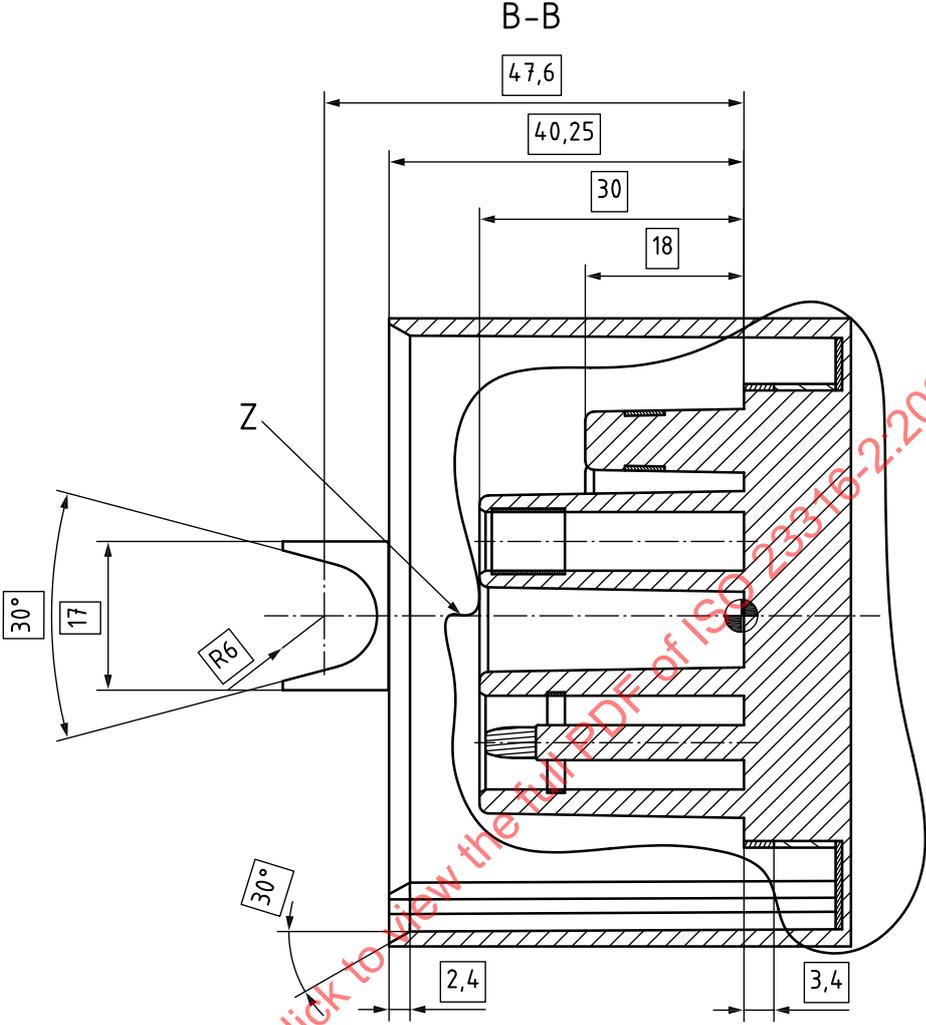
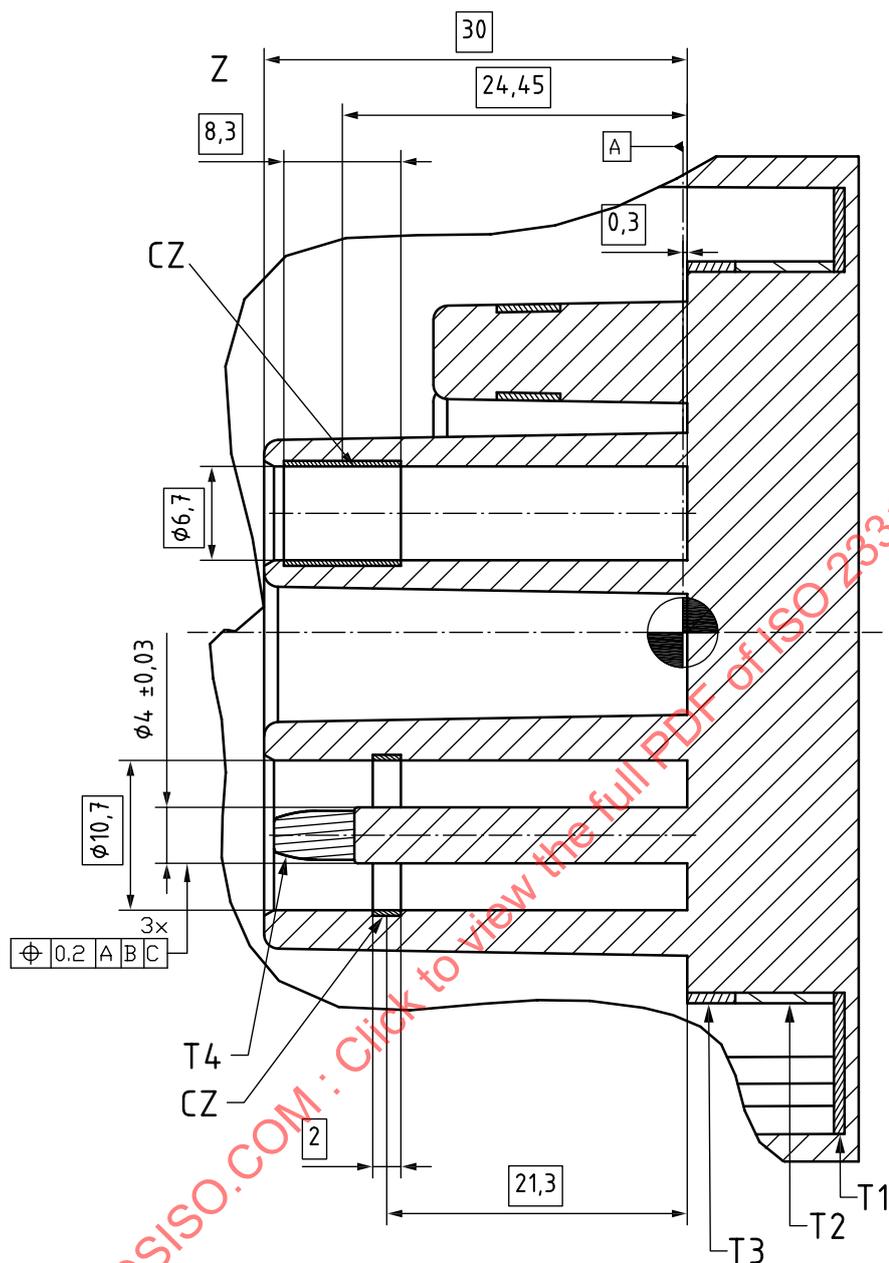


Figure 13 — Main front view, section B-B



Key

- CZ contact zone
- T1 area for axial tolerance compensation
- T2 area for sealing
- T3 area for shield transfer
- T4 finger protection cap

Figure 14 — Main front view, section B-B, detail Z

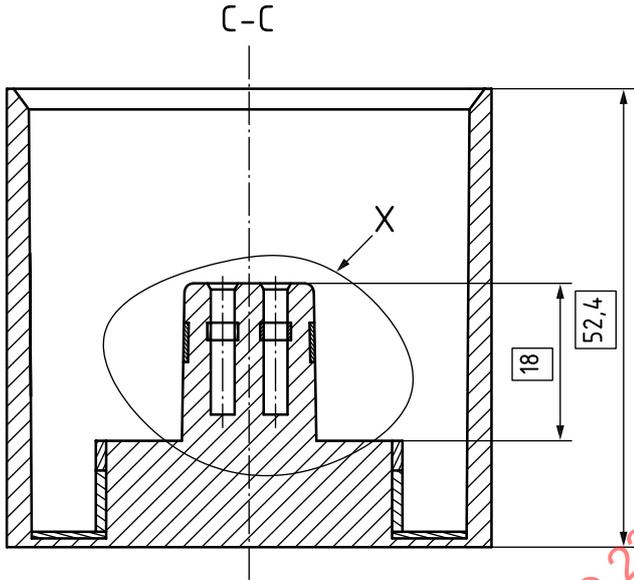
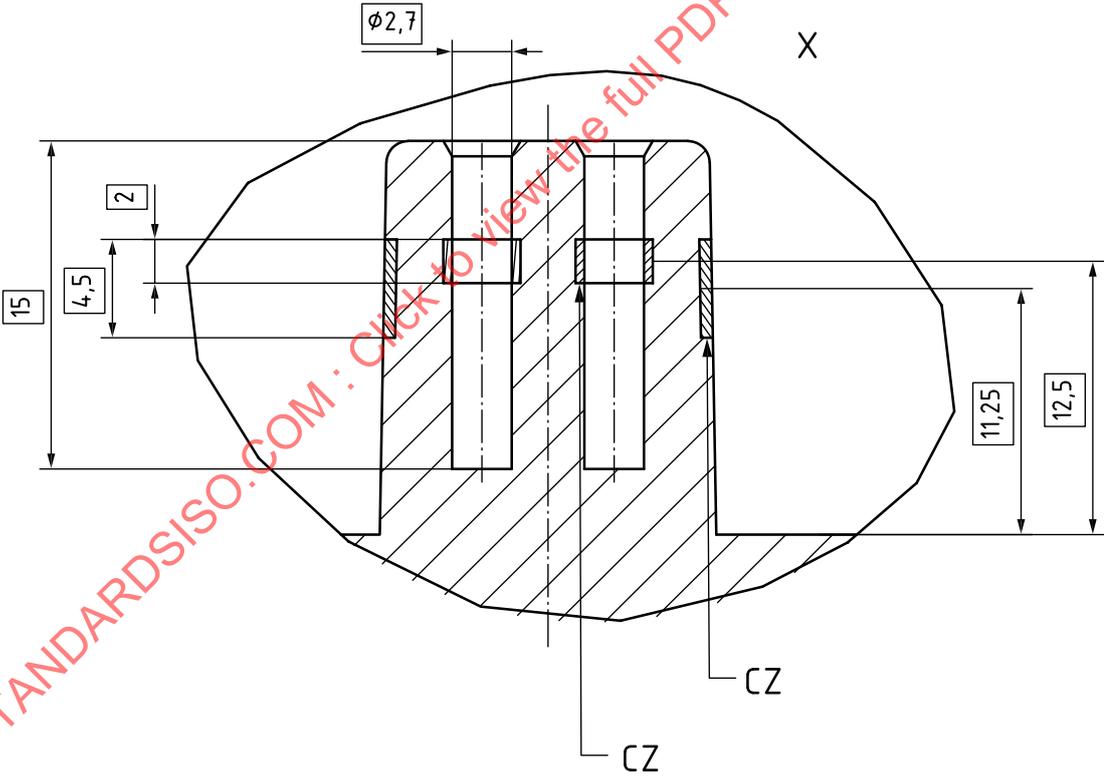


Figure 15 — Main front view, section C-C



Key
CZ contact zone

Figure 16 — Main front view, section C-C, detail X

4.3.2.4 Maximum material model for the implement side

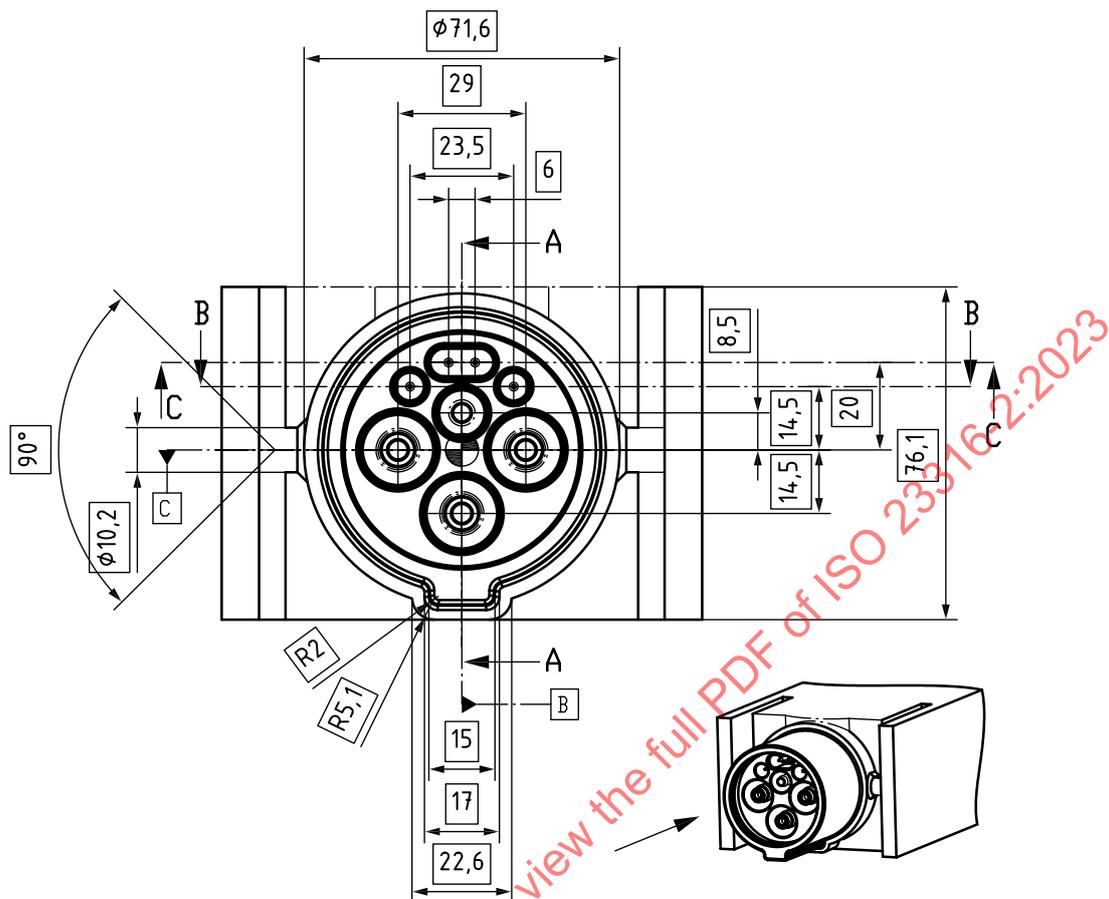


Figure 17 — Main front view of the implement side in maximum material model

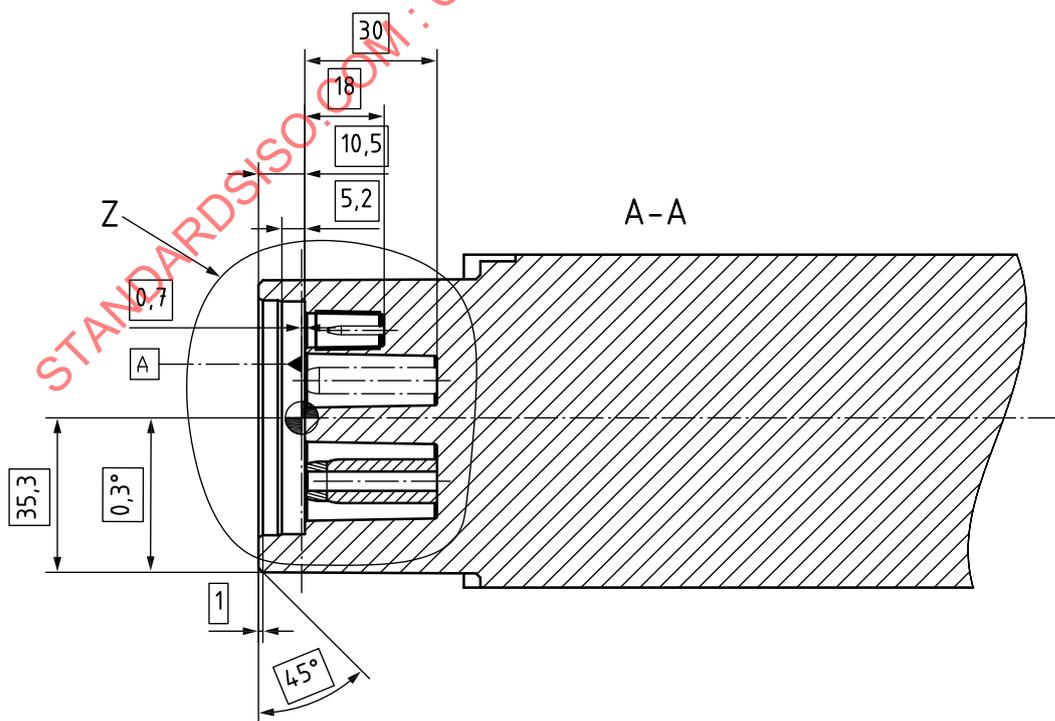
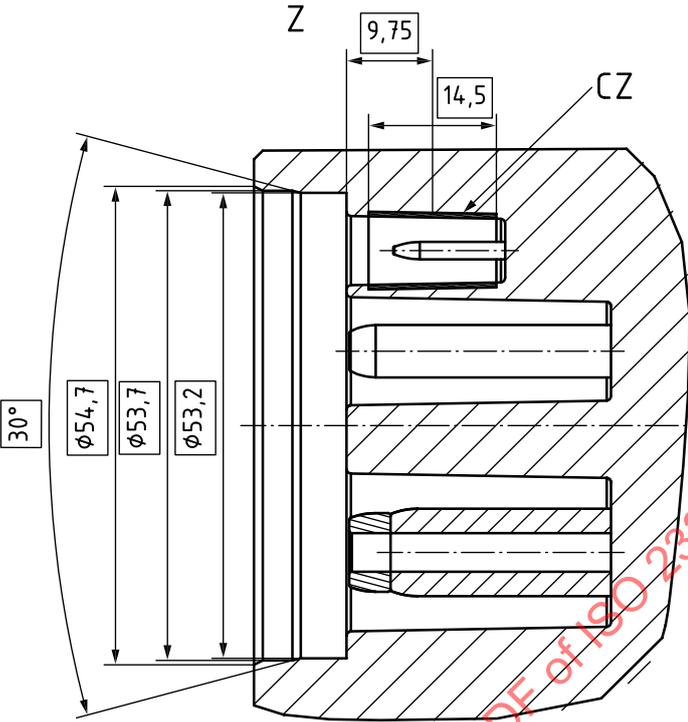


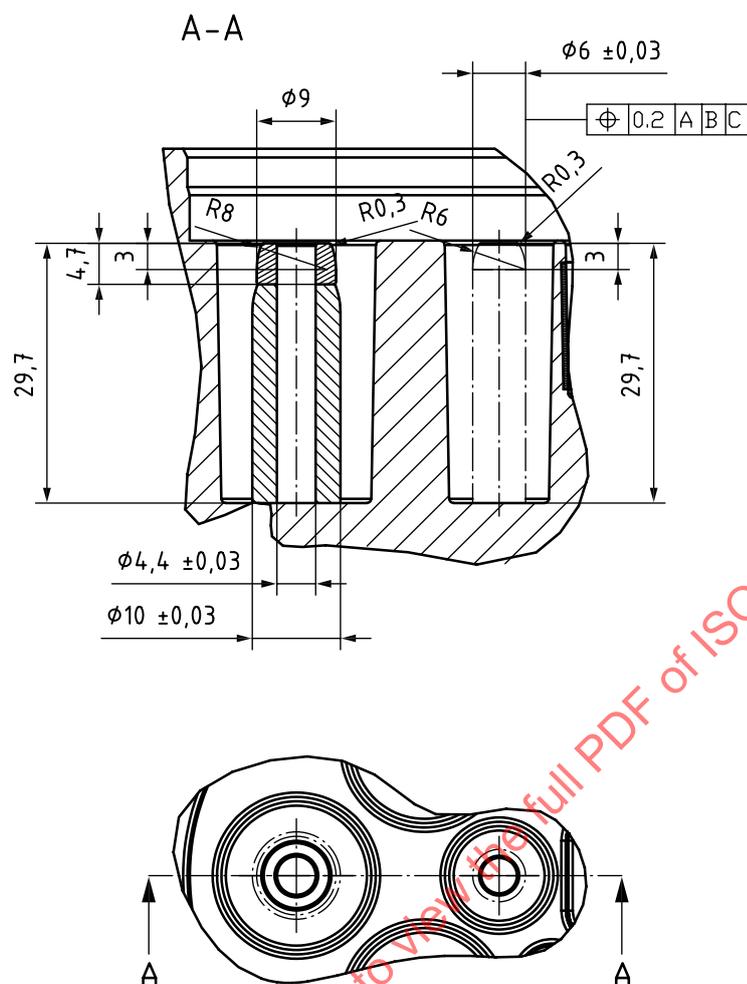
Figure 18 — Main front view, section A-A



Key
CZ contact zone

Figure 19 — Main front view, section A-A, detail Z

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NOTE Pins dimensions are valid for minimum and maximum models of implement connector

Figure 20 — Main front view, section A-A, pin dimensions

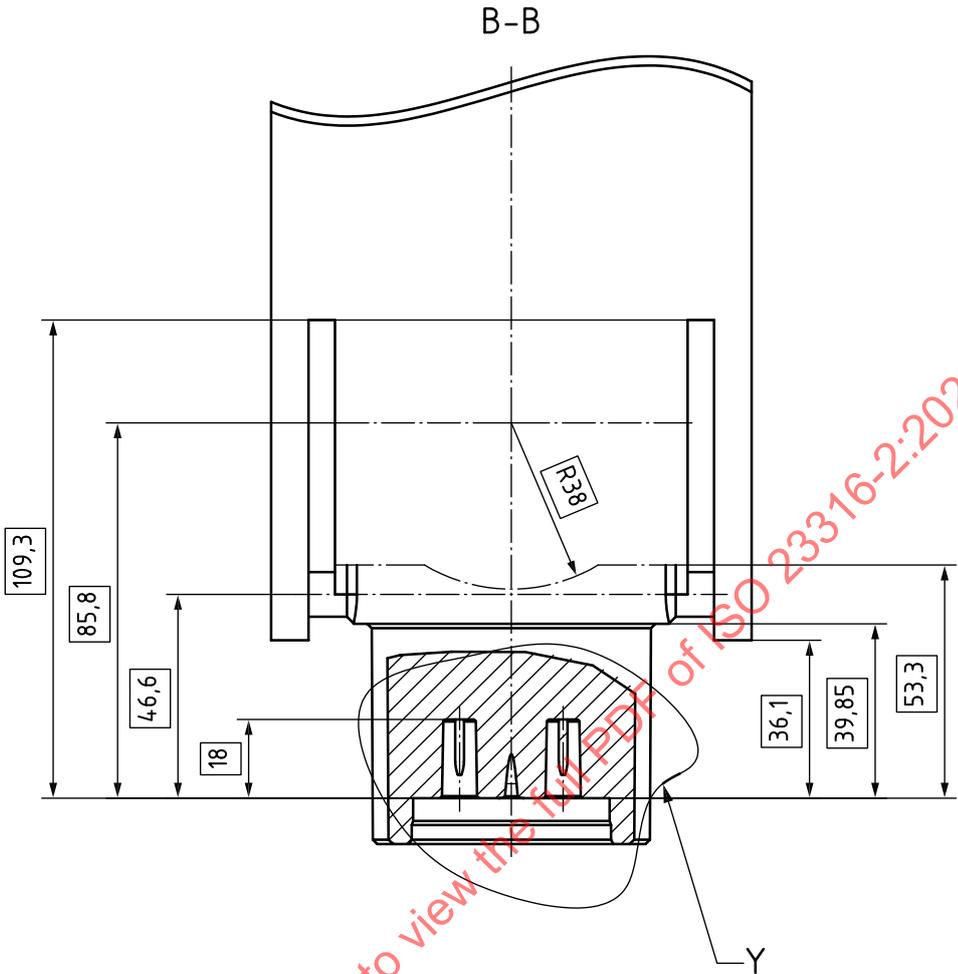


Figure 21 — Main front view, section B-B

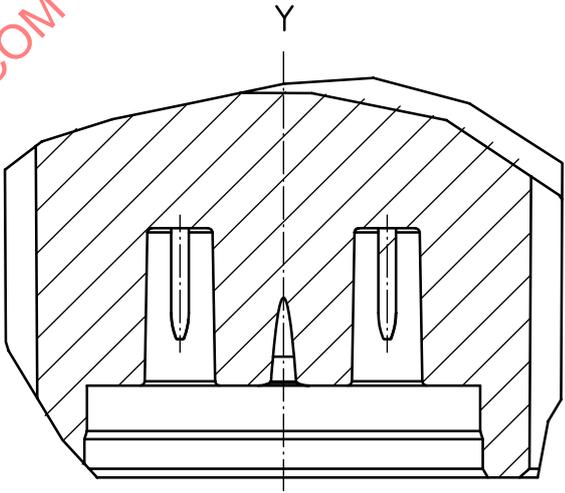
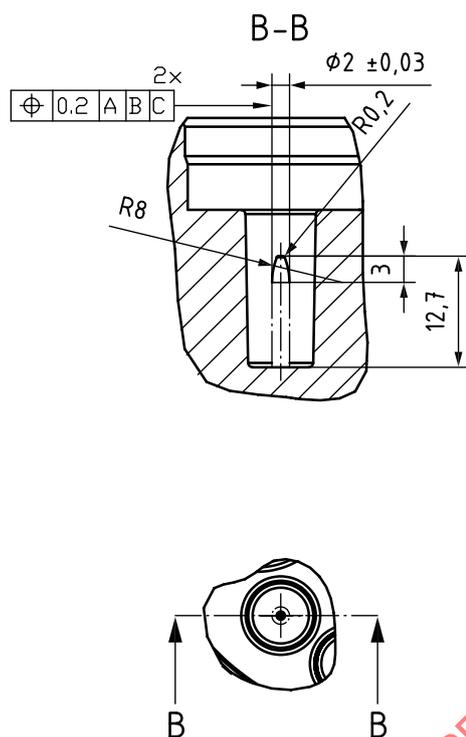
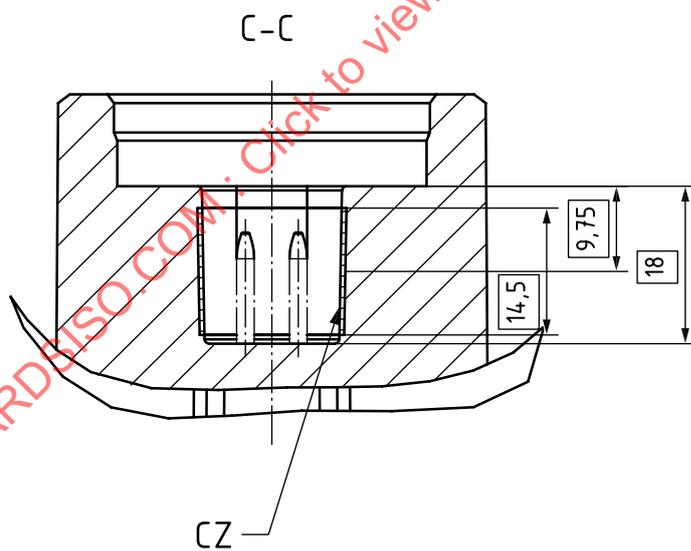


Figure 22 — Main front view, section B-B, detail Y



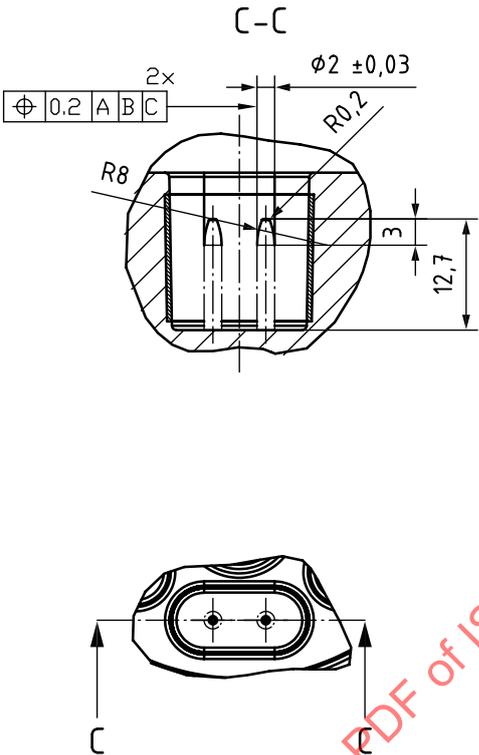
NOTE Pins dimensions are valid for minimum and maximum models of implement connector.

Figure 23 — Main front view, section B-B, pin dimensions



Key
CZ contact zone

Figure 24 — Main front view, section C-C



NOTE Pins dimensions are valid for minimum and maximum models of implement connector.

Figure 25 — Main front view, section C-C, pin dimensions

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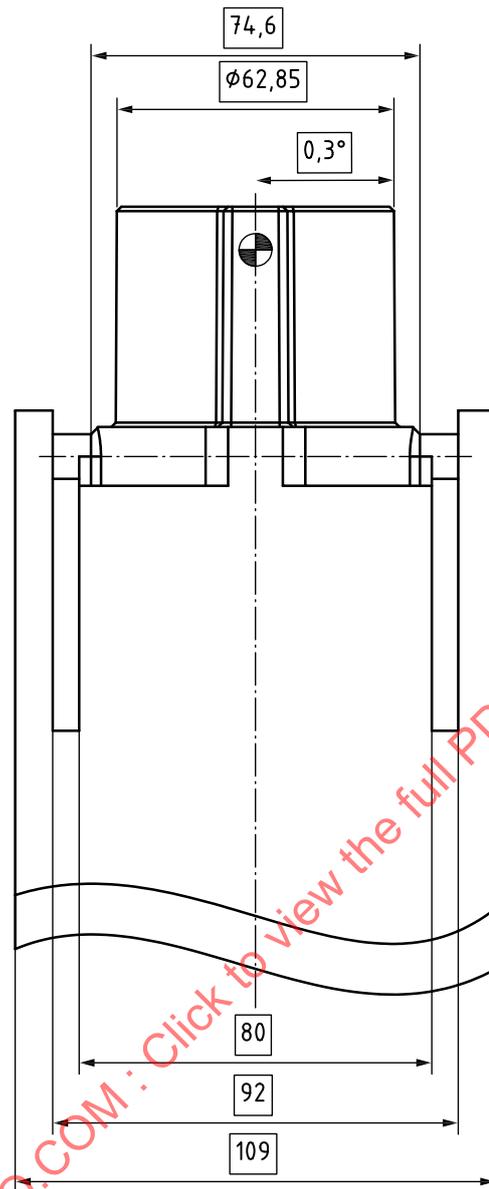


Figure 26 — Top view

4.3.2.5 Minimum material model for the implement side

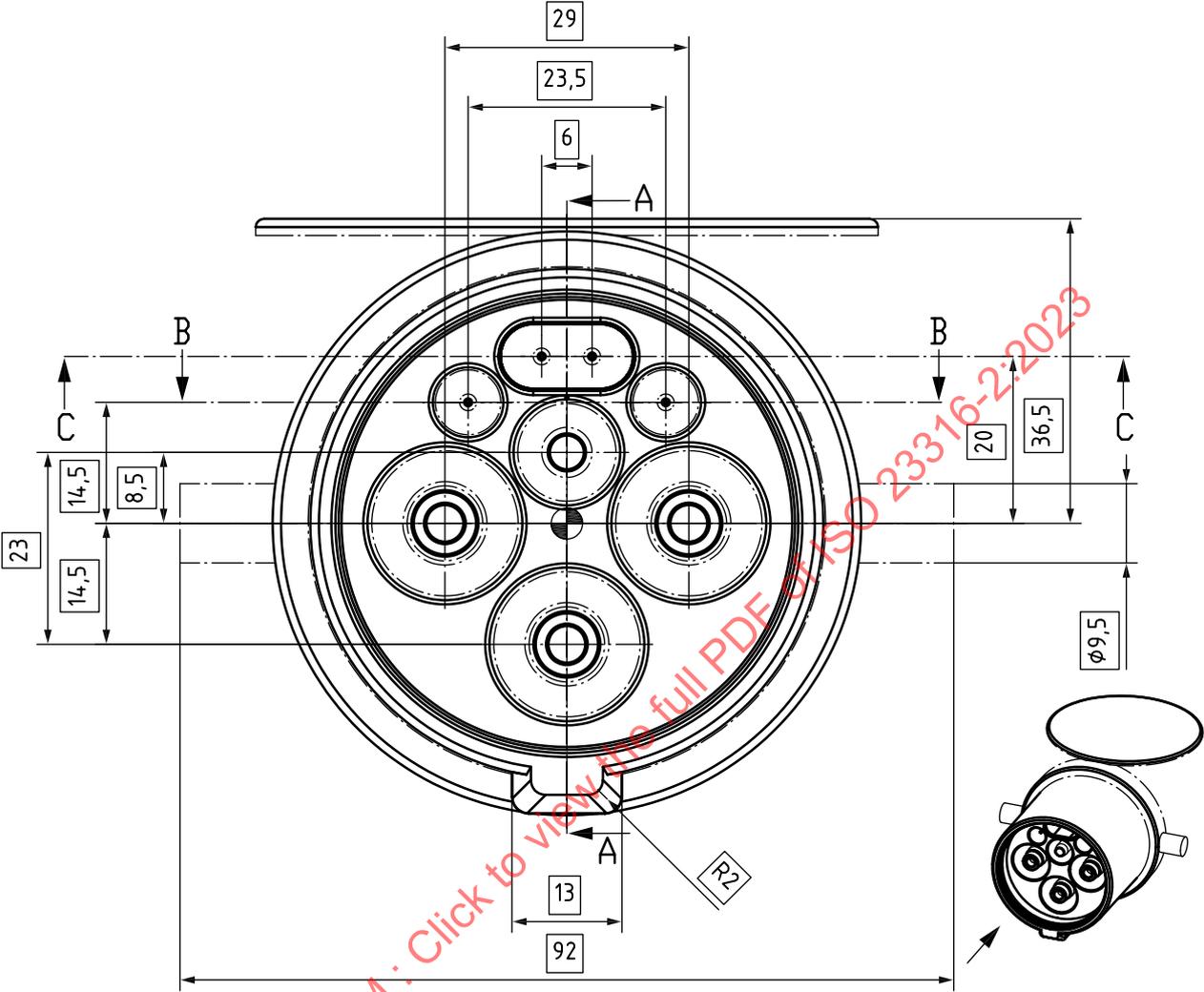
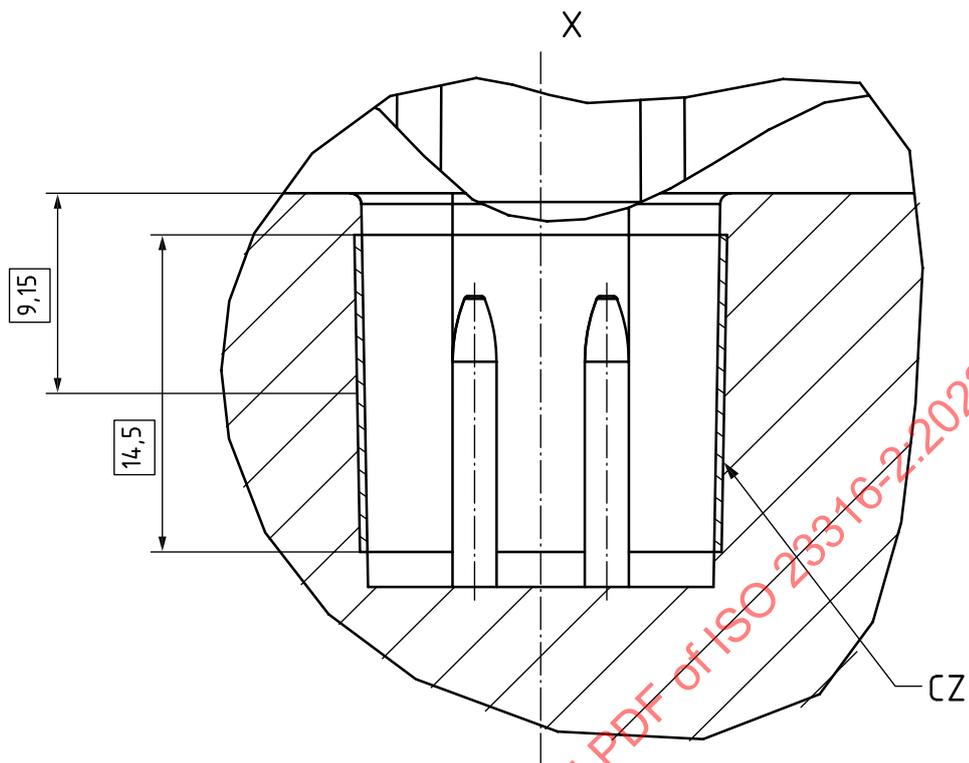


Figure 27 — Main front view of the implement side in minimum material model



Key
 CZ contact zone

Figure 29 — Main front view, section C-C, detail X

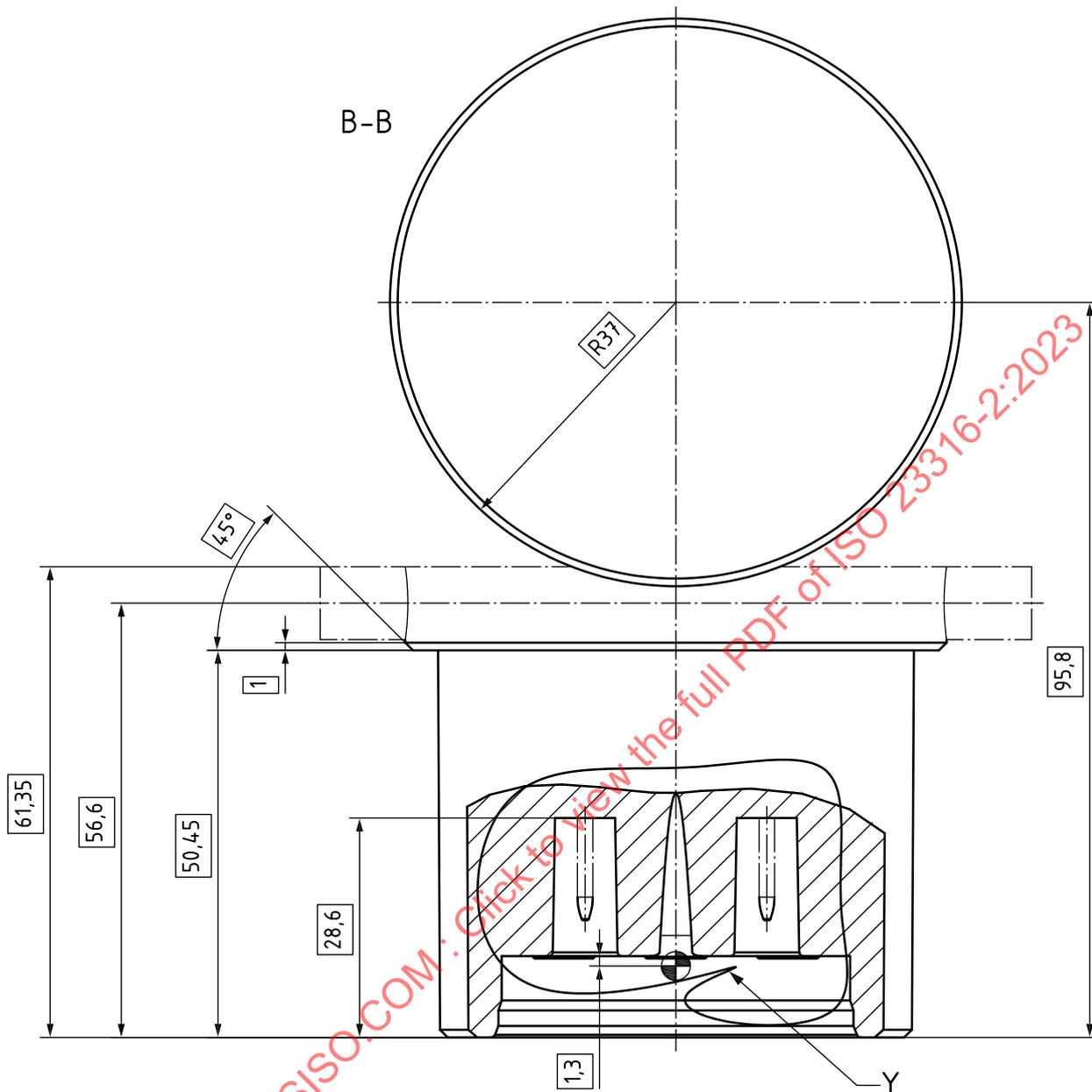


Figure 30 — Main front view, section B-B

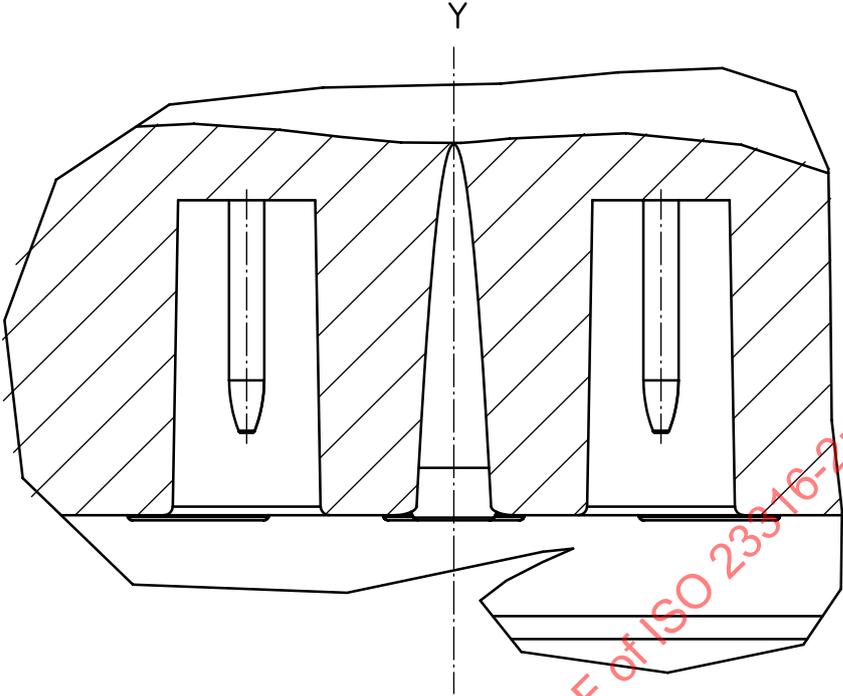


Figure 31 — Main front view, section B-B, detail Y

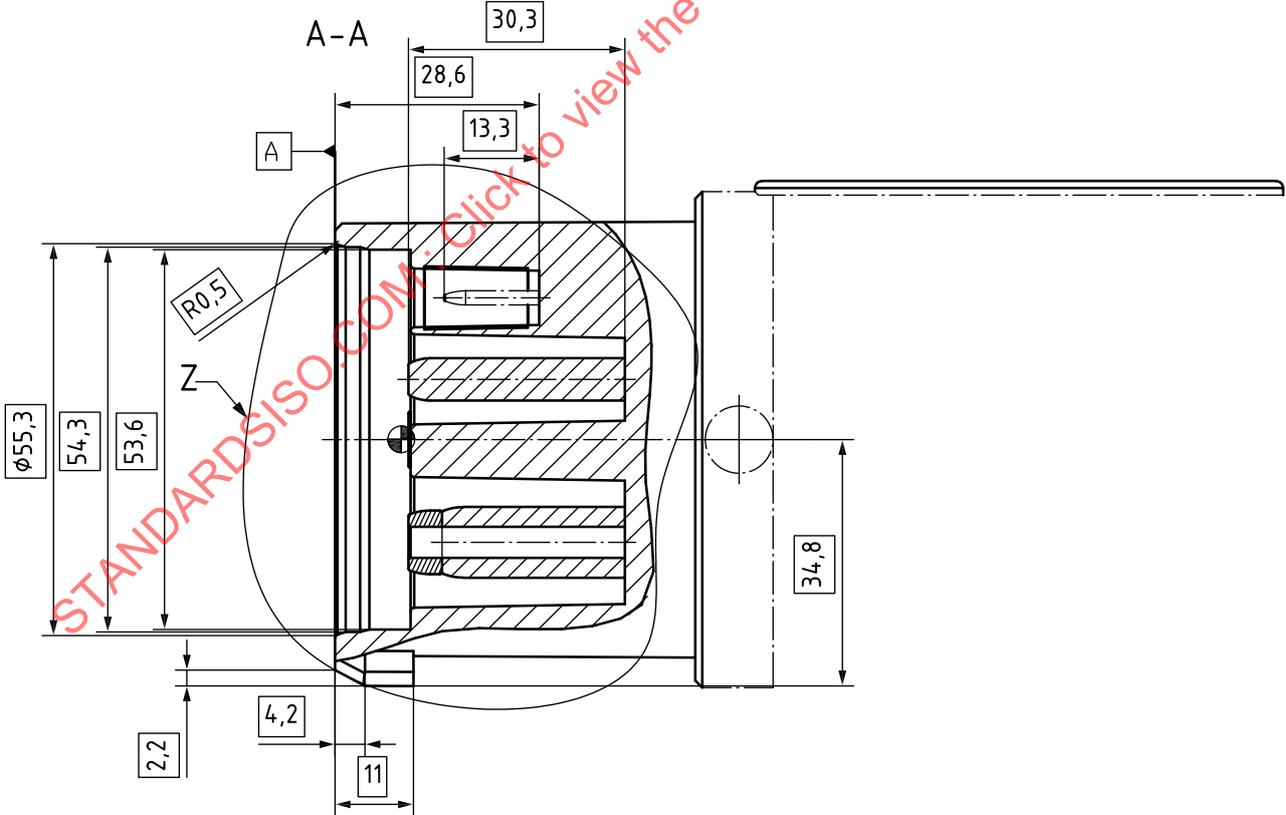


Figure 32 — Main front view, section A-A

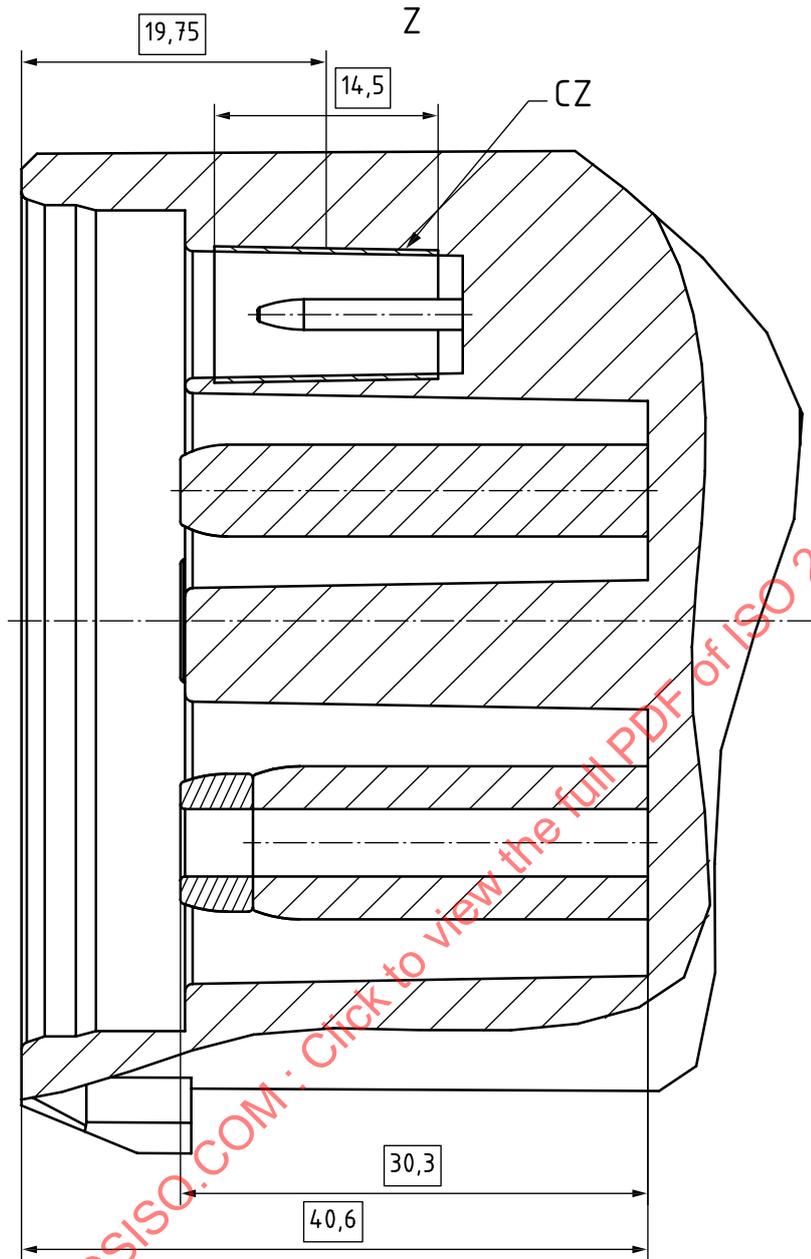


Figure 33 — Main front view, section A-A, detail Z

4.3.2.6 Connecting pins sequences

A-A

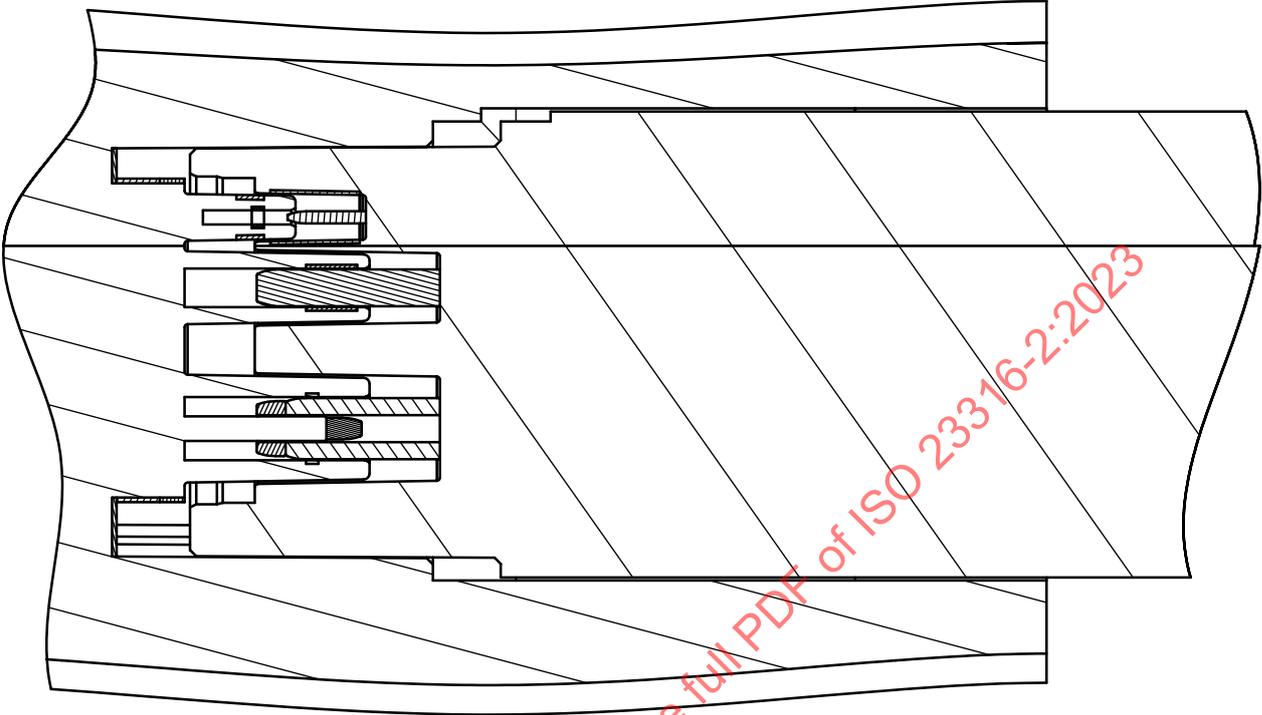


Figure 34 — Interlock pins connecting sequence

A-A

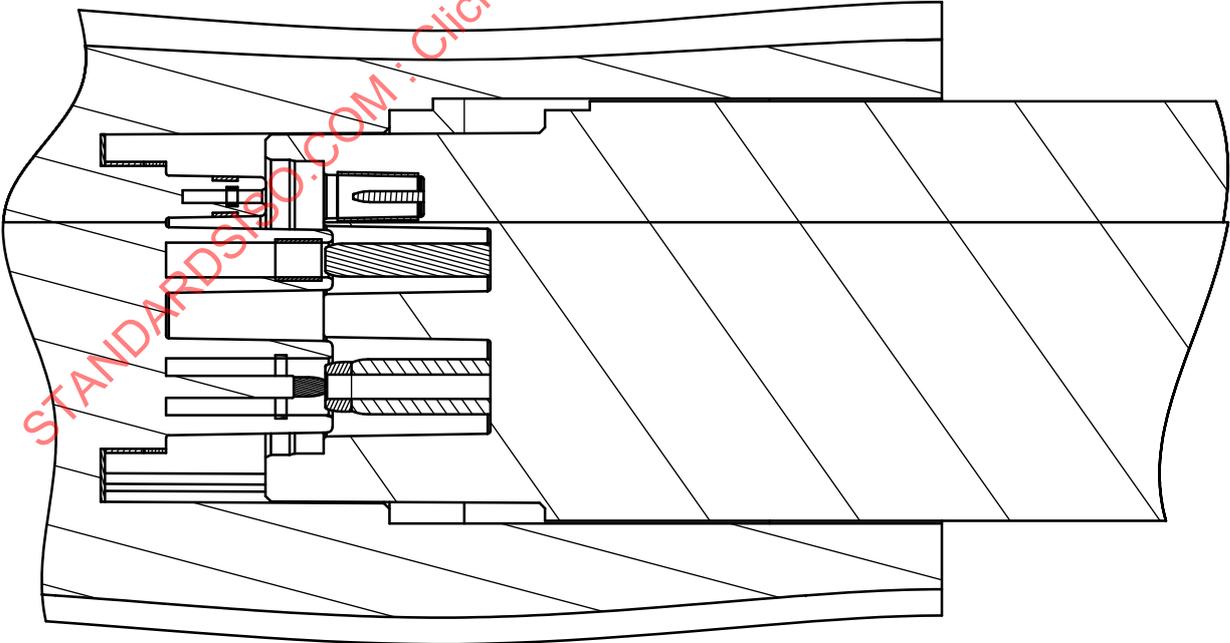


Figure 35 — PBC pins connecting sequence

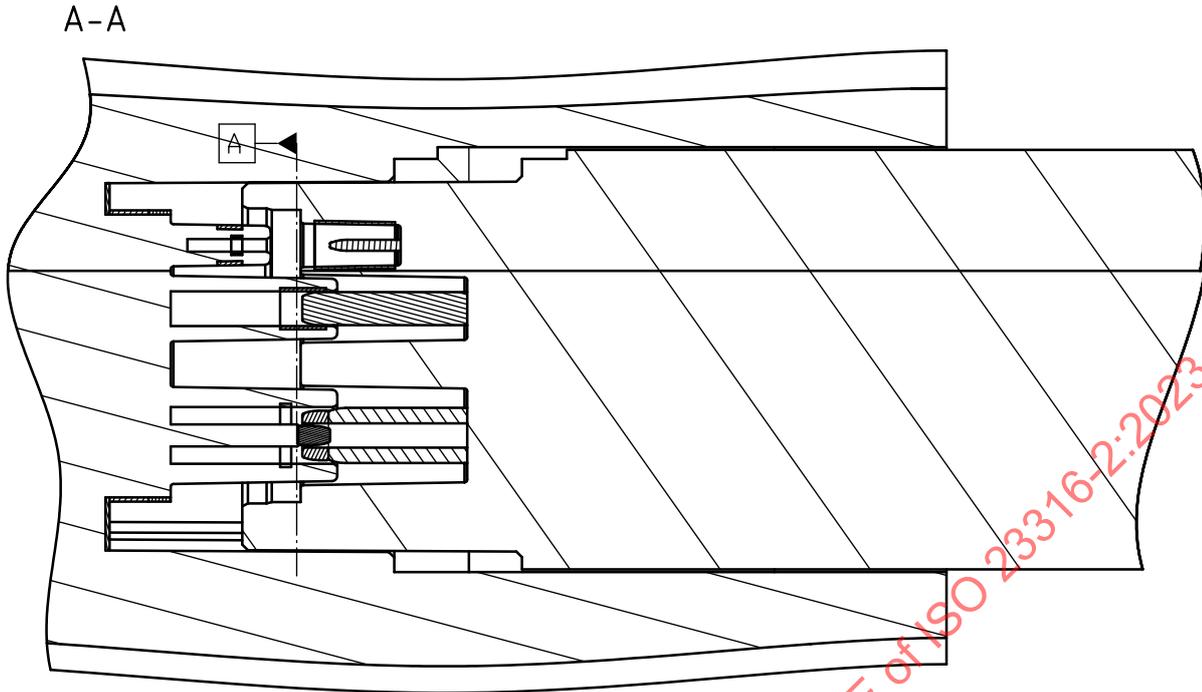


Figure 36 — Power pins connecting sequence

4.4 Connector external requirements

The following basic external requirements shall apply to the connector.

- a) All edges shall be free of burs.
- b) Any edges that the operator can touch shall be chamfered or rounded to prevent injury.
- c) External parts shall provide space to attach type and information decals.
- d) The design envelope shall be as small as practically possible.
- e) The colour of the connector and the colour of connector parts may be customer specific.

Receptacle and a plug connector, which are intended to be used together as a part of electrical high-power interface 700 V DC/480 V AC system, shall comply with the requirements of the relevant part of ISO 23316, if applicable.

In general, compliance is checked by carrying out all the tests specified.

Deviations from the dimensions that are specified in this document may be made, but only if they provide a technical advantage and do not adversely affect the purpose and safety of the connectors complying with the relevant ISO 23316 parts, especially regarding compatibility.

4.5 Phase contacts

4.5.1 General

The design of the connector is intended to accommodate different power ratings. However, amongst the various ratings, their geometric properties, particularly the contact diameters, shall remain the same.

The connector shall incorporate three phase contacts for electrical power transmission.

Phase contacts shall have mechanical strength, electrical conductivity, and resistance to corrosion adequate to intended agriculture and forestry use.

Suitable base metals for current carrying parts, used within a permissible temperature range and under conditions of chemical pollution specified in this document, are:

- for base material:
 - copper;
 - an alloy containing at least 58 % copper for parts that are worked cold or at least 50 % copper for other parts;
- for electroplating material:
 - silver for phase contacts, PBC contact and DC interlock contacts;
 - gold for communication contacts;
 - nickel as underplating barrier directly on base material, if required to protect the plating layer from diffusion into the base material.

Plating for base material is required to protect it against corrosion.

Phase contact with multiple contacting areas are allowed only in tractor-side receptacle connector.

Compliance shall be verified by visual inspection and by chemical analysis.

4.5.2 AC/DC current

The connector's phase contacts shall be capable of carrying either AC and DC electric current.

4.5.3 AC/DC voltage ratings

The nominal and maximum AC and DC voltage ratings shall be in accordance with the definitions in ISO 23316-1:2022, Table 1 and Table 2.

4.5.4 Withstand voltage

Withstand test voltage for test location at 2 000 m above sea level shall be 5,3 kV according to IEC 60664-1:2007, 5.1.

For equipment test locations at altitude other than 2 000 m, local impulse test voltages shall be determined in accordance with IEC 60664-1:2007, 6.1.2.2.1.

4.5.5 Clearance and creepage distances

Pollution degree 2 in accordance with IEC 60664-1 applies to space inside the connector.

Pollution degree 3 in accordance with IEC 60664-1 applies to exposed connector parts and surfaces.

The shortest clearance distance in tractor-side connector face is 12,1 mm.

The shortest clearance distance in implement-side connector face is 8,9 mm.

The shortest creepage distance in tractor-side connector face is 38,1 mm.

The shortest creepage distance in implement-side connector face is 36,2 mm.

According to ISO 16230-1, clearance and creepage distances shall meet the requirements for double or reinforced insulation as defined in IEC 60664-1:2007, 5.1 and 5.2.

NOTE The comparative tracking index (CTI) value for distances calculation is evaluated in IEC 60112:2009, Clause 11.

4.5.6 Rated continuous current

The rated continuous AC RMS or DC current shall be a minimum of 200 A. Peak current depends on system application and shall be reviewed in detail by the connector manufacturers.

Connector suppliers shall provide derating curves and typical duty cycles for their design.

Contacts shall be able to accept a conductor cross section of up to 70 mm².

4.5.7 Contact resistance

Contact resistance shall be lower than 150 µΩ. The value may increase to 3x contact resistance after performing the proposed test sequence defined in [Annex A](#).

4.5.8 Protection against access

The phase contacts shall be finger proof to IPXXB / IP2X according to ISO 20653.

4.5.9 Reference altitude

For connector system dimensioning, the reference altitude above sea level is 4 000 m.

4.6 Protective bonding conductor (PBC) contact

The following requirements shall apply to PBC contact.

- a) The contact shall be able to accept a protective bonding conductor (PBC) cross section of at least 10 mm².
- b) The contact resistance shall be lower than 200 µΩ. The value may increase to 3x contact resistance after performing the test sequence defined in [Annex A](#).
- c) The PBC shall be bonded to the connector housing with a cross section of minimum 2 mm² and a connection resistance shall not exceed 2 mΩ. The value of the resistance may increase by 3 times after performing proposed test sequence defined in [Annex A](#).
- d) The PBC contact shall connect first and disconnect last (see [Figure 39](#) and [Figure 40](#)).

4.7 DC interlock

The connector shall incorporate two contacts to detect the status of the connector as being properly connected and also "no connector is present".

- a) Maximum voltage shall be 60 V DC.
- b) Maximum current shall be 20 mA.
- c) Contact resistance shall be lower than 5 mΩ. The value may increase to 3x contact resistance after tests according the test sequence defined in [Annex A](#).
- d) Conductor cross section shall be max 2,5 mm².
- e) During the connecting process the interlock shall connect as last contact. During the disconnecting process the interlock contacts shall disconnect as first contacts (see [Figure 39](#) and [Figure 40](#)).

4.8 Communication contacts and link segment

4.8.1 General aspects

Communication contacts are optional.

When communication contacts are implemented, the connector shall incorporate two data contacts for transmitting control data between vehicle and implement.

These data contacts shall have the identifier C1 and C2 and shall have a 360° EMC shield.

Contacts C1 and C2 shall be arranged inside the connector as illustrated in [Figure 40](#) and [Figure 41](#).

Electrical transmission parameters for communication contacts shall be verified by test for standalone communication pins with a shielded housing.

The basic requirements for the communication systems are:

- a) The contacts and the connector link segment shall fulfil requirements in accordance with ISO/IEC/IEEE 8802-3:2021, 96.7 (100BASE-T1).
- b) The cabling system shall be one twisted pair, balanced, shielded cabling with impedance of 100 Ω (nominal $\pm 10\%$) in accordance with IEC 60512-25-7 and ISO/IEC/IEEE 8802-3:2021, 96.7.1.
- c) The differential characteristic impedance shall be 100 Ω measured with time-domain reflectometer and rise time set not lower than 700 ps as defined in ISO/IEC/IEEE 8802-3:2021, 96.7.1.1 d), Communication contacts shall be part of AC mode data interlock system (see [Figure 41](#)).
- e) Contact resistance shall be lower than 5 m Ω . The value may increase to 3x after test sequence defined in [Annex A](#).
- f) During the insertion process, the communication contacts shall connect as last contacts.
- g) During the extraction process it shall disconnect as first contact (see [Figure 40](#)).

For future potential use of power over the communication channel according to ISO/IEC/IEEE 8802-3:2021, Clause 104 (48 V regulated PSE):

- the maximum voltage shall be 60 V DC,
- the maximum current shall be 1 360 mA.

The cabling model of ISO/IEC/IEEE 8802-3:2021, 96.7.1 only considers cable sections that all have the same impedance. Impedance changes within the cabling system cause reflections and thus deteriorate the signal quality. Therefore, for heterogeneous systems, a usage of an extended calculation model is recommended. Due to package constraints, care shall be taken on the cable junction length inside the connector to reduce any impact on measured values.

4.8.2 Communication contacts requirements

The resulting requirements for communication contacts shall be in accordance with [Table 2](#).

Table 2 — Communication contacts requirements — Electrical transmission parameter

Parameter	Test standard	Frequency limit MHz	Value dB
Insertion loss ^a	IEC 60512-25-2	1	≤0,025
		10	≤0,038
		16	≤0,040
		33	≤0,050
		66	≤0,075
Return loss ^a	IEC 60512-25-5	1	≥38
		33	≥38
		66	30,5
Longitudinal conversion loss Longitudinal conversion transmission loss	IEC 60603-7-7:2010 Annex J	1	≥46
		200	≥34

^a For connected connector system.

4.8.3 Communication link segment requirements

The cabling system (link segment) characteristics are specified in ISO/IEC/IEEE 8802-3:2021, 96.7 with transmission parameters as defined in [Table 3](#).

Table 3 — Communication cable requirements — Electrical transmission parameters

Parameter	Test standard	Frequency limit MHz	Limit dB
Insertion loss	ISO/IEC 11801 DIN EN 50289-1-1	1	≤0,9
		10	≤2,4
		33	≤4,6
		66	≤6,8
Return Loss		1	≥20
		20	≥20
		66	≥20
Longitudinal conversion loss Longitudinal conversion transmission loss		1	46
		50	46
		200	34

NOTE Communication channel length as defined in ISO/IEC/IEEE 8802-3:2021, Clause 96

4.8.4 Cross talk from environment

[Table 3](#) lists the test parameters and limits that are required for the joined connector evaluation.

For the purpose of this test, the pins C1 and C2 are the victim pair under the test and pins 1, 2, 3 are the aggressor pins. Coupling attenuation from each single aggressor pin to the victim pair shall be measured. The form and quality of test signal at aggressor pin shall conform to definitions in ISO 23316-4.

Table 4 — Communication pins requirements — Cross talk from environmental system

Parameter	Test standard	Frequency limit	Value
		MHz	dB
Cross talk mode conversion ANEXTDS ^a /ANEXTSD ^b AFEXTDS ^a /AFEXTSD ^b	IEC 60603-7-7	1	46
		10	46
		16	46
		33	46
		66	42
		<100	40
		200	34
^a	DS suffix - Single-End to Differential coupling		
^b	SD suffix - Single-End to Differential coupling		

4.9 EMC shielding

4.9.1 Connector shielding

The connector system shall incorporate an EMC shield.

Inside the connector, the following electrical components shall be covered 360° by shielding material:

- power conductors and pins;
- PBC conductor and pin;
- low voltage conductors and pins;
- communication connector.

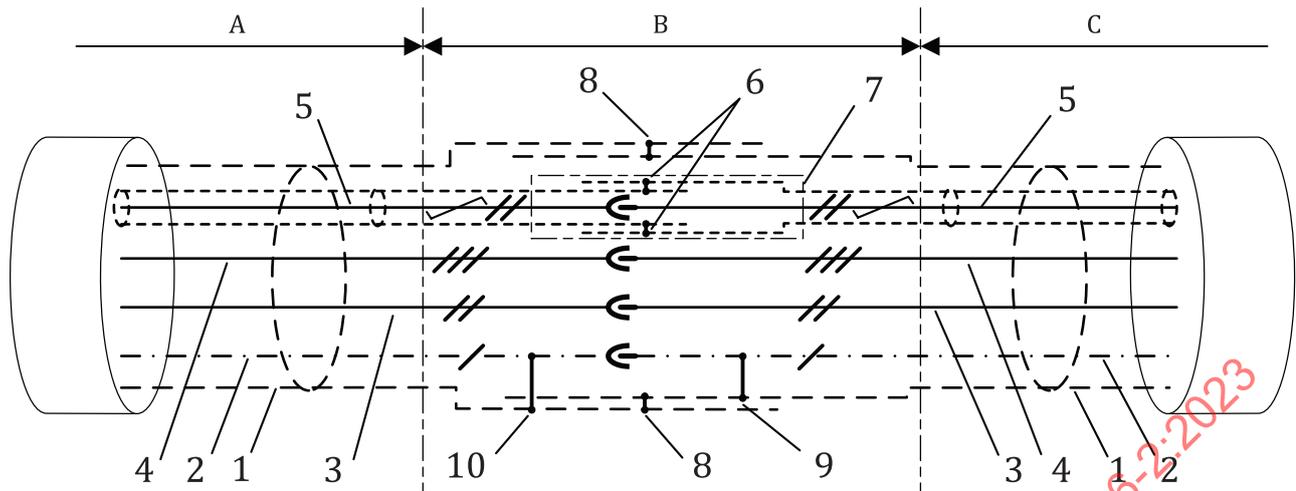
The EMC shielding shall have no gaps.

Cable shielding to the connector shall cover 360°.

A connector shall provide a feature to connect the common shield from a multicore cable or the single-core shields from a single cable.

4.9.2 Communication pins shielding

When joined, the integrity of the 360° EMC shielding surrounding pins C1 and C2 on both sides of the connectors shall be maintained.



Key

- A tractor hybrid cable
- B connected plug and receptacle
- C implement hybrid cable
- 1 hybrid cables shield
- 2 PBC cable core
- 3 DC interlock cable cores
- 4 phases cables cores
- 5 communication twisted and shielded cores
- 6 360° communication cores shield connection
- 7 communication connector insert
- 8 360° hybrid cables shield connection
- 9 PBC connection to plug housing
- 10 PBC connection to receptacle housing

Figure 37 Connector schematic with shielding

4.9.3 Shields performance

4.9.3.1 General

Shield performance is determined by DC resistance of shielding, transfer impedance in the low frequency range (from 10 kHz to 150 MHz) and coupling attenuation.

Shield performance shall be verified separately for the shield of communication connector and for common implement connector shield. The requirements from [4.9.1](#) and [4.9.2](#) apply for both shielding systems inside connector.

The tests will be performed in accordance with [4.9.3.2](#) and [4.9.3.3](#).

4.9.3.2 DC resistance

The test method for DC resistance of shielding shall be in accordance with IEC 60512-2-1, the test shall be conducted with a test current of 10 A AC RMS or DC at a maximum voltage of 2 V DC or AC RMS.

Measuring connection points shall be selected as close as possible to connector components to reduce the effect of cable shield resistance.

Shielding components in connector shall have minimum continuous current capacity of 10 A and a current capacity of 25 A at minimum time of 60 s for the entire connector application temperature range.

DC resistance R_{dc} shall not exceed 25 m Ω for all shield transfers inside a connected connector pair in parts new condition. Shield R_{dc} for single receptacle or plug connector shall not exceed 12 m Ω .

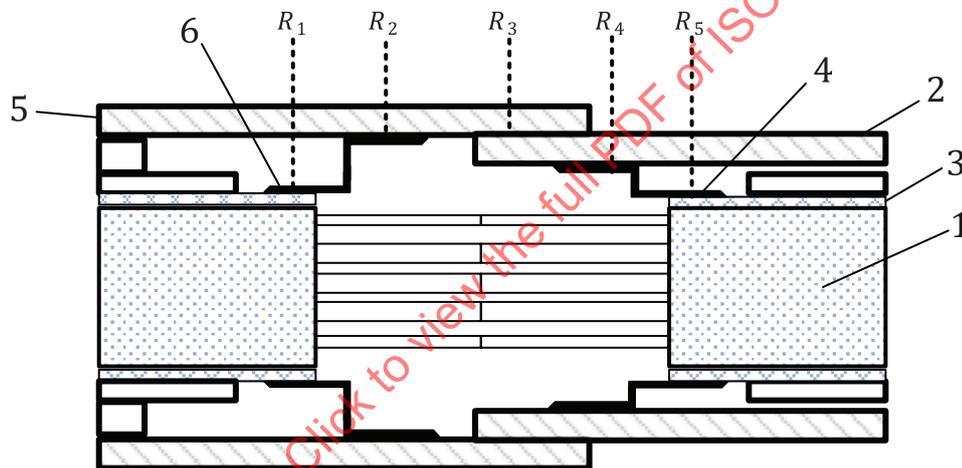
Test limits shall be considered for entire connector application temperature range.

Due to aging, the maximum DC resistance in the service life test shall not exceed 50 m Ω for connected pair and 25 m Ω for single tractor or implement connector.

Shield DC resistance is the total value of single connection resistances inside a connector per [Figure 38](#) and [Formulae \(1\)](#) and [\(2\)](#):

$$R_{dc} \leq 25 \text{ m}\Omega \quad (1)$$

$$R_{dc} = R_1 + R_2 + R_3 + R_4 + R_5 \quad (2)$$



Key

- R_1, R_2 DC contact resistances in receptacle connector housing
- R_3 DC contact resistance between the plug and the receptacle housings
- R_4, R_5 DC contact resistances in plug connector housing
- 1 plug connector cable
- 2 plug connector housing
- 3 plug connector overall shield
- 4, 6 shield 360° interface component
- 5 receptacle connector housing

Figure 38 — Shield DC resistance

4.9.3.3 Transfer impedance

4.9.3.3.1 Test for communication connector

Shield transfer impedance test for communication connector with pins C1 and C2 shall be performed in accordance with the method described in IEC 62153-4-7 within the frequency range from 10 kHz to 150 MHz.

4.9.3.3.2 Test for implement connector

The implement connector transfer impedance test shall be conducted in accordance with one of the injection line methods described in IEC 62153-4-6 or IEC 60512-23-7 within frequency range from 10 kHz to 150 MHz.

4.9.3.3.3 Transfer impedance limits

Transfer impedance of the connector shall not exceed the following limits:

- a) In frequency range 300 kHz – 10 MHz:

$$Z_T \leq 0,1 \cdot f^{0,3} \text{ } [\Omega] \text{ } f[\text{MHz}]$$

- b) In frequency range 10 MHz – 150 MHz:

$$Z_T \leq 0,02 \cdot f \text{ } [\Omega] \text{ } f[\text{MHz}]$$

4.9.3.4 Coupling attenuation

Coupling attenuation a_c is considered to be the sum of the unbalance attenuation a_u of the twisted pair and the screening attenuation a_s of the screen, shown as [Formula \(3\)](#):

$$a_c = a_u + a_s \tag{3}$$

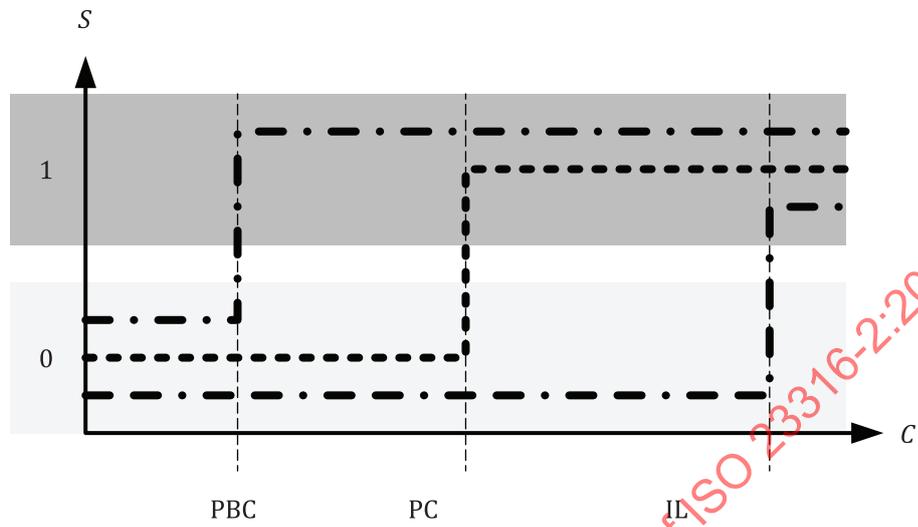
Communication connector coupling attenuation shall be tested according to the test method defined in IEC 62153-4-7. It is recommended to conduct this test in one test set-up with transfer impedance verification according to IEC 62153-4-7.

Coupling attenuation a_c shall be measured in frequency range 30 MHz – 150 MHz. See [Formula \(4\)](#):

$$a_{c \text{ MIN}} = 60 \text{ } [\text{dB}] \tag{4}$$

4.10 Connecting sequences

4.10.1 Connecting sequence



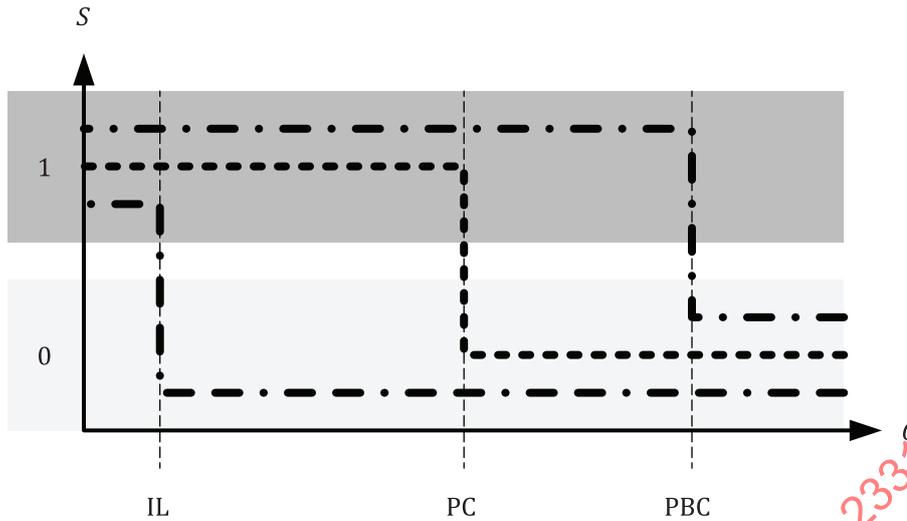
Key

- S status of connection
- 0 open
- 1 closed
- C connecting sequence
- PBC protective bonding conductor contact 4 acc. [Table 5](#)
- PC phase contacts 1, 2, 3 acc. [Table 5](#)
- IL contacts C1, C2, 5, 6 acc. [Table 5](#)

Figure 39 — Connecting sequences of contacts

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4.10.2 Disconnecting sequence



- Key**
- S status of connection
 - 0 open
 - 1 closed
 - C connecting sequence
 - PBC protective bonding conductor contact 4 acc. [Table 5](#)
 - PC phase contacts 1, 2, 3 acc. [Table 5](#)
 - IL contacts C1, C2, 5, 6 acc. [Table 5](#)

Figure 40 — Disconnecting sequences of contacts

4.11 Connector pinning

Table 5 — Connector pinning (see [Figure 41](#) and [Figure 42](#))

Pin designation	Signal description
1	Phase L1 in AC mode or (+) in DC mode
2	Phase L2 in AC mode
3	Phase L3 in AC mode or (-) in DC mode
4	PBC
5	DC Interlock
6	DC Interlock
C1	Communication TRD+ (used as interlock in AC mode) ^a
C2	Communication TRD- (used as interlock in AC mode) ^b
^a Recommended wire colour is white.	
^b Recommended wire colour is blue.	

4.11.1 Tractor side

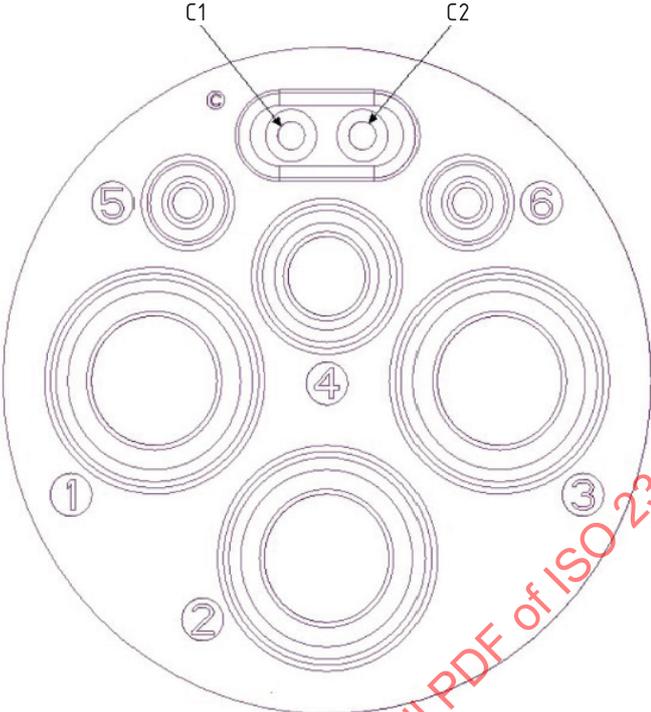


Figure 41 — Tractor side connector face view

4.11.2 Implement side

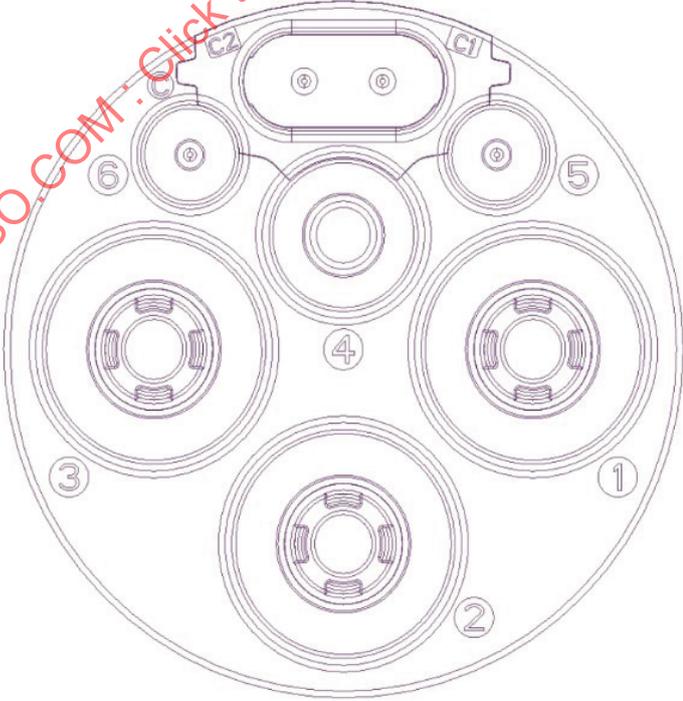


Figure 42 — Implement side connector face view

Geometrical requirements shall be as specified in [4.3](#).

4.12 Insulation resistance

In accordance with IEC 62196-1:2014, Clause 21, the connector insulation resistance shall be greater than 5 M Ω .

4.13 Connecting procedure

- a) Any making and breaking forces of the connector shall not exceed 100 N.
- b) The connector shall be connected and disconnected without separate tools.
- c) When joined the implement connector shall be retained by a mechanical locking device on the tractor connector.

4.14 Mechanical loads

- a) Electric contacts shall be retained by the connector body in a way to prevent mechanical damage to the body by extraction or insertion forces associated with the contact type.
- b) Pulling at the cable attached to the plug at a force of 1 kN shall not damage the connector. This shall be especially applicable for all sealing.
- c) The connector shall break-away in the connector cable direction at a force of 500 N to 800 N. The break-away functionality shall be implemented on tractor side (receptacle) and one of the following options shall be fulfilled:
 - 1) In case of a break-away the connector shall have a specified [predetermined breaking point](#). After break-away, an inspection as well as a repair shall be required.
 - 2) The connector shall withstand a break-away event until a max. angle of 22,5° after which an inspection is required. Angles greater than 22,5° may damage the connector housing and non-repairable parts of the connector.
- d) The connector shall handle the rated voltage and the rated current during the break-away event
- e) The sealing shall be protected against electromechanical influences.
- f) The sealing shall not slip or be otherwise dislocated unintentionally, especially during connection and disconnecting sequence.

4.15 Ingress protection level of components

4.15.1 Requirements

The connector shall be sealed against dust, liquids and be corrosion resistant.

The connector shall fulfil IP6K9K and IP6K7 in accordance ISO 20653 in the following states:

- a) connected condition;
- b) disconnected, connector with closed lid;
- c) disconnected, plug in parking position.

4.15.2 Implement connector park housing

On the implement there shall be a park housing to protect the connector in the disconnected state.

4.15.3 Cover

A connector cover shall be of an orange colour.

NOTE Specifications of orange colour is given, e.g. in standards in the US (8.75R5.75/12.5), Japan (8.8R5.8/12.5) according to the Munsell colour system and In Europe (ECE R 100) by RAL colour system in reference with orange colour in IEC 60304.

4.16 Environmental conditions

The connector shall resist typical agricultural conditions. Test definitions are defined in [Clause 5](#). A protection cover or park housing (implement side) shall be provided.

The connector shall suffer no damage or loss of electrical performance when exposed to an ambient temperature range from -40 °C to 85 °C.

4.17 Durability

Connector shall handle as a minimum 3 000 mating cycles.

4.18 Marking

4.18.1 Accessories marking

The connector and plug shall be marked with following:

- a) text string "ISO 23316-2";
- b) a degree of protection in accordance with ISO 23316-2:2023, 4.15.1;
- c) the maximum voltage shall be marked on the connector accordingly to nominal voltage for high-power interface defined in ISO 23316-1;
- d) the maximum amperage shall be marked on the connector accordingly to ISO 23316-2:2023, 4.5.5.
- e) either the name or trademark of the manufacturer or of the responsible vendor;
- f) the type reference, which can be a catalogue or part number.

When symbols are used, those found in IEC 60309-1 shall be used.

4.18.2 Pin marking

The pin description, as per definition in [4.11](#), shall be placed close to the relevant terminals and they shall not be placed on screws, removable washers or other removable parts.

Any integrated pin identification marking shall not be impacted by successive make and break connections

Compliance is verified by visual inspection.

4.18.3 Markings shall be indelible and easily legible.

Compliance is verified by inspection and by test as defined in [5.26](#).

5 Environmental qualification tests

5.1 General

5.1.1 Requirement

For qualification testing, test samples shall be subjected at minimum to the tests described in this clause with a minimum quantity of three samples per test group.

5.1.2 Test sequence

[Annex A](#) provides a proposed sample test sequence. The test sequences may deviate as tests on the supplier side could be conducted internally or externally.

5.1.3 Test methods

Unless otherwise specified, samples are to be tested at an ambient temperature of (20 ± 5) °C and humidity between 30 % and 80 %.

If a test description does not provide acceptance criteria, then the purpose of that test is to conduct conditioning for other tests in the sequence.

Plug and receptacle connectors comply with this standard if no sample fails in the entire appropriate test sequences.

If one sample fails a particular test, this test shall be repeated on new set of three samples. Preceding tests in the sequence, having influence on the failed test shall be also repeated.

5.2 Examination of product

A visual examination shall be conducted for damage, including at least:

- a) torn or damaged seals;
- b) cracked or discoloured plastic;
- c) evidence of liquid or dust ingress;
- d) evidence of arcing, charring or melting;
- e) complete loss of plating material;
- f) inability to mate or higher than allowed insertion forces;
- g) misalignment of terminals;
- h) deformation in shape;
- i) if applicable, the cover (see [4.15.3](#)) closure and integrity.

Any of the listed damages shall be cause for rejection.

5.3 Insulation resistance

The insulation resistance test shall be conducted according to IEC 62196-1:2014, Clause 21. The insulation resistance and voltage levels described in this document shall apply.

5.4 Connection resistance

The measurement of connection resistance shall be in accordance with ISO 8092-2. The resistance of a cable equal in length to that of the two measuring points shall be subtracted from the measured values.

5.5 Pressure washing, cleaning

The pressure washing test shall be in accordance with ISO 20653, but with pressure = 150 bar and duration = 5 min.

No water shall enter the connector and the inner housing. The test shall be performed with:

- a) the plug and connector connected;
- b) the connector lid closed;
- c) the plug-in park position in park housing.

5.6 Ultraviolet effects

The connected connector shall be tested for 500 h, in accordance with ISO 4892-3 Method A (cycle 1: duration 8 h dry, 4 h condensation).

5.7 Connecting and disconnecting forces

Test the maximum required force to connect and disconnect the connector and the plug pair.

The force shall not exceed 100 N. Test procedure in accordance with ISO 8092-2:2005, 4.3 and 4.6.

5.8 Durability

5.8.1 General

Carry out the test with plug and receptacle equipped with all contacts and cables terminated in contacts.

One cycle consists of the following operations:

- a) unlatching the locking lever until end position reached;
- b) opening of the cover if required separately;
- c) full insertion of the plug into the receptacle;
- d) withdrawal of the plug;
- e) uncontrolled and unassisted closing of the receptacle cover if required separately;
- f) latching the locking lever until end position reached.

Insert and withdraw the plug at a velocity of (500 ± 100) mm/min. Carry out 4 cycles/min.

Connected pair shall have horizontal orientation during the test cycles. Initial misalignment shall be considered.

After completing the cycles of operation mentioned in [5.8.2](#) and in [5.8.3](#):

- the tested parts must not show any signs of damage;
- coating on metallic contacts parts shall be rated for corrosion level in accordance with ISO 10289; (The acceptable rating shall be specified by the purchaser.)
- control review the plating thickness after mating cycle test.

5.8.2 Test A

Apply a minimum 3 000 mating cycles.

5.8.3 Test B

Apply 1 000 mating cycles.

5.9 Salt environment

Test in accordance with ISO 9227 process NSS (4 cycles, 24 h each). The test shall be performed in connected and disconnected condition (connector with lid closed and plug in park housing).

5.10 Thermal shock

The connected pair shall be tested in accordance with IEC 60068-2-14, process Na and the following conditions:

- a) Exposure time: 1 h,
- b) Transfer time: less than 10 s; Joined connector and plug shall not be electrically in operation,
- c) Cycles: 50,
- d) $T_a = -40\text{ °C}$,
- e) $T_b = +85\text{ °C}$.

5.11 Chemical and liquid immersion

The connector and plug shall be tested according to ISO 16750-5:2010, Table 1.

The following additional liquids shall be tested:

- a) fertilizer (nitrogen 28 % / 60 min / 23 °C);
- b) muriatic acid (HCl 31-33 % / 60 min / 23 °C);
- c) de-icing salt;
- d) grass juice;
- e) corn juice.

The kind of testing (immersion, brushing) and the defined connector and plug condition (material sample, single connector or plug, joined pair) shall be defined by the supplier.

5.12 Vibration

5.12.1 Vibration shall be tested in accordance with IEC 60068-2-6 with following conditions:

- a) Vibration form: Sine, 1 octave;
- b) Minimum frequency range: 10 Hz to 2 000 Hz to 10 Hz;
- c) Acceleration: 10 g;
- d) Displacement: 1,5 mm at 10 Hz to 57 Hz;
- e) Test duration per axis: 32 h per connector or connected pair under test;