CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

REQUEST FOR PROPOSAL
RE-BID

To: ALL BIDDERS

CTBTO Ref. No.: **2024-0037/RE-BID**
(PLEASE QUOTE ON ALL COMMUNICATIONS)

Tel. No.: +43 (1) 26030-6350
E-mail: procurement@ctbto.org

Attn:

Date: 24 May 24

Subject: **RE-BID:** Design, Upgrade of Infrastructure and Support Services for relocation of IMS Primary Seismic Station PS34, Norilsk, the Russian Federation

Deadline for Submission: 12 Jun 24 ***Vienna Local Time:*** 17:00

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (hereinafter referred to as the 'Commission') hereby invites you to submit a proposal that meets the requirements of the attached documents.

You are kindly requested to complete and return the acknowledgement form by email as soon as possible.

If you have any questions you should contact the email address indicated above.

Yours sincerely,

SAS
Sally Alvarez De Schreiner
Chief, Procurement Services Section

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

ACKNOWLEDGEMENT FORM

Solicitation No: 2024-0037/RE-BID ***Title:*** Design, Upgrade of Infrastructure and Support Services for relocation of IMS Primary Seismic Station PS34, Norilsk, the Russian Federation	***Closing Date:*** 12 Jun 24 ***Vienna Local Time:*** 17:00

Procurement Staff: Bugubai Apylov ***CTBTO Req. No.:*** 0010023884

Please complete 'A' or 'B' or 'C'
and Return

WITHIN FIVE (5) DAYS

THE PREPARATORY COMMISSION FOR THE
COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION (CTBTO)

by email to
procurement@ctbto.org

A: We shall submit our proposal

Company Name: _____

By: _____ Contact Name: _____
(date)

Email/Tel: _____

B: We may submit and will advise

Company Name: _____

By: _____ Contact Name: _____
(date)

Email/Tel: _____

C: We will not submit a proposal for the following reason(s)

___ our current workload does not permit us to take on additional work at this time;
___ we do not have the required expertise for this specific project;
___ insufficient time to prepare a proper submission;
___ other (please specify) _____

Company Name: _____

Contact Name: _____

Email/Tel: _____

INSTRUCTIONS FOR PREPARATION AND SUBMISSION OF PROPOSALS

1. General

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (the Commission) with its headquarters in Vienna is the International Organization mandated to establish the global verification system foreseen under the Comprehensive Nuclear-Test-Ban Treaty (CTBT), which is the Treaty banning any nuclear weapon test explosion or any other nuclear explosions. The Treaty provides for a global verification regime, including a network of 321 stations worldwide, a communication system, an International Data Centre and on-site inspections to monitor compliance with the Treaty.

This Request for Proposal (RFP) is for the provision of goods and services as described in the attached Terms of Reference (TOR).

The Proposal shall meet all requirements stated in this RFP. For this project, the Commission is seeking capabilities, which will ensure that the services are delivered, and the tasks are accomplished expeditiously and at a reasonable cost.

2. Documents included in this RFP

This RFP consists of the following documents:

(a) Letter of Invitation
(b) These Instructions for Preparation and Submission of Proposals with its Attachment:
  - Attachment 1: Evaluation and Selection Method
  - Attachment 2: Procedure for Submission of Electronic Offers in 2 Sealed Files
(c) Statement of Confirmation
(d) Bidder's Statement
(e) Vendor Profile Form
(f) The Commission's Model Contract and its Annexes A – B:
  - The Commission's General Conditions of Contract (Annex A);
  - The Commission's Terms of Reference and its Attachments (Annex B)

Note: In the event of award, the Proposal will be incorporated as Annex C to the Contract.

3. Amendment of RFP Documents

At any time prior to the closing date for submission of Proposals, the Commission may, for any reason, modify the RFP documents by amendment. The Commission may consider extending the deadline in order to allow adequate time for considering the modifications in the preparation of the Proposal.

4. Language of the Proposal

The Proposal and all correspondence and documents relating to it shall be in English.

5. Format and Submission of the Proposal

The Proposal shall be typed, dated and signed by an official legally authorized to enter into contracts on behalf of your organization. The Proposal shall not contain any interlineation, erasures or overwriting except as necessary to correct errors, in which case such corrections shall be initialled by the authorized person(s) signing the Proposal.

The Proposal shall be prepared in **three separate pdf files**, one containing a Technical Proposal, one containing a Financial Proposal *with* prices, and one containing a Financial Proposal *without* prices.

No pricing/financial information shall be included in the Technical Proposal. Note however that a complete list of the items being offered (without the prices) shall be included in the Technical Section of the Proposal.

The Proposal shall be submitted electronically according to the attached "PROCEDURE FOR SUBMISSION OF ELECTRONIC OFFERS IN 2 SEALED FILES" (please refer to Attachment 2).

The Proposal shall be received not later than the closing date indicated in the Letter of Invitation. The subject of the email shall contain the following:

NAME OF THE PROJECT: [Description indicated in Letter of Invitation]
CTBTO REFERENCE No.: [Description indicated in Letter of Invitation]

6. Request for Clarifications and Contacting the Commission

The Commission will issue clarifications if required. Bidders are requested to e-mail any questions pertaining to this RFP as soon as possible after receipt of the solicitation documents, but in any case, no later than 5 business days prior to the Closing Date. No requests for clarifications will be entertained after this time. Questions will only be accepted via e-mail and should be sent to:

E-mail: procurement@ctbto.org
Subject: RFP No. 2024-0037/RE-BID - Request for Clarifications

The Commission will make all reasonable efforts to issue the clarifications not later than 4 business days prior to the Closing Date.

Except in the case of responding to an RFP clarification, no bidder shall contact the Commission on any matter relating to this RFP and the Proposal after its submission and until the award of the Contract. Any attempt to influence the Commission in its evaluation of the Proposal or the contract award decision may result in the rejection of the Proposal.

7. Mandatory Bidders' Conference (!)

(a) A mandatory Bidders' Conference will take place on-line via Microsoft Teams Application on **29 May 2024, at 13:00 hrs Vienna (Austria) local time**.

(b) Bidders shall confirm their participation to procurement@ctbto.org not later than **28 May 2024**, including a list of the names, emails and position of the person(s) attending the conference on behalf of the bidder. Please also include the e-mail, telephone and the name of the bidder's focal contact. Not more than 3 persons are allowed to attend the conference on behalf of a bidder.

(c) The purpose of the bidders' conference is to allow prospective bidders to acquaint themselves with the required documents and facilitate the preparation and submission of proposals.

(d) The Commission will confirm in writing the bidder's attendance registration.

(e) The specific link to join the conference will be communicated by the Commission to the registered suppliers the day before the conference.

(f) The Bidders' Conference will be conducted in the English language.

(g) The Bidders' Conference will have a set agenda consisting of a presentation with a brief introduction of this RFP and requirements of the Terms of Reference and a Question/Answer session, when potential bidders will have the opportunity to ask questions concerning this RFP.

(h) The Commission's presentation and answers to questions raised during the Bidder's Conference will be shared via email with the bidders that attended the Bidder's Conference.

(i) The Commission shall not be responsible or liable for any costs associated with the bidders' participation in the Bidder's Conference, regardless of the outcome of this RFP.

(j) No bidder shall contact directly the Commission's representatives or (if applicable) any other party attending the Bidder's Conference in support of the presentations referred to in (g) above. Any communication with respect to this RFP shall be addressed in accordance with Section 6 of these RFP instructions.

ATTENDING THE BIDDER'S CONFERENCE IS A MANDATORY REQUIREMENT FOR BIDDERS TO BE ELIGIBLE UNDER THIS RFP.

8. Eligible Goods and Services

The goods and services (if any) to be rendered under the Contract shall have their origin in the States Signatories of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), a list of which is available in the CTBTO website at www.ctbto.org under Status of Signatures and Ratifications | CTBTO. For purposes of this paragraph, "the origin" means the place from where the materials, goods and/or from which the services are supplied.

9. Type of Contract and Payment

The Commission wishes to engage a contractor for this project based on firm-fixed price in accordance with the attached Model Contract. The terms and conditions of payment for the work are described in Clause 12 of the attached Model Contract.

10. Preparation of the Proposal

The Proposal shall contain, but not necessarily be limited to, the information described below.

The Proposal shall be composed of the following separate parts:

I. **Technical Proposal**; and
II. **Financial Proposal**;
III. **Financial Proposal without prices**

providing, but not limited to, the following information:

PART I: TECHNICAL PROPOSAL

Section 1 – Statement of Confirmation, Bidder's Statement and Vendor Profile Form
The attached Statement of Confirmation, Bidder's Statement and Vendor Profile Form shall be duly signed and submitted together with the Proposal.

Section 2 – Eligibility, Qualifications and Capability of the bidder

Only Russian Suppliers and that attended the mandatory Bidder's Conference are eligible to submit a Proposal under this RFP.

The Proposal shall include the following concerning the bidder's qualifications and capability:

(a) Copy of the company's Certificate of State Registration (preferably with English translation);
(b) Copy of the Extract from the Common State Register of Legal Entities (preferably with English translation);
(c) Copies of necessary licences allowing to conduct the Work;
(d) A statement that the capacity of the bidder, in terms of qualified manpower resources, is adequate to conduct the Work.
(e) Written confirmation that the bidder has obtained or will obtain from the Station Operator required permits and security clearance (including land-use rights) for access to the Station with the sole purpose of performing the Work as set out in the Terms of Reference. The description of the security clearance procedure is provided in Attachment C to Annex B "Terms of Reference".
(f) Mandatory attendance of Bidders' Conference, as described in Section 7 of the Instructions for Preparation and Submission of Proposal under this RFP.

Section 3 – Scope of Work
The Proposal shall include a brief description on how the bidder will perform the Work and the overall plan for the execution of the tasks described in the Terms of Reference. The bidder shall furnish such description by providing a section-by-section response to all items in the Terms of Reference.

The Proposal shall also provide any other relevant issue which the bidder would like to bring to the attention of the Commission, whether or not having cost implications. This shall include details of warranties/manufacturer's guaranties in respect to any items of the Station and/or equipment.

Any deviation from the Terms of Reference or other documents contained in the RFP shall be clearly stated and justified. The Commission reserves the right to accept or reject such deviations.

Section 4 – Point of Contact and Personnel

Point of Contact
The Proposal shall state the contact details and legal address (name, telephone and fax numbers, and e-mail address) of the person (point of contact) in your company dealing with this RFP.

Personnel
The Proposal shall include a list of capable and experienced personnel, including their function, duration of assignment, curriculum vitae of key personnel proposed to perform the Work.

Use of former Preparatory Commission for the CTBTO ("Commission") employees in the preparation of Quotations:

A bidder must not, in the absence of prior written approval from the Commission, permit a person to contribute to, or participate in, any process relating to the preparation of a Quotation or the procurement process if the person:

a. At any time during the 12 months immediately preceding the date of issue of the Solicitation was an official, agent, servant or employee of, or otherwise engaged by the Commission;
b. At any time during the 24 months immediately preceding the date of issue of the Solicitation was an employee of the Commission personally engaged, directly or indirectly, in the definition of the requirements, project or activity to which the Solicitation relates

Section 5 – Sub-Contractors

The Proposal shall include names, legal status, address and qualifications of subcontractor(s), if any, involved in the Project and the scope of the subcontracted services. You shall provide a statement that your organization shall be fully responsible for the performance of your sub-contractors. All sub-contractors shall be legally established in one of the CTBT States Signatories, a list of which is available in the CTBTO website at www.ctbto.org under Status of Signatures and Ratifications | CTBTO.

Section 6 – Model Contract

The bidder shall provide the necessary information required for the preparation of the Contract, such as registered name and address of the organization, the name and position of the legal representative authorized to sign the contract on behalf of the organisation.

Section 7 – Time Schedule

The Proposal shall contain a bar chart indicating an estimation of the duration of the services, including the duration of each task required by the Terms of Reference. Delivery time shall be indicated in weeks after receipt of an order and shall be firm from the submission of the Proposal until conclusion of the Contract.

Section 8 – Insurance

Insurance to be included in the Proposal must be for All Risk, covering 110% of the cost of the equipment proposed, and from the date/place of the shipment to the date/place the delivery is completed. The insurance shall be in the name of the supplier and the Commission. You are requested to confirm that you will provide this insurance coverage.

PART II: FINANCIAL PROPOSAL

Provide a written statement in the Proposal attesting that the bidder is offering the CTBTO the most favoured customer status: "It is certified that the pricing offered does not exceed selling prices to other customers for the same or substantially similar items and/or services for comparable quantities under similar terms and conditions".

Section 1 – Total Price

The Financial Proposal shall be prepared in **United States Dollars or Euro** and shall breakdown, separately, the costs for each task required by the Terms of Reference.

A firm fixed price shall be quoted, providing a proper breakdown of the details for equipment, materials, supplies, remuneration and expenses, which are part of the total contract price, as referred in more details below. The remuneration shall include basic salaries, fees, overheads and other charges, which would be due to be paid in as much as they are levied in conclusion or implementation of the contract, specifying unit rate per hour/day/month of the personnel

involved and total number of days. Overhead, fees or other charges included in the remuneration costs shall be quoted separately with a proper breakdown and justification of each charge.

Section 2 – Cost Breakdown
The Financial Proposal shall provide the detailed prices related to each Work task referred to in the Terms of Reference:

Design Documentation
(a) Cost of personnel (please provide the person-day rates, etc.) per each activity;
(b) Travel costs (if applicable - please provide the details);
(c) Documentation and Reporting.

Work Tasks
(d) Cost of equipment, materials and supplies (please provide the details and separate cost breakdown for each item);
(e) Cost of sub-contractors (please provide the cost details for each item or activity);
(f) Cost of personnel (please provide the person-day rates, etc.) per each activity;
(g) Travel costs (if applicable - please provide the details);
(h) Documentation and Reporting.

Other Costs
(i) Any other costs (please provide explanation and separate cost breakdown for each item).

A proper cost breakdown, cost details, justifications and explanations of each of the cost items would enable the Commission to evaluate the Proposal promptly and proceed with less requests for clarifications/justifications in a later stage. This is also a factor influencing the decision for contract award.

Section 3 – Taxes
In principle the Commission is exempt from taxes. **"Taxes"** means all direct and indirect taxes (including value added tax, general sales tax or goods and services tax), assessments, fees, customs duties, liens and charges in as much as they are levied in conclusion or implementation of the contract, including customs restrictions and charges of similar nature in respect of articles imported or exported for the Commission's official use.

Due to the Facility Agreement concluded between the Commission and the Government of Russian Federation on 22 March 2005 which entered into force on 27 December 2006, the Commission is exempt from payment of indirect taxes and customs duties. Additionally, the Joint Executive Order No. 2872/36H dated 29 February 2012, registered by the Ministry of Foreign Affairs and the Ministry of Finance of the Russian Federation, includes the Commission as part of the list of international organizations and their agencies which carry out activities on Russian Federation territory free of value added tax.

11. Completeness and Correctness of the Proposal

The Commission reserves the right to verify all information furnished by you in the Proposal through a source of its choice. Any inaccurate information so given may lead to the rejection of the Proposal.

12. Validity of the Proposal

The Proposal shall be valid for 90 (ninety) days after the deadline for its submission to the Commission, unless an extension of validity has been requested by the Commission.

13. Correction of Errors

The Commission will check the Proposal for any arithmetic errors. If there is a discrepancy between the unit price and the total price that is obtained by multiplying the unit price and quantity, the unit price shall prevail and the total price shall be corrected.

14. Evaluation of Proposals

(a) The Commission will first conduct a technical evaluation based on the criteria specified in Attachment 1 (Evaluation and Selection Method).

(b) If the Proposal fails to meet the minimum technical requirements for any one criterion, the entire Proposal will not be considered further. Only the Financial Proposals of those bidders that meet or exceed the minimum technical requirements of all items will be opened and evaluated for its commercial acceptability and to determine the financial score for each responsive bidder in accordance with Attachment 1. The Commission will evaluate the following:

(i) Financial acceptability;
(ii) Contractual compliance.

15. Negotiations of the Proposal and Award

The Commission reserves the right to request clarifications on the Proposal and to enter into negotiations regarding technical or commercial aspects of the Proposal before awarding the contract under this RFP.

The Commission also reserves the right, as it deems appropriate, to award to a single bidder, to award to multiple bidders in any combination or not to award to any of the bidders as a result of this RFP.

16. Modification and Withdrawal of the Proposal

Bidders may modify or withdraw their Proposals after their submission, provided that written notice of the modification or withdrawal is received by the Commission by the closing date for the submission of the Proposal. The Proposal may not be modified subsequent to the closing date.

17. The Commission's Right to Reject the Proposal

The Commission reserves the right to accept or reject the Proposal or to annul this procurement process at any time prior to the award of contract without having to inform the bidders of the grounds therefore, without thereby incurring any liability to the bidders.

18. Costs of preparation and submission of the Proposal

Bidders shall bear all the costs associated with the preparation and submission of their Proposal and the Commission will not be responsible or liable for those costs, regardless of the outcome of this RFP.

19. Proprietary Information

All documentation and information contained in this RFP are proprietary to the Commission and shall not be duplicated, used or disclosed -in whole or in part- for any purpose other than

to evaluate them and respond to the Commission's request for Proposal or otherwise without prior written agreement of the Commission.

ATTACHMENT 1
EVALUATION AND SELECTION METHOD
RFP: 2024-0037/RE-BID
Design, Upgrade of Infrastructure and Support Services for relocation of IMS Primary Seismic Station PS34, Norilsk, the Russian Federation

TABLE 1	
Eligibility criteria **as set out in RFP Instructions, Section 10 "PART I: TECHNICAL PROPOSAL"**	
The Bidder is a Russian supplier. The Proposal shall include the following concerning the bidder's qualifications and capability: (a) Copy of the company's Certificate of State Registration (preferably with English translation); (b) Copy of the Extract from the Common State Register of Legal Entities (preferably with English translation); (c) Copies of necessary licences allowing to conduct the Work; (d) A statement that the capacity of the bidder, in terms of qualified manpower resources, is adequate to conduct the Work. (e) Written confirmation that the bidder has obtained or will obtain from the Station Operator required permits and security clearance (including land-use rights) for access to the Station with the sole purpose of performing the Work as set out in the Terms of Reference. The description of the security clearance procedure is provided in Attachment C to Annex B "Terms of Reference". (f) Mandatory attendance in the Bidders' Conference, as described in Section 7 of the Instructions for Preparation and Submission of Proposal under this RFP.	**PASS/FAIL**

Only offers of bidders meeting the above eligibility criterion will be considered for the next stage of the evaluation (quality evaluation/scoring)

Technical Evaluation Criteria	**Max Points**	**Weight Factor**	**Max Obtained Score**
Column 1	***Column 2***	***Column 3***	***Column 4***
1. Understanding of Scope of Work (Section 2 of TOR)	5	1	5
2. Fulfilment of General Obligations (Section 3 of TOR)	5	1	5
3. Ability to acceptably complete Work Tasks 1 – 2 (sub-Section 4.1 and 4.2 of TOR)	5	2	10
4. Ability to acceptably complete Work Task 3 (sub-Section 4.3 of TOR)	5	3	15
5. Ability to acceptably complete Work Task 4 (sub- Section 4.4 of TOR)	5	3	15
6. Ability to acceptably complete Work Task 5 (sub- Section 4.5 of TOR)	5	3	15
7. Ability to acceptably complete Work Task 6 (sub- Section 4.6 of TOR)	5	3	15
8. Ability to acceptably complete Work (Section 5 of TOR)	5	2	10
9. Readiness to conduct Optional Work and ability to comply with Reporting (Sections 6 and 7 of TOR)	5	1	5
10. Acceptable delivery time (Section 8 of TOR)	5	1	5
Total Obtained Points	**50**		**100**

Technical Evaluation Score	Obtained score*70%

Points (column 2) will be given to Technical Proposal against each the technical evaluation criteria (column 1) of Table 1 in accordance with Table 2 below.

The minimum "technically acceptable Proposal" is the Technical Proposal, which has obtained minimum 3 points against each technical evaluation criteria. If a Technical Proposal obtains less than 2 points in any technical evaluation criteria, this Proposal shall be considered as "not technically acceptable proposal", as it does not meet the minimum technical requirements and the Bidder will be excluded from the evaluation process.

A Technical Proposal, which meets the minimum evaluation criteria and in some area(s) has exceeded minimum requirements, will be assigned additional points, up to 5 points. Upon finalization of the technical evaluation, all technical scores at the technical evaluation stage will be converted according to 70% weight for technical part of evaluation.

TABLE 2

Scoring	**Points**
Does not meet the minimum technical, functional, or performance related criterion. Response incomplete, inadequate and/or non-responsive to the criterion. Bidder does not clearly understand the requirement.	1
Meets the criterion in *most* areas but is lacking details and responsiveness in some areas of the requirement.	2
Meets the minimum acceptable requirements in all areas.	3
Meets the minimum acceptable requirements in all areas and exceeds it in some areas.	4
Technical Proposal exceeds the minimum level of requirements in all areas and adds additional technical, functional and performance related value to the proposed equipment, services or work.	5

TABLE 3

Subject to the compliancy of the Technical Proposal to the minimum technical requirements based on the technical evaluation criteria, the Financial Proposal shall be evaluated in accordance with the formula given below:

$$X = Y/Z * 30$$

Legend
X = Score of the Financial Proposal
Y = Price of the lowest priced offer, which is "technically acceptable offer"
Z = Price of the financial offer being evaluated

TABLE 4

Total Combined Score = Technical Evaluation Score + Financial Score

The weight of the technical and evaluation components is 70% and 30% respectively.

The Contract will be awarded to the Bidder, whose Proposal obtains the “highest total combined score” resulting from the technical and financial evaluation and subject to commercial and contractual acceptability: Any deviation submitted by the bidders to the provisions of Commission’s Model Contract and General Conditions of Contract may be a factor in the Commission’s contract award decision.

Attachment 2

"Procedure for Submission of Electronic Offers in 2 Sealed Files"

The Commission invites you to submit your sealed offer (Bid or Proposal) in response to the solicitation forming part of this request.

Please be sure to follow the instructions below very carefully, so that the documents you submit are encrypted, and cannot be opened without an encryption key (password). If the documents are not encrypted, they will not be accepted as part of this tender process.

CRITICAL INFORMATION:

Create separate zip files for the technical offer and financial offer (labeling them clearly in the title) with different encryption keys. Instructions for how to do this are provided below.

Step 1: You provide the encryption key (password) for the *Technical Offer only* (in accordance with the below instructions)!

Step 2: After the Commission has performed the evaluation of the Technical Offer, if your Technical Offer is considered to be acceptable, the Commission will request the encryption key (password) for the Financial Offer you have already submitted by the tender Deadline.

Should you have any questions, please send an email to procurement@ctbto.org.

We recommend that you leave yourself plenty of time to complete the below process (including getting any necessary assistance from the Commission), as late offer will not be accepted.

INSTRUCTIONS:

1. In a **WINDOWS** environment, one way of meeting the requirements is as follows.

   We recommend using the open-source, free software **7-zip**, but if you are comfortable with other tools, the result should be the same, as long as you can apply encryption to the archive. In the below, we'll use 7-zip as an example.
   (You can download the 7-zip code for Windows at: 7-zip.org)

2. In **LINUX** environment, you can use, for instance, "sha1sum" on the command line.

Creating the archives for submission

Regardless of whether the offer is a single file, or a collection of files, the files are easier to manage if delivered as a single, compressed file. Compressing the archive is a common way to meet size limitations in email systems.

As an example of how to submit your offer in the required format: assuming you are supplier "SOFTCOMP" and have the following files related to the offer for "RFP 2020-0010/EDWALD". *(You will need to replace these elements with the real information for your actual offer in line with the relevant Instructions for Preparation and Submission of Proposals/Bids.)* Assuming further that you have installed the 7-zip software on the Windows system you are using.

We will only go through the creation of the Technical Offer (Proposal/Bid) component; the Financial Offer (Proposal/Bid) component is similar.

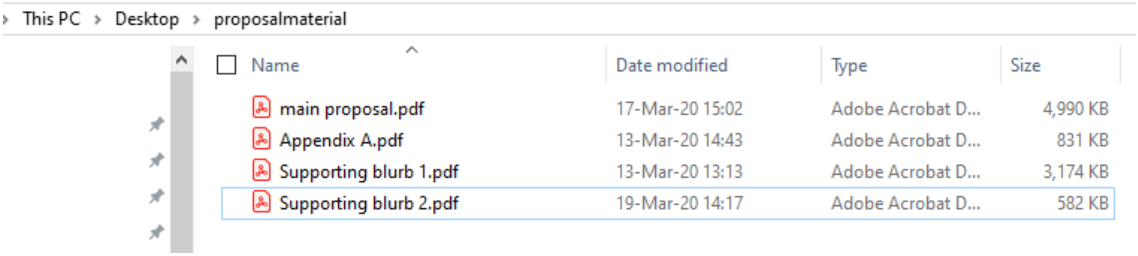

Figure 1 An example set of files to be submitted

Select the four files and right-click; a Dialog box pops up, with one of the options being "**7-ZIP >**". Hover your cursor over the " **>**" part and a few more options appear, select the "**Add to archive**" option.

Another dialog box pops up (see 'Figure 2, *Creating an Archive*', next page):

Using the standard Windows methods, select a suitable location for the archive (if you don't change it, the archive gets created right where the selected files are), and give it a name in the form of: "SOFTCOMP-2020-0010-EDWALD-TECHNICAL-BID", of course replacing all the elements with the true values for the offer in question: the actual company indicator, and the actual RFP/ITB identification string. Note that it is not possible to put a slash "/" in the filnename, and therefore put a dash "-" instead. Leave the file extension ".zip' as is.

Leave all the other settings as is, except: **add a password to the encryption** (see figure 2 below). This is done by typing the same password (of your choosing) twice in the two text fields in the lower right hand corner.

Make a note of this password. You must choose different passwords for the two zip archives, that is, the Technical and the Financial Proposal/Bid.

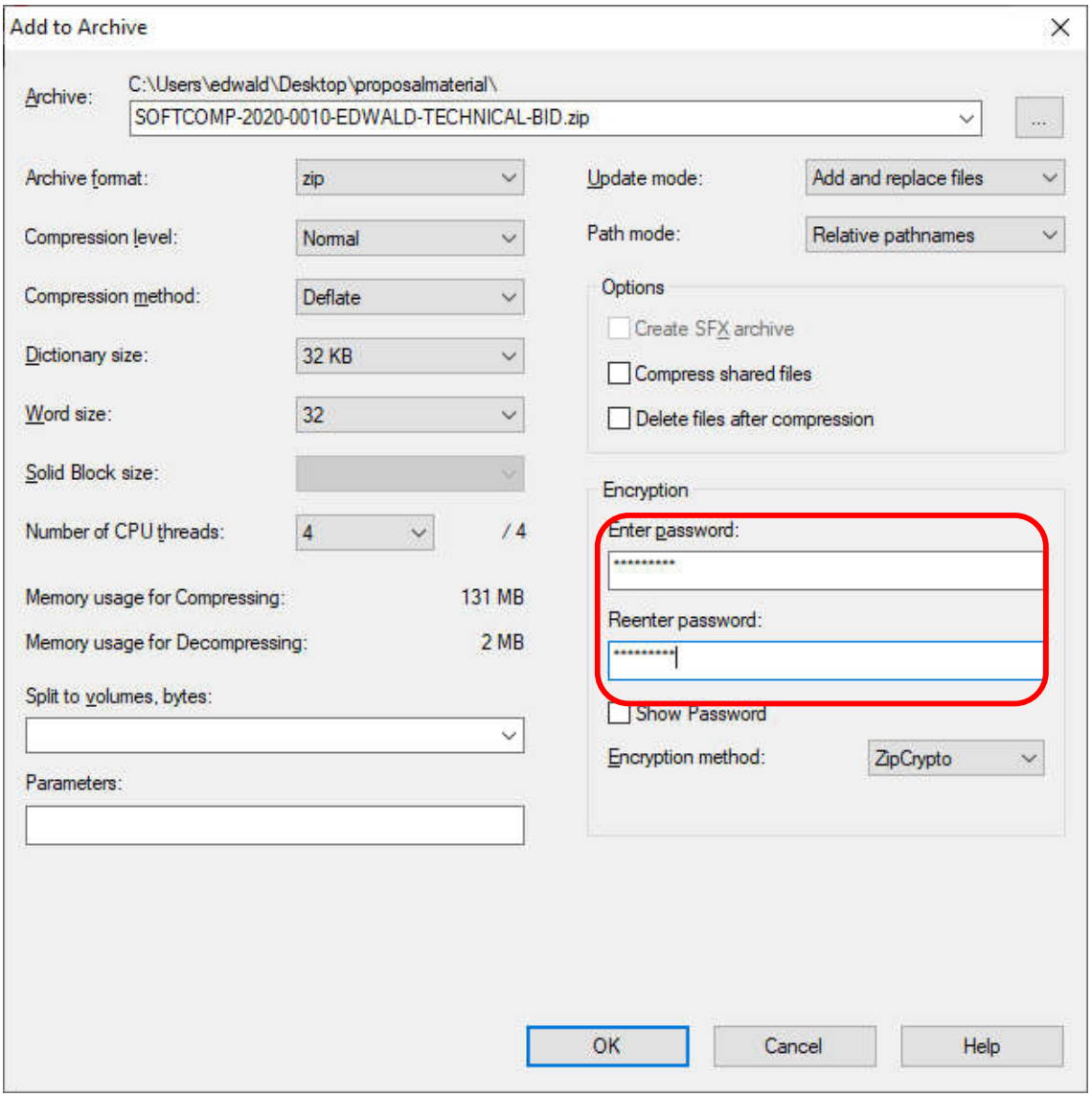

Figure 2 Creating an Archive

Now, we seek the "SHA1 Hash", and electronic fingerprint of the archive you have just created. The hash is a string calculated from your file(s) and can be used to guarantee that the file hasn't been modified since you created it. Any change to the file will result in a different hash value.

There are many ways of calculating this; two common options are decribed below.
If the appropriate functionality is available in your Windows environment: Select the compressed archive in the Windows file manager, (eg. SOFTCOMP-2020-0010-EDWALD-TECHNICAL-BID.zip) and right click. One of the options to select is "**CRC SHA >**". Hovering over the " >" brings a few more options to light, select the **SHA-1** option. A smaller dialog pops up: (see Figure 3, *SHA1* below). Clicking Ctrl-C grabs the contents of this box. You can close the box after copying the contents. (You can paste the contents into a mail message, for instance.)

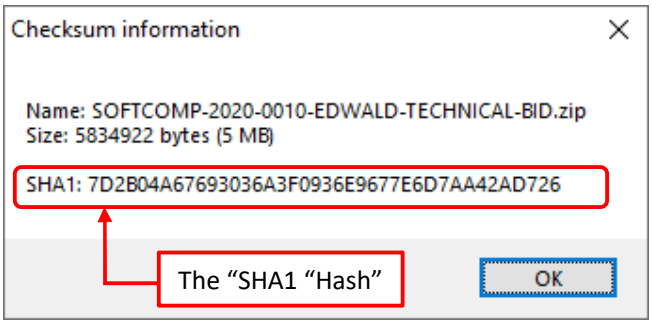

Figure 3 SHA1

If this CRC SHA function is not available by 'right-click' on your Windows version, you can also do this from 'the command line', a slightly more complicated way. Open a CMD window (see sidebar below), move to the folder where your archive is, and execute the command:
"`certutil -hashfile SOFTCOMP-2020-0010-EDWALD-TECHNICAL-BID.zip sha1`"
where you obviously replace the name of the file with your real file name. The output of this command is the SHA1 "hash". You can copy-and-paste the string for use in the email (below).

Sidebar: How to open a CMD window in Windows:

The way to open a Command window (or 'terminal') depends on the version of Windows you have. The different methods are very clearly described in the following article, but a quick internet search will find multiple descriptions.

https://www.lifewire.com/how-to-open-command-prompt-2618089

Finally,

1. Create a new email, Subject: example- "SOFTCOMP-2020-0010-EDWALD". Add the two compressed archives, that is, the Technical Offer and the Financial Offer archives as attachments. The text of the email should contain the SHA1 information for both archives. **SEND THIS TO:** sealed_bids@ctbto.org (note that there is an underscore "_" between "sealed" and "bids"). (Should the email become larger than your mail system allows, you can try sending the two archives in separate emails. Take care to include the right SHA1 information with each file.)

2. Create a new email, Subject: example- "SOFTCOMP-2020-2010-EDWALD-Technical Offer" the contents of which must contain the Encryption Key for the Technical Offer (the password you used when creating the Technical Offer). (Again, note the underscore between 'bid' and 'keys'.)
   SEND THIS TO: bid_keys@ctbto.org

   IMPORTANT NOTE: As stated above, only send the Encryption Key for the Technical Offer to the bid_keys@ctbto.org mailbox when sending your Technical and Financial Offer to the sealed_bids@ctbto.org mailbox. You shall only send the Encryption Key for the Financial Offer to the Commission if and when informed by the Commission that your Technical Offer had been evaluated as "technically acceptable".

The Financial Offer Encryption Key will need to be provided by you to the same e-mail (bid_keys@ctbto.org) within 48 hours of the Commission's request, clearly marked in Subject: Encryption Key for (example):"SOFTCOMP 2020-2010 EDWALD-Financial Offer". If your Offer is not considered "technically acceptable", the Commission will not request an Encryption Key for your Financial Offer, and it will remain unopened.

As mentioned above, should you have questions or difficulties, please send an e-mail to procurement@ctbto.org.

We recommend that you leave yourself plenty of time to complete the above process (including getting any necessary assistance from the Commission), as late offers will not be accepted.

STATEMENT OF CONFIRMATION

On behalf of (name of firm or organization):_____, I hereby attest and confirm that:

a) The firm/organization possesses the legal status and capacity to enter into legally binding contracts with the Commission for the supply of equipment, supplies, services or work.

b) The firm/organization is not insolvent, in receivership, bankrupt or being wound up, and not under administration by a court or a judicial officer, and that it is not subject to the suspension of its business or legal proceedings for any of the foregoing reasons.

c) The firm/organization has fulfilled all its obligations to pay taxes and social security contributions.

d) The firm/organization has not, and that its controlling shareholders, directors and officers have not, within the last five years been convicted of any criminal offense related to proscribed practices nor related to professional conduct or the making of false statements and/or misrepresentations as to their capacity or qualifications to enter into a procurement or supply contract.

e) The Commission, in the event that any of the foregoing should occur at a later time, will be duly informed thereof, and in any event, will have the right to disqualify the firm/organization from any further participation in procurement proceedings.

f) The firm/organization and its shareholders, directors and officers did not/will not attempt to influence any other bidder, organization, partnership or corporation to either submit or not submit a proposal/bid/quotation.

g) The firm/organization will not, in the absence of a written approval from the Commission, permit a person to contribute to, or participate in, any process relating to the preparation of a Quotation/Bid/ Proposal or the procurement process if the person:

   a. at any time during the 12 months immediately preceding the date of issue of the Solicitation was an official, agent, servant or employee of, or otherwise engaged by the Commission;
   b. at any time during the 24 months immediately preceding the date of issue of the Solicitation was an employee of the Commission personally engaged, directly or indirectly, in the definition of the requirements, project or activity to which the Solicitation relates.

h) Neither the organization/firm, its parent entities (if any), nor any of its subsidiary or affiliated entities (if any) have been identified on, or associated with any individual, groups, undertakings and entities identified on, the list established pursuant to the UN Security Council Resolution 1267 (Consolidated Sanctions List).[1]

i) Neither the organization/firm, its parent entities (if any), nor any of its subsidiary or affiliated entities (if any) are subject to any form of sanction imposed by an organization or body within the United Nations System, including the World Bank.

[1] The Consolidated United Nations Security Council Sanctions List can be found on the following website: **https://www.un.org/securitycouncil/content/un-sc-consolidated-list**

j) Neither the organization/firm, its parent entities (if any), nor any of its subsidiary or affiliated entities (if any), is engaged in any practice inconsistent with the rights set forth in the Convention on the Rights of the Child, including Article 32 thereof, which, inter alia, requires that a child shall be protected from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development.

k) Neither the organization/firm, its parent entities (if any), nor any of its subsidiary or affiliated entities (if any) will use the funds received under contracts/purchase orders with the Commission to provide support to individuals, groups, undertakings or entities associated with terrorism.

l) The prices in the firm/organization's proposal/bid/quotation have been arrived at independently, without consultation, communication or agreement with any other interested companies, their shareholders, competitor(s) or potential competitor(s) with a view to restricting competition. Any of the bidder's stakeholder has no interest in any of other potential bidders/competitors (e.g. is not a shareholder in another potential bidder/competitor or have a conflict of interest).

m) The Commission shall have the right to disqualify the firm/organization from participation in any further procurement proceedings, if it offers, gives or agrees to give, directly or indirectly, to any current or former staff member of the Commission a gratuity in any form, an offer of employment or any other thing of service or value, as an inducement with respect to an act or a decision of, or a procedure followed by, the Commission in connection with a procurement proceeding.

n) The Commission shall have the right to disqualify the firm/organization from participation in any further procurement proceedings if it does not disclose to the Commission any situation that may appear as a conflict of interest, and if it does not disclose to the Commission if any official or professional under contract with the Commission have an interest of any kind in the firm/organization's business or any kind of economic ties with the firm/organization.

o) The firm/organization expressly agrees to abide by the United Nations Supplier Code of Conduct.[1]

Name (print):_____ Signature: _____

Title/Position: _____

Place (City and Country):_____ Date: _____

[1] https://www.un.org/Depts/ptd/about-us/un-supplier-code-conduct

BIDDER'S STATEMENT

PLEASE FILL-IN & SUBMIT WITH THE PROPOSAL

Delivery Time:

Shipping weight (kg) and Volume (m^3) – if applicable:

List of recommended consumables and spares including prices and details on local availability, if applicable (please tick):

☐ For one-year period ☐ For a period of …….

Warranty period applicable (it shall be for a **minimum of 24 months**, starting from the acceptance of the goods/services by the Commission) – please tick below:

☐ For a two-year period ☐ For a period of …….

Availability of local service in Vienna, Austria (if any):

State country of origin or assembly of all items quoted:

Quantity discount and early payment discount (if any):

Include documentary evidence of qualifications to perform the order, which shall establish to the Commission's satisfaction that the bidder has the financial, technical and production capability necessary to perform the order in its entirety and to provide spare parts and other necessary on-going services as required.

Included in this quotation: **Yes** ☐ **No** ☐

Confirmation that the bidder has reviewed the Commission's Model License Agreement (if attached), the Commission's General Conditions for Goods (if attached), the Commission's General Conditions of Contract (if attached), Draft Contract (if attached), and the Special Conditions (if attached), and agreed to all terms and conditions.

Yes ☐ **No** ☐

Remarks:

With regards to the software provided with the equipment, state and confirm whether the software licenses are transferable to third parties, i.e. the Commission or the Commission's State Signatories (Member States).

Yes ☐ **No** ☐ **Not applicable** ☐

Remarks:

Name:

Name & Title of Contact Person:

Signature & date:

VENDOR PROFILE FORM (VPF) – FOR PRODUCTS/SERVICES/WORK

1. Name of Company:	
2. Street Address:	3. Telephone:
P.O. Box: City:	4. E-Mail:
Zip Code: Country:	5. Website:
6. Contact Person:	Title:
7. Legal Status (e.g. Partnership, Private Limited Company, Government Institution)	
8. Year Established:	9. Number of Employees:
10. Gross Corporate Annual Turnover (US$m)*:	11. Annual Export Turnover (US$m)*:
12. Type of Business/Products: Manufacturer ☐ Sole Agent ☐ Supplier ☐ Other ☐ (please explain)	
13. Type of Business/Services/Work: Engineering ☐ Civil Work ☐ Governmental Institution ☐ Other ☐ (please explain)	
14. References (your main customers, country, year and technical field of products, services or work): **	
15. Previous Supply Contracts with United Nations Organizations (over the last 3 years)** Organization: Value in US$ Equivalent: Year: Organization: Value in US$ Equivalent: Year:	
16. Summary of any changes in your company's ownership during the last 5 years:	

* Please provide a copy of the most recent audited annual report and accounts. Note: Export includes services or work performed abroad or for foreign clients.
** Please provide supplementary documentation on these items.

17. List of Products/Services/Work offered:

Product/Service/Work #	Product/Service/Work Description

18. This section shall be **signed and stamped** by an official legally authorized to enter into contracts on behalf of your organization:

Name: Title: Signature: Date:

Bank Details	**Beneficiary Details**
Bank Name: Bank Address: Exact Account Holder Name:	Beneficiary Name: (exactly as stated on bank statements) IBAN: (if applicable) Account number: SWIFT/BIC: ABA/Sort Code:

Additional Details (if applicable)

Correspondent bank:

Correspondent account number:

Correspondent SWIFT/BIC:

Tax Identification Number:

FOR CTBTO USE ONLY		
Evaluated By:	Initials	Date:
Updated By:	Initials	Date:
Remarks:		

* Please provide a copy of the most recent audited annual report and accounts. Note: Export includes services or work performed abroad or for foreign clients.
** Please provide supplementary documentation on these items.

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

MODEL CONTRACT

(SAP No. _____)

between

THE PREPARATORY COMMISSION

FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY

ORGANIZATION

and

_____

for

DESIGN, UPGRADE OF INFRASTRUCTURE AND SUPPORT SERVICES FOR RELOCATION OF IMS PRIMARY SEISMIC STATION PS34, NORILSK, THE RUSSIAN FEDERATION

This Contract comprises this cover page, a table of contents, 8 (eight) pages of text, a signatories page, a List of Annexes and 3 (three) Annexes (A to C)

Month 2024

TABLE OF CONTENTS

MODEL CONTRACT

This Contract is entered into between the **PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION** (hereinafter referred to as the "**Commission**"), having its office located at Wagramer Strasse 5, A-1400 Vienna, Austria, and (hereinafter referred to as the **"Contractor"**), having its registered office located at _____, hereinafter, the Commission and the Contractor are collectively referred to as the **"Parties"** and individually as a **"Party"**.

WHEREAS, the Commission has the responsibility to take all the necessary measures for the establishment of the International Monitoring System (hereinafter referred to as the **"IMS"**) under the Comprehensive Nuclear-Test-Ban Treaty (hereinafter referred to as the **"Treaty"**);

WHEREAS, the Russian Federation signed the Treaty on 24 September 1996 and ratified it on 30 June 2000;

WHEREAS, the Russian Federation signed the Facility Agreement on Conduct of Activities relating to Facilities of the IMS provided by the Treaty (hereinafter referred to as the **"Facility Agreement"**) on 22 March 2005 and ratified it on 27 December 2006;

Whereas, Joint Executive Order No. 3913/19n dated 24 March 2014 of the Ministry of Foreign Affairs and the Ministry of Finance of the Russian Federation (Order No. 3913/19n) includes the Commission in the list of the international organizations and their agencies, whose activities on the territory of the Russian Federation shall be free from value added tax;

Whereas, in accordance with Articles 4, 10 and 13 of the Facility Agreement and Federal Law No. 95 FZ of the Russian Federation "About grants (technical assistance)" dated 4 May 1999, the goods and the services supplied under contracts with the Commission shall be exempt from taxes or similar duties levied by the Russian Federation and are bestowed as a part of the technical assistance provided by the Commission for the ownership of the Russian Federation under the Treaty;

Whereas, on behalf of the Russian Federation, the Ministry of Defense of the Russian Federation is the beneficiary of the technical assistance;

Whereas, the Ministry of Defense of the Russian Federation is assigned to operate the stations of the IMS in the Russian Federation under a contract for post-certification activities with respect to the IMS stations located in the territory of the Russian Federation (Contract No. 2006-1251) concluded with the Commission;

Whereas, the Commission has selected a contractor to provide design, perform upgrade of infrastructure and provide support services for IMS Primary Seismic Station PS34, Norilsk, the Russian Federation, and the Ministry of Defense has agreed to provide an access to the station to the Contractor;

WHEREAS, the Contractor represents that it is ready, willing and able to provide such goods and services.

NOW, THEREFORE, the Parties mutually agree as follows:

1. DEFINITIONS

In this Contract, words and expressions shall have the same meanings as respectively assigned to them in the General Conditions of Contract and the Terms of Reference. In addition, the following words and expressions shall have the meanings hereby assigned to them:

"Annex A" means the Commission's General Conditions of Contract.

"Annex B" means the Commission's Terms of Reference.

"Annex C" means the Contractor's Proposal.

"Contract" means this document, its Annexes and any further modifications or such further documents as may be expressly incorporated in this Contract by the Parties in accordance with Clause 20 below.

"Contractor" means the legal entity named in the preamble of this Contract or its successors. The Contractor shall be the only interface for all matters pertaining to execution of the work under this Contract.

"Party(ies)" means the Commission and/or the Contractor, as the context requires.

"**Rule(s)"** means any regulation(s), official directive(s), ordinance(s), guideline(s), customs and practices.

"Taxes" means all direct and indirect taxes (including value added tax, general sales tax or goods and services tax), assessments, fees, customs duties, liens and charges in as much as they are levied in conclusion or implementation of the Contract, including customs restrictions and charges of similar nature in respect of articles imported or exported for the Commission's official use.

"Work" means the goods and services to be provided by the Contractor for the performance of the Tasks(s), including as the case may be, but not limited to, the design, drawings, technical specifications, site preparation and construction, supply and installation of the Contractor's Equipment, its spare parts and supplies, installation of the Commission's Equipment, provision of the installation support to the Commission and the Commission's Equipment Suppliers and any other goods, and the services to be provided by the Contractor or its subcontractors, as applicable for each Task, in order to fulfil the Contractor's obligations in accordance with this Contract, and the remedying of any defects therein

2. AIM OF THE CONTRACT

The aim of this Contract is for the design, upgrade of infrastructure and support services for the IMS Primary Seismic Station PS34, Norilsk, Russian Federation (hereinafter referred to as the "Work") for the Commission.

3. ENTRY INTO FORCE AND DURATION OF THE CONTRACT

This Contract shall enter into force upon the date of the last signature by the authorized representatives of the Parties (hereinafter referred to as the "Effective Date") and it shall remain in force until the Parties fulfill all their obligations hereunder.

4. COMMENCEMENT AND COMPLETION OF THE WORK

The Contractor shall commence the Work on the Effective Date. The Work shall be completed not later than _____.

5. STANDARD OF WORK

The Contractor shall furnish the highest skill and judgement and cooperate with the Commission, including all the Commission's consultants and agents, in best furthering the interests of the Commission and the aim of this Contract. The Contractor shall provide efficient business administration and supervision and perform the Work in the best way and in the most expeditious and economical manner consistent with the requirements set forth in this Contract.

6. RESPONSIBILITIES OF THE CONTRACTOR

(a) The Contractor shall perform and complete the Work in compliance with Annexes B and C.

(b) The Contractor shall provide qualified English-speaking personnel as necessary to perform the Work under this Contract. The key personnel shall be available for possible tasks related to the Work throughout the duration of the Contract period. Any replacement of the key personnel shall be made in accordance with Clause 7 of Annex A.

7. WARRANTY

The provisions of Clause 28 of Annex A shall apply to the Work performed by the Contractor.

8. PERMITS, NOTICES, LAWS AND ORDINANCES

(a) The Contractor shall obtain and pay for all permits and inspections necessary for the proper execution and completion of the Work that are customarily obtained upon execution of this Contract and that are legally required at the time the Proposal is received by the Commission.

(b) The Contractor shall give all notices required by the nature of the Work.

(c) If the Contractor notices that the Work or any part thereof required under this Contract is not in accordance with applicable laws and Rules, or with technical or safety standards, it shall promptly notify the Commission thereof in writing.

9. PROTECTION OF PERSONS AND PROPERTY

(a) The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions and programmes in connection with the Work.

(b) The Contractor shall take all reasonable precautions for the safety of, and shall provide all reasonable protection to prevent damage, injury and loss to:

(i) all employees on the Commission's premises and all other persons who may be affected thereby;

(ii) all the Work, Equipment, its spare parts, materials and supplies to be incorporated therein, whether in storage on or off the Commission's premises, which are under the care, custody or control of the Contractor or any of its subcontractors; and

(iii) other property on the Commission's premises or adjacent thereto.

(c) The Contractor shall give all notices and comply with all applicable laws and Rules bearing on the safety of persons and property and/or their protection from damage, injury and loss.

(d) The Contractor shall erect and maintain, as required by existing conditions and progress of the Work, all reasonable safeguards for the safety and protection of persons and property, including posting danger signs and other warnings against hazards and promulgating safety regulations.

(e) When the use or storage of combustible, explosive or other hazardous materials is necessary for the execution of the Work, the Contractor shall exercise the utmost care and shall carry on such activities under the supervision of properly qualified personnel.

(f) The Contractor shall be responsible for the prevention of accidents on the Commission's premises during the execution of the Work.

(g) In any emergency affecting the safety of persons or property, the Contractor shall promptly act to prevent threatened damage, injury and loss.

(h) The Contractor shall promptly remedy all damage and loss to any property, referred to in sub-Clause (b) above, caused in whole or in part by the Contractor, any subcontractor, or anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable and for which the Contractor is responsible under sub-Clause (b) above, except damage and loss attributable to the acts or omissions of the Commission or anyone directly or indirectly employed by it, or of anyone for whose acts the Commission may be liable, and not attributable to the fault or negligence of the Contractor. The foregoing obligations of the Contractor are in addition to its obligations under Clause 9 of Annex A.

10. RESPONSIBILITIES OF THE COMMISSION

The Commission shall designate members of its staff to act as points of contact for the Contractor to ensure that the Work are carried out in accordance with Annexes B and C, and shall promptly notify the Contractor thereof. The Commission shall respond promptly to requests for information by the Contractor regarding the Work.

11. CONTRACT PRICE

(a) The Commission shall pay to the Contractor, in consideration of the full and proper performance of its obligations under the Contract, a firm fixed price of _____ and if applicable, the amount agreed by the Parties for any optional work if ordered by the Commission in accordance with Section 6 of Annex B (hereinafter altogether referred to as the **"Contract Price"**).

(b) The Contract Price shall cover all costs and expenses, excluding Taxes, incurred by the Contractor for the full and proper performance of all obligations under the Contract (including travel, allowances, management and remuneration of the personnel, national income tax, medical insurance, and social security contributions). It also includes work performed by the Contractor's personnel outside the Commission's normal working hours.

(c) The Contract Price shall be firm and fixed and shall not be subject to escalation. The Contractor shall not do any work, provide any materials or equipment, or perform any services which may result in any charges to the Commission over and above the Contract Price without the prior written consent of the Commission and a formal written amendment to this Contract.

(d) No Taxes are applicable under this Contract.

12. PAYMENT

(a) The Contract Price shall be paid in accordance with the following payment schedule and subject to the below conditions. If applicable, payment of any optional work, as referred to in Section 6 of Annex B, shall be made in accordance with the relevant amendment or purchase order for such optional work.

(i) Upon acceptance by the Commission of Conceptual Design Report/Revised Report, as referred to in Section 7.1 of Annex B, the Commission shall pay the Contractor the amount of _____;

(ii) Upon acceptance by the Commission of the Final Design Report/Revised Report, as referred to in Section 7.2 of Annex B, the Commission shall pay the Contractor the amount of _____;

(iii) Upon acceptance by the Commission of the Site Preparation Report Report/Revised Report, as referred to in Section 7.3 of Annex B, the Commission shall pay the Contractor the amount of _____;

(iv) Upon acceptance by the Commission of Final Report/Revised Final Report, as referred to in Section 7.4 of Annex B, the Commission shall pay the Contractor the amount of _____.

(b) The Commission shall make the payments to the Contractor on the basis of an invoice submitted by the Contractor as per sub-Clause 12 (d) below. All payments shall be made within 30 (thirty) days of the receipt and acceptance of the invoice, provided that the Work has been satisfactorily completed and has been accepted by the Commission.

(c) The making of any payment hereunder by the Commission shall not be construed as an unconditional acceptance by the Commission of the Work accomplished by the Contractor up to the time of such payment.

(d) The Contractor shall submit an invoice in 1 (one) original and 2 (two) copies or electronically, from the Contractor's official e-mail address in PDF format, duly signed and sealed by the Contractor and submitted to the Commission's email address specified in Clause 21 below. Each invoice shall contain the Contract number (CTBTO and SAP numbers), detailed banking instructions, including the name and address of the Contractor's bank, account number, account holder's name and SWIFT, IBAN and/or ABA codes for payment by electronic transfer. All bank charges and fees of the Contractor's bank, including its correspondent banks, shall be borne by the Contractor.

13. TEMPORARY SUSPENSION OF WORK

The Commission may, at any time, temporarily suspend the Work, in whole or in part, being performed by the Contractor under this Contract by giving 30 (thirty) days' advance notice in writing to the Contractor. The Work so suspended shall be resumed by the Contractor on the basis of a revised time schedule and on terms and conditions to be mutually agreed upon between the Parties.

14. DELAYS AND EXTENSION OF TIME

(a) If the Contractor is delayed at any time in the progress of the Work by any act or omission of the Commission or by any of its employees, or by any other contractor employed by the Commission, or by changes in the Work ordered by the Commission, or by any causes beyond the Contractor's reasonable control, or by any other cause which the Commission determines may justify the delay, then the time for completion of the Work shall be extended by an amendment to this Contract in accordance with Clause 20 below for such reasonable time as the Commission may determine.

(b) Any request for extension of the time for reasons referred to in sub-Clause 14 (a) above shall be submitted to the Commission not later than 20 (twenty) days after the commencement of the delay, otherwise said request shall be deemed to be waived. Such request shall state grounds for the delay and shall provide an estimate of the probable effect of such delay on the progress of the Work.

15. CONTRACTOR'S CLAIMS AND REMEDIES

In no event shall the Contractor make any claim against the Commission for or be entitled to additional costs or compensation resulting from any delays in the progress or completion of the Work or any portion thereof, whether caused by the acts or omissions of the Commission, including, but not limited to, damages related to overheads, loss of productivity, acceleration due to delay and inefficiency. The Contractor's sole remedy in such event shall be an extension of time for completion of the Work, provided the Contractor otherwise meets the requirements and conditions set forth in this Contract.

16. ENTIRE AGREEMENT

This Contract represents the final agreement in respect of the Work and shall supersede all prior agreements and representations between the Parties in this respect. Annexes A to C shall constitute integral parts of this Contract and shall be of full force and effect.

17. DISCREPANCIES

If there are discrepancies or conflicts between any of the documents that are part of this Contract, the document to prevail shall be given precedence in the following order:

(i) This document;
(ii) The Commission's General Conditions of Contract (Annex A);
(iii) The Commission's Terms of Reference (Annex B);
(iv) The Contractor's Proposal (Annex C).

18. SEVERABILITY

If any term and/or provision of this Contract is or becomes invalid, illegal or unenforceable, the validity, legality and enforceability of the remaining provisions of this Contract shall not in any way be affected or impaired thereby.

19. NO WAIVER

Failure by a Party to enforce a right shall not be deemed to be a waiver of that right unless otherwise expressly provided in this Contract.

20. CONTRACT AMENDMENT

No modification of, or change in, this Contract, or waiver of any of its provisions, or additional contractual relationship with the Contractor shall be valid unless approved in the form of a written amendment to this Contract, signed by duly authorized Representatives of the Parties.

21. TRANSMISSION OF NOTICES AND OTHER DOCUMENTS

Notices, invoices, reports and other documentation under the Contract shall be delivered or sent to the relevant Party as follows (or to such person/title, address or email address as the Party may substitute by notice after the date of the Contract):

(a) The Commission:

For Contractual Issues:

Chief, Procurement Section
CTBTO, Vienna International Centre
Wagramerstrasse 5, P.O. Box 1200
1400 Vienna, Austria
Tel: + (43 1) 26030 6350
E-mail: procurement@ctbto.org

For Payments:

Invoices shall be submitted to:
E-mail: Payable_Invoices@ctbto.org

Inquiries related to invoices shall be sent to:
Accounts Payable
CTBTO Financial Services Section
Vienna International Centre
Wagramer Strasse 5, P.O. Box 1200
1400 Vienna, Austria
E-mail: Payments@ctbto.org

(b) The Contractor:

_____
_____
_____

22. EFFECTIVENESS

(a) Except as provided below, any communication in connection with the Contract will be deemed to be given as follows:

(i) if delivered in person, at the time of delivery;
(ii) if by registered mail or courier, when received;
(iii) if by electronic communication, when retrievable by the Commission in document form.

(b) A communication given under sub-Clause 22 (a) above that is received or becomes retrievable on a non-working day or after business hours at the seat of the Commission will only be deemed to be given on the next working day of the Commission.

IN WITNESS hereof, the duly authorized Representatives of the Parties have executed this Contract:

For and on behalf of the **PREPARATORY COMMISSION FOR THE COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION:**

_____

[Name and position]

Date: _____ Place: Vienna, Austria

For and on behalf of **[CONTRACTOR]:**

_____

[Name and position]

Date: _____ Place: _____

LIST OF ANNEXES

ANNEX A: THE COMMISSION'S GENERAL CONDITIONS OF CONTRACT

ANNEX B: THE COMMISSION'S TERMS OF REFERENCE

ANNEX C: THE CONTRACTOR'S PROPOSAL

ANNEX A

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

General Conditions of Contract

1. DEFINITIONS

(a) In these general conditions of contract the terms beginning with a capital letter shall have the meaning as defined in the Contract.
(b) "Services" means all services to be rendered under the Contract.
(c) "Goods" shall mean all goods, equipment, materials and/or other supplies to be provided under the Contract.
(d) "Taxes" shall mean all direct and indirect taxes (including value added tax, general sales tax or goods and services tax), assessments, fees, customs duties, liens and charges in as much as they are levied in conclusion or implementation of the Contract, including customs restrictions and charges of similar nature in respect of articles imported or exported for the Commission's official use.

2. LEGAL STATUS

The Contractor shall be considered as having the legal status of an independent contractor vis-à-vis the Commission. Neither the Contractor and any subcontractor, nor their personnel shall be considered to be an employee or an agent of the Commission.

3. ASSIGNMENT

The Contractor shall not assign, transfer, pledge or make other disposition of the Contract or any part thereof, or any of the Contractor's rights, claims or obligations under the Contract except with the prior written consent of the Commission.

4. SUBCONTRACTING

In the event the Contractor requires the services of one or more subcontractors, the Contractor shall obtain the prior written approval and clearance of the Commission for such subcontractor(s). The Commission's approval of a subcontractor shall not relieve the Contractor of any of his obligations under the Contract, and the terms of any subcontract shall be subject to and in conformity with the provisions of the Contract.

5. SOURCE OF INSTRUCTIONS

(a) The Contractor shall neither seek nor accept instructions from any authority external to the Commission in connection with the performance of its obligations under the Contract. The Contractor shall refrain from any action which may adversely affect the Commission and shall fulfil its commitments with the fullest regard to the interests of the Commission.
(b) While present at the Commission's premises, personnel of the Contractor shall, at all times, obey and conform to all requests and instructions of the Commission's officials and the United Nations Security Staff.

6. CONTRACTOR'S RESPONSIBILITY FOR EMPLOYEES

The Contractor shall be responsible for the professional and technical competence of its employees and will select, for the performance under the Contract, reliable individuals who will perform effectively in the implementation of the Contract, respect the local laws and customs and conform to a high standard of moral and ethical conduct.

7. ASSIGNMENT OF PERSONNEL

(a) The Contractor shall not replace or withdraw any personnel referred to in the Contract for the performance of the Services without the prior written approval of the Commission or unless requested by the Commission.
(b) Prior to assignment, replacement or withdrawal of personnel for the performance of the Services, the Contractor shall submit to the Commission for its consideration, the curriculum vitae or detailed justification to permit evaluation by the Commission of the impact which such assignment, replacement or withdrawal would have on the Services.
(c) In the event of withdrawal of personnel, all costs and additional expenses resulting from the replacement, for whatever reasons, of any of the Contractor's personnel shall be for the account of the Contractor. Such withdrawal shall not be considered as termination in part or in whole of the Contract.

8. CONFLICT OF INTEREST

No employee, officer, adviser, agent and/or subcontractor of the Contractor assigned to perform Services under the Contract shall engage, directly or indirectly, in any business, profession or occupation connected or related to the Services or Goods to be provided under the Contract if this constitutes a conflict of interest.

9. INSURANCES

(a) The Contractor shall provide and thereafter maintain appropriate insurance, or its equivalent, with respect to its employees to cover claims for personal injury or death in connection with the Contract.
(b) The Contractor shall provide and thereafter maintain insurance against all risk in respect of its property and any equipment used for the execution of the Contract.
(c) The Contractor shall also provide and thereafter maintain liability insurance in an adequate amount to cover third party claims for death, bodily injury, loss of and damage to property arising from any operations carried out by the Contractor in performing its obligations in connection with the Contract or from operation of any vehicles, boats, airplanes and other equipment owned or leased by the Contractor or its agents, servants, employees or subcontractors.
(d) Except for insurance mentioned in paragraph (a), the insurance policies under this clause shall:
  (i) Name the Commission as additional beneficiary;
  (ii) Include a waiver of subrogation of the Contractor's rights to the insurance carrier against the Commission.
(e) The Contractor shall, upon request, provide the Commission with satisfactory evidence of the insurance required under the Contract.
(f) Any amounts not insured, not recovered from or not claimed by the insurer shall be borne by the Contractor.
(g) Information concerning reduction of coverage shall be furnished by the Contractor to the Commission with at least thirty (30) days prior written notice.
(h) The Contractor undertakes that provisions to the same effect as the provisions in sub-clauses (a) through (c) above will be inserted in all subcontracts made in performance of the Contract, except sub-contracts exclusively for furnishing Goods.

10. ENCUMBRANCES/LIENS

The Contractor shall not cause or permit any lien, attachment or other encumbrance by any person to be placed on file in any public office or on file with the Commission against any monies due or to become due for any Services or Goods provided under the Contract, or by reason of any other claim or demand against the Contractor.

11. OBSERVANCE OF THE LAW

(a) The Contractor shall comply with all laws, ordinances, rules and regulations, including but not limited to health, environmental and labour laws bearing upon the performance of its obligations under the terms of the Contract.
(b) In particular, the Contractor shall comply with the labour laws of the country in which the Services or Goods are to be furnished providing for benefits covering injury or death in the course of employment.

12. CONFIDENTIALITY

(a) All technical, financial or other documentation and data the Contractor compiled for or received from the Commission under the Contract shall be treated as confidential and shall be delivered only to the Commission's authorized officials on completion of the Services or as requested by the Commission.
(b) Either Party acknowledges that all knowledge and information concerning the other Party that may be acquired in connection with the performance of its obligations under the Contract, including but not limited to, any information relating to its operations and procedures, are confidential and proprietary information of the other Party and it shall receive such confidential and proprietary information of the other Party in confidence and shall not disclose or permit disclosure of any such knowledge or information to any person and/or entity without the prior written consent of the other Party.
(c) The Contractor shall not, at any time, use such confidential information to its own advantage.
(d) The restrictions on confidentiality shall not apply to the information which:
  (i) presently is in the public domain;
  (ii) hereafter becomes part of the public domain without the other Party's fault;
  (iii) was in the possession of the other Party at the time of the disclosure, as shown by written evidence;
  (iv) is disclosed to the other Party at any time hereafter by a third Party.
  (v) is required to be disclosed to governing bodies, or to governmental authorities to the extent required by law or to obtain needed authorization to perform the Contract or pursuant to reporting requirements imposed by those governing bodies or the government of the State of the Contractor.
(e) These obligations do not lapse upon satisfactory completion of the Services, delivery of the Goods or termination of the Contract by the Commission.

13. LANGUAGES, WEIGHTS AND MEASURES

Unless otherwise specified in the Contract, the English language shall be used by the Contractor in all written communications to the Commission with respect to the Services or Goods to be provided and all documents procured or prepared by the Contractor. The Contractor shall use metric units, except when otherwise specified in the Contract.

14. PUBLICITY

(a) The Contractor shall not advertise or otherwise make public the fact that it is providing or has provided Services and Goods for the Commission. Also, the

Contractor shall not, in any manner whatsoever, use the name, emblem or official seal of the Commission or any abbreviation of the name of the Comprehensive Nuclear-Test-Ban Treaty Organization in connection with its business or otherwise.

(b) These obligations do not lapse upon satisfactory completion of the Services, delivery of the Goods or termination of the Contract.

15. OFFICIALS NOT TO BENEFIT/CONTINGENT FEES

(a) The Contractor warrants that:
   (i) No person or selling agency has been employed or retained by it to solicit or secure the Contract upon an agreement or understanding for a commission, percentage, brokerage, contingent fee or retainer, except regular employees or bona fide and officially established commercial or selling agencies maintained by the Contractor for the purpose of securing business;
   (ii) No official or servant or retired employee of the Commission who is not a regular employee of the Contractor, has been or shall be admitted by the Contractor to any direct or indirect benefit arising from the Contract or the award thereof.

(b) In case of breach by the Contractor of the warranties referred to in previous clauses, the Commission shall have the right to deduct from the Contract Price, or otherwise recover from the Contractor, the full amount of any such commission, percentage, brokerage, contingent fee or retainer so paid.

16. INTELLECTUAL PROPERTY AND OTHER PROPRIETARY RIGHTS

(a) Except to the extent the Contractor has granted a license to the Commission, the Commission, shall be entitled to all intellectual property, including but not limited to copyrights, patents and trademarks, with regard to products, documents or other materials which bear a direct relation to or are produced or collected under the Contract. The Contractor shall take all necessary steps, prepare and process all necessary documents and assist in securing such property rights and transferring them to the Commission and/or to the government where the Services or Goods are to be provided, in compliance with the requirements of the applicable law.

(b) The Contractor declares that it does not know of any intellectual property rights of third parties, which might be infringed in the execution of the Contract. Should, contrary to the Contractor's expectation, claims be raised against the Commission charging it with infringement of intellectual property rights, the Contractor shall hold harmless the Commission and shall indemnify it to the full extent of any damages or awards arising from such claims. This obligation of the Contractor shall continue to be in full force and effect up to the expiration of such intellectual property rights.

(c) The Commission shall give the Contractor due notice in writing of any charges of infringement brought against the Commission and of the filing of any suit for infringement of intellectual property rights of third parties due to the execution of the Contract, and, without prejudice to the immunity enjoyed by the Commission as an international organization from every form of legal process, including enforcement and execution, the Commission shall give the Contractor the opportunity to defend the Commission against the said suit at its discretion and shall not, without the Contractor's consent in writing, make any admission or consent to any claim of any third party, which might be prejudicial to the Contractor's position.

17. DEFAULT BY THE CONTRACTOR

(a) In case the Contractor fails to fulfil its obligations and responsibilities under the Contract and provided the Contractor has not remedied such failure(s) within thirty (30) days of having been given written notification by the Commission of the nature of the failure(s), the Commission may, at its entire discretion and without prejudice to its right to withhold payment(s), hold the Contractor in default under the Contract.

(b) When the Contractor is thus in default, the Commission may, by giving written notice to the Contractor, terminate the Contract as a whole or such part or parts thereof in respect of which the Contractor is in default. Upon such notice, the Commission shall have the right to seek completion, at the Contractor's expense, of that part or those parts of the Contract with respect to which the Contractor is in default.

(c) The Contractor shall, in this case, be solely responsible for any reasonable costs of completion of the Services and/or delivery of Goods, including such costs, which are incurred by the Commission over and above the originally agreed Contract Price.

18. WITHHOLDING OF PAYMENT

(a) The Commission may withhold any payment to the Contractor or, on account of subsequently discovered evidence, nullify the whole or part of any payment approval theretofore given, to such an extent as may be necessary to protect the Commission from loss under the Contract on account of:
   (i) The Contractor's failure to carry out its obligations or to make adequate progress with the obligations, except for failure arising out of force majeure;
   (ii) The Contractor's failure to remedy unsatisfactory performance, when such failure has been drawn to his attention by the Commission;
   (iii) The Contractor's failure to submit on time the reports required.

(b) The withholding by the Commission of any interim payment shall not affect the Contractor's obligation to continue performance of his obligations under the Contract.

(c) No interest shall accrue on payments eventually withheld by the Commission in application of the stipulations of this paragraph.

19. LIQUIDATED DAMAGES

Subject to Clause 20 below (force majeure), if the Contractor fails to deliver any or all of the Services and/or Goods within the latest time period(s) specified in the Contract, the Commission may, without prejudice to its other remedies under the Contract, deduct from the Contract Price as liquidated damages, a sum equivalent to 0.2 per cent of the portion of the Contract Price for the delayed Services and/or Goods for each working day of delay until actual performance, up to a maximum of sixty (60) working days. The recovery by the Commission of proven damages shall not be excluded.

20. FORCE MAJEURE

(a) Force majeure as used herein shall mean acts of God, industrial disturbances, acts of the public enemy, civil disturbances, explosions and any other similar cause of equivalent force not caused by nor within the control of either party and which neither party is able to overcome.

(b) As soon as possible after the occurrence of any cause constituting force majeure, the Contractor shall give notice and full particulars in writing to the Commission of such force majeure if the Contractor is thereby rendered unable, wholly or in part, to perform its obligations and meet its responsibilities under the Contract.

(c) In this event, the following provisions shall apply:

(i) The obligations and responsibilities of the Contractor under the Contract shall be suspended to the extent of its inability to perform them and for as long as such inability continues;

(ii) The term of the Contract shall be extended for a period equal to the period of suspension taking, however, into account any special conditions which may cause the time for completion of the obligations to be different from the period of suspension;

(iii) If the Contractor is rendered permanently unable, wholly or in part, by reason of force majeure to perform its obligations and meet its responsibilities under the Contract, the Commission shall have the right to terminate the Contract on the same terms and conditions as are provided for in the Termination Clause of the Contract, except that the period of notice may be seven (7) days instead of thirty (30) days;

iv) For the purpose of the preceding sub-clause, the Commission may consider the Contractor permanently unable to perform in case of any period of suspension in excess of ninety (90) days. Any such period of ninety (90) days or less shall be deemed temporary inability to perform.

21. INSOLVENCY AND BANKRUPTCY

Should the Contractor be insolvent, adjudged bankrupt, or should the Contractor make a general assignment for the benefit of its creditors, or should a receiver be appointed on account of the Contractor's insolvency, the Commission may, without prejudice to any other right or remedy it may have under the terms of the Contract, terminate the Contract forthwith by giving the Contractor written notice of such termination.

22. INDEMNIFICATION

The Contractor shall indemnify, hold and save harmless and defend at its own expense the Commission, its officers, agents, servants and employees from and against all suits, claims, demands and liability of any nature or kind, including cost and expenses arising out of acts or omissions of the Contractor or its employees or subcontractors in the performance of the Contract. This requirement shall extend, inter alia, to claims or liabilities in the nature of workers' compensation and to claims or liabilities pertaining to intellectual property rights. The obligations under this clause do not lapse upon termination of the Contract.

23. AMICABLE SETTLEMENT

The parties shall use their best efforts to settle amicably through negotiation any dispute, controversy or claim arising out of, or relating to, the Contract or the breach, termination or invalidity thereof. If the parties cannot reach such amicable settlement through negotiations, the matter shall first be referred to conciliation, by a request by either party for conciliation procedures. The conciliation shall take place in accordance with the United Nations Commission on International Trade Law (UNCITRAL) Conciliation Rules then prevailing, or according to such other procedure as may be agreed between the parties, within a time period of ninety (90) days. There shall be one conciliator. The conciliation shall be in Vienna, Austria, and it shall be conducted in the English language.

24. ARBITRATION

(a) In the event of a failure to reach an amicable settlement in accordance with Clause 23 above (Amicable Settlement), any dispute arising out of the interpretation or application of the terms of the Contract or any breach thereof shall be settled in accordance with the arbitration rules established by UNCITRAL as at present in force. The number of arbitrators shall be one. The arbitration shall be in Vienna, Austria, and it shall be conducted in the English language.

(b) The arbitrator shall take into account the internationally recognized general principles of commercial transactions. The arbitrator shall have no authority to award punitive damages, nor to award interest in excess of five (5) per cent, and any such interest shall be simple interest only. The parties shall be bound by any arbitration award rendered as a result of such arbitration as the final adjudication of any such dispute.

25. PRIVILEGES AND IMMUNITIES

Nothing in or relating to the Contract shall be deemed a waiver, express or implied, of any of the privileges and immunities of the Commission and its employees.

25(a). TAX EXEMPTION

In principle, the Commission is exempt from all Taxes. Since the arrangement under which such exemption is respected varies from country-to-country, the Contractor shall collaborate with the Commission to achieve Tax exemption at source or to pursue reimbursement of Taxes paid by the Commission, as the case may be.

26. TERMINATION

The Commission may terminate the Contract in whole or in part, and at any time, upon thirty (30) days' notice of termination to the Contractor. In the event such termination is not caused by the Contractor's negligence or fault, the Commission shall be liable to the Contractor for payment in respect of Services already satisfactory accomplished or Goods delivered and accepted and in conformity with the terms of the Contract, for necessary terminal expenses of the Contractor, and for the cost of such urgent work as is essential and as the Contractor is asked by the Commission to complete. The Contractor shall keep expenses at a minimum and shall not undertake any forward commitment from the date of receipt of the Commission's notice of termination.

27. GOODS

In the event that the Contract requires the Contractor to supply Goods, Clauses 28-35 shall apply in addition to the above.

28. WARRANTY

(a) The Contractor warrants that the Goods, including packaging, conform to the specifications for the Goods ordered under the Contract and are fit for the purpose for which such Goods are ordinarily used and for purposes expressly made known to the Contractor by the Commission, and are new and free from defects in design, workmanship and materials.
(b) This warranty shall remain valid for twenty-four (24) months after the Goods or any part thereof have been delivered and accepted, whichever is later, unless the Contractor has granted a longer period. Should the Commission transfer the title of the Goods to a third party during the warranty period, the right to enjoy the warranty shall be transferable to the new title-holder.
(c) If, during the warranty period mentioned in sub-clause (b) above, the Goods or any part thereof are found to be defective or not in conformity with the specifications under the Contract, the Contractor shall, upon notification, promptly and at its own expense correct all such defects and non-conformities. If these defects and non-conformities cannot be corrected, the Commission shall have the right, at the Contractor's expense, to either demand replacement of the defective item, or receive appropriate reimbursement, or have the defective item repaired or otherwise procured from a third party.

29. INSPECTIONS AND TESTS

(a) The Commission shall have the right to inspect and/or to test the Goods to confirm their conformity to the technical specifications. The technical specifications shall specify what inspections and tests the Commission requires.
(b) The inspections and tests may be conducted on the premises of the Contractor or its subcontractor(s), at a point of delivery designated by the Commission and/or at the Goods' final destination. The Contractor shall give all reasonable facilities and assistance-including drawings and production data-to the Commission at no charge to the Commission.
(c) Should any inspected or tested Goods fail to conform to the technical specifications, the Commission reserves the right to reject them and the Contractor shall either replace the rejected Goods or make all alterations necessary to meet specification requirements free of cost to the Commission.
(d) The Commission's right to inspect, test and, where necessary, reject the Goods after the Goods' arrival at the point of delivery designated by the Commission or at the Commission's offices, shall in no way be limited or waived by reason of the Goods' having previously been inspected, tested and passed by the Commission.
(e) Nothing in this Section on Inspections and Tests shall in any way release the Contractor from any warranty or other obligations under the Contract.
(f) All equipment/material supplied under the Contract may be subject to pre-shipment inspection by a third party to be specified by the Commission. The Contractor is not liable for cost of this inspection.

30. PACKING

The Contractor shall comply or ensure compliance with the following provisions concerning packing:

(a) The Goods shall be packed as is required to prevent their damage or deterioration during transit to their final destination. The packing shall be sufficient to withstand, without limitation, rough handling during transit.
(b) In the case of a cross-border shipment, the Goods shall have appropriate export packing. If necessary, all cases/crates must be wrapped inside with heavy-duty plastic lined paper, should be steel-strapped and must be able to withstand tough handling. Skids for truck handling are imperative if the gross weight is more than 30 kilograms.
(c) The consignment shall be marked and shipped as per address shown on the Purchase Order Form.
(d) Neither partial delivery nor transhipment shall be made unless specifically agreed by the Commission in writing.
(e) Each case/crate/package shall carry a consecutive number, dimensions, volume, and weight (i.e. Case No. X of Y cases, A x B x C cm, E m3, D Kg.) and shall be marked as follows:

EQUIPMENT FOR
THE PREPARATORY COMMISSION FOR THE
COMPREHENSIVE NUCLEAR-TEST-BAN
TREATY ORGANIZATION.
[point of delivery]

PURCHASE NO._____
GROSS WEIGHT _____
NET WEIGHT _____

(f) Markings shall be done with weatherproof materials. All non-containerized Goods shall be shipped below deck.
(g) Each case/crate/carton shall carry (outside) a copy of the packing list describing the contents of the case/crate/carton. Outside Case No. 1 should be attached with invoice covering the actual delivery. The accompanying papers must be made out in the English language.
(h) Prior to delivery, a fax (or a letter by courier service) shall be sent to the consignee, if any, advising of the following:
- purchase order/Contract number;
- waybill number or equivalent reference number of the shipment (if any);
- number of boxes/cartons/crates/etc.;
- estimated time of departure (ETD);
- point of departure and name of freight carrier;
- estimated time of arrival (ETA) to final destination.

(i) The following documents shall be enclosed with the shipment in case of shipping by air:
- airway bill;
- proforma or commercial invoice;
- packing list.

(j) The above documents are indispensable and must reach the consignee, if any, on time to permit customs clearance and in order to avoid demurrage charges.

31. DELIVERY AND TRANSPORTATION

(a) Delivery of the Goods shall be made by the Contractor in accordance with the terms specified in the Contract, and the Goods shall remain at the risk of the Contractor until delivery has been completed.
(b) Transport of the Goods to the port of discharge or such other point in the country of destination and/or forwarding to the consignee, if any, (door-to-door) specified in the Contract shall be arranged and paid for by the Contractor and the cost thereof shall be included in the Contract Price.

32. TAKE-OVER/HAND-OVER

Upon successful completion of delivery or of installation and a testing and evaluation period, as specified in the Contract, responsibility for the Goods will be handed over to the consignee or other designated entity.

33. EXPORT LICENCES

If an export licence or any other governmental authorization is required for the Goods, it shall be the obligation of the Contractor to obtain such licence or governmental authorization. In the event of failure to obtain such licence or authorization within reasonable time, the Commission may declare the Contract null and void.

34. SPARE PARTS

In accordance with the Contract, the Contractor may be required to provide any or all of the following materials and notifications pertaining to spare parts manufactured and/or distributed by the Contractor:

(a) Such spare parts as the Commission may choose to purchase from the Contractor, provided that the Contractor is not relieved of any warranty obligations under the Contract;
(b) In the event of termination of production of the spare after delivery of the Goods:
  (i) advance notification to the Commission of the pending termination, in sufficient time to permit the Commission to place a final order;
  (ii) following such termination, furnishing at no cost to the Commission, the blueprints, drawings and specifications of the spare parts, if and when requested.

35. UNITED NATIONS CONVENTION ON CONTRACTS FOR THE INTERNATIONAL SALE OF GOODS

Questions concerning matters arising under the Contract, but not settled in it, shall be settled in conformity with the United Nations Convention on Contracts for the International Sale of Goods (Vienna, 1980), which shall be applicable to the Contract. The applicable language version of the Convention shall be the version in which the Contract is written.

36. SUSTAINABLE BUSINESS PRACTICES

The Commission requires the Contractor and its personnel to:
(a) support and respect the protection of internationally proclaimed human rights[1] and to observe the highest standards of ethics and integrity throughout its supply chains.
(b) abide by the United Nations Supplier Code of Conduct[2].
(c) to take appropriate steps, whenever possible to perform its obligations in a manner that takes into account economic, environmental and social considerations.
(d) certify that they have not and will not engage in harassment or sexual harassment, proscribed practices or any further practice described in Clauses 37, 38, 39, 40

[1] UN Guiding Principles on Business and Human Rights, available at https://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf.

[2] Available at https://www.un.org/Depts/ptd/about-us/un-supplier-code-conduct.

and 41, during the procurement process and the performance of the Contract.

37. PREVENTION OF HARRASSMENT AND SEXUAL HARRASSMENT

(a) The Commission is committed to providing a professional work environment that upholds the highest standards of equality, respect and dignity for all. In this regard, and without limitation to any other provision contained herein:
   (i) The Contractor shall adhere to zero tolerance for harassment and therefore accepts and agrees to refrain from any conduct which could, in the view of the Commission, meet the definition of harassment and/or sexual harassment. For the avoidance of doubt, "harassment" shall be understood as any improper or unwelcome conduct that might reasonably be expected or be perceived to cause offence or humiliation to another person when such conduct interferes with work, is made a condition of employment, or creates an intimidating, hostile or offensive work environment. "Sexual harassment" shall be understood as harassment of a sexual nature, and the above definition of harassment applies equally to sexual harassment. Sexual harassment may occur between persons of opposite sex or of the same sex.
   (ii) The Contractor shall take all reasonable and appropriate measures to prevent and deter harassment and sexual harassment or abuse of anyone by its employees, agents, officials or any other persons engaged or controlled by the Contractor to perform the Services.
   (iii) The Contractor shall promptly report to the Commission any actual, reported or suspected cases of harassment, sexual harassment or abuse of anyone by its employees, agents, officials or any other persons engaged or controlled by the Contractor to perform the Services of which the Contractor becomes aware. Such reports to the Commission may be on a no name basis, if necessary.
   (iv) In addition to notifying the Commission pursuant to sub-clause (iii) above, on becoming aware of any allegation of harassment, sexual harassment or abuse of anyone, the Contractor shall take all reasonable and appropriate measures to address the matter, including engaging in good faith consultations with the Commission, while ensuring minimum impact and/or disruption of the Services.

(b) The Contractor acknowledges and agrees that any breach of the provisions of this Clause 37, as determined by the Commission, shall permit the Commission, at its sole discretion, to:
   (i) Request the Contractor to remove, temporarily or permanently, from the relevant assignment, any Contractor's personnel reported for having committed harassment, sexual harassment or abuse of anyone.
   (ii) Terminate the Contract, and/or any other agreement, arrangement or partnership concluded by the Commission with the Contractor, immediately upon written notice to the Contractor, without any liability for termination charges or any other liability of any kind, on the terms and conditions as are provided for in Clause 26 (Termination) above; and/or
   (iii) Exclude the Contractor from participating in any ongoing or future solicitations, and/or entering into any future contractual or collaborative relationships with the Commission and/or suspend the Contractor from the Commissions supplier roster.

(c) The Commission shall be entitled to report any breach of the provisions of this Clause 37, as determined by the Commission, to the Commission's governing bodies, other UN agencies and/or donors.

38. PROSCRIBED PRACTICES

The Commission requires that the Contractor and its personnel certify that they have not and will not engage in proscribed practices and proscribed conduct during the procurement process and the performance of the Contract. The Commission defines Proscribed Practices as follows:

Fraudulent practice: is any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation;

Corrupt practice is the offering, giving, receiving, or soliciting, directly or indirectly, anything of value to influence improperly the actions of another party;

Coercive practice is the impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of any party in order to influence the actions of that party;

Collusive practice is the proposing or entering into an arrangement between two or more parties designed to achieve an improper purpose, including influencing improperly the actions of another party**;**

Unethical practice is conduct or behaviour that is contrary to the conflict of interest, gifts and hospitality, post-employment provisions or other published requirements of doing business with the Commission;

Obstructive practice is any act which deliberately and in an effort to compromise an investigation, destroys, falsifies, alters or conceals information or documents that may be relevant to a fraud and corruption investigation, or material that could become evidence as a result of such investigation; or the making of false statements to investigators during such an investigation.

39. CHILD LABOUR

The Contractor represents and warrants that neither it, its parent entities (if any), nor any of the Contractor's subsidiary or affiliated entities (if any) is engaged in any practice inconsistent with the rights set forth in the Convention on the Rights of the Child, including Article 32 thereof, which, inter alia, requires that a child shall be

protected from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development.

40. MINES

The Contractor represents and warrants that neither it, its parent entities (if any), nor any of the Contractor's subsidiaries or affiliated entities (if any) is engaged in the sale or manufacture of anti-personnel mines or components utilized in the manufacture of anti-personnel mines.

41. TERRORISM

The Contractor shall ensure that none of the funds received from the Commission under the Contract are used, directly or indirectly, to provide support to individuals or entities subject to sanctions or other measures promulgated by the United Nations Security Council and appearing in the Consolidated United Nations Security Council Sanctions List. This provision shall be included in all subcontracts or sub-agreements entered into under the Contract.

42. FULL DISCLOSURE

(a) The Contractor will immediately notify the Commission upon becoming aware of any Proscribed Practices or other prohibited practices or conduct or suspicion thereof, as per Clauses 37-41, by itself or its personnel during the procurement process or the performance of the Contract. The Contractor will take all appropriate measures to prohibit and prevent its personnel from engaging in Proscribed Practices or any other prohibited conduct, as well as to investigate allegations thereof, or to take corrective action when such a Proscribed Practice or any other prohibited conduct has occurred.

(b) The Contractor further warrants that it is not the subject of any sanctions, or otherwise identified as ineligible by any government, supranational organization (e.g., European Union), another entity of the United Nations System or multilateral development finance institution. The Contractor will disclose to the Commission if it becomes subject to any sanction or temporary suspension during the term of the Contract. The Contractor recognizes that a breach of this provision constitutes a fraudulent practice.

43. DATA PROTECTION

(a) **Use of the Commission's data:** Use (including accessing, processing, retention, storage) of the Commission's data is limited to the purposes contained in the Contract and such use will be limited to Contractor's personnel on a "need to know" basis. Use of the Commission's data for internal research, marketing, sales, or promotional purposes is strictly prohibited. Subject to Clause 12 (Confidentiality), the Contractor will treat the Commission's data as confidential and may neither disclose it nor make it available to any third-party except with the prior written authorization of the Commission.

(b) **Compliance:** The Contractor confirms that it has a data protection policy in place that meets applicable legal requirements and that it will apply such a policy to the Commission's data, without prejudice to the privileges and immunities of the Commission. The Contractor will implement technical and organisational measures to ensure appropriate protection of the Commission's data, in conformity with the abovementioned requirements and internationally recognised standards and best practices. In addition, the Contractor will:
   (i) at its sole expense and risk, return, delete, or destroy all the Commission's data, including data backups, upon written instruction of the Commission. The Commission will provide a reasonable period of time and take into account the Contractor's legitimate interests, as well as the termination or expiration date of the Contract;
   (ii) process, retain or store the Commission's data exclusively in countries that are signatories to the Comprehensive Nuclear-Test-Ban Treaty and that ensure adequate legal protection of the Commission's privileges and immunities; and
   (iii) be liable for any resulting damages or penalties for its failure to comply with its obligations.

(c) **Data security:** Upon discovery of a data security breach, the Contractor will immediately notify the Commission and undertake at its sole expense to:
   (i) propose immediate remedial actions (including containment);
   (ii) implement, as directed by the Commission, all necessary damage mitigation and remedial actions;
   (iii) where applicable, as directed by the Commission, restore the Commission's and end-users' access; and
   (iv) keep the Commission informed of its progress.

(d) The Contractor, at its sole expense, will cooperate fully with any Commission investigation, remediation steps and response to a data security breach.

44. ESSENTIAL TERMS

The Contractor acknowledges and agrees that each of the provisions in Clauses 36 to 43 above constitutes an essential term of the Contract and that any breach of any of these provisions shall entitle the Commission to terminate the Contract or any other contract the Contractor has with the Commission, immediately upon notice to the Contractor, without any liability for termination charges or any other liability of any kind. Furthermore, the Commission is entitled to exclude the Contractor from participating in future tenders should the Contractor breach any of the provisions included in Clauses 36 to 43.

ANNEX D

TERMS OF REFERENCE

Design, Upgrade of Infrastructure and Logistic Support for relocation of IMS Primary Seismic Station PS34, Norilsk, Russian Federation

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1. SUMMARY

1.1 GENERAL

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (the "Commission") intends to re-establish the IMS seismic monitoring station PS34 in Norilsk, the Russian Federation (the "Station") in accordance with Annex 1 to the Protocol of the Comprehensive Nuclear-Test-Ban Treaty ("CTBT").

This Station is designated as a facility of the seismic network of the Comprehensive Nuclear-Test-Ban Treaty. The Special Monitoring Service of Ministry of Defence (MoD) of the Russian Federation ("SMS") has provided facility for the Station, which shall host a Central Recording Facility (CRF) of the PS34 station.

Following the Preparatory Commission decision (CTBT/PC-61/2) and site visit, it was decided to establish the 3-component (3C) seismic station using the existing infrastructure of the IMS RN55 station in Kayerkan town. The relocation of the Station will include the installation of a new seismometer, digitizer, communication equipment, power supply, data acquisition equipment, upgrade of the Central Recording Facility (CRF), drilling a borehole and the installation of a borehole enclosure.

1.2 PURPOSE

The Commission would like to engage a supplier (the "Contractor") to provide goods, services and works for the design, site preparation, upgrade of infrastructure, supply and installation of the Contractor's equipment, logistic support and initial testing at the IMS Primary Seismic Station PS34/NRSK, Norilsk, the Russian Federation" (the "Work") in accordance with the present Terms of Reference document (the "ToR"). The ToR defines the technical framework of all related activities of the Work and contains all technical requirements for the activities, which shall be carried out by the Contractor.

The Contractor shall carry out the preparation of design, site preparation and upgrade of infrastructure, supply and install Contractor's equipment (the "Contractor's Equipment") in order to prepare the Station to host the data acquisition equipment (the "Commission's Equipment"). The Commission and the Commission's equipment supplier(s) will provide, install and test the Commission's Equipment at the Station.

The Contractor shall also be required to provide support services to the Commission, the Commission's equipment supplier(s) and to SMS (which is the Station Operator), both during the installation of the Commission's equipment and during the Initial Testing phase of the Station.

The Contractor shall carry out the Work in accordance with the ToR and in the most cost-effective possible manner.

1.3 SMS

SMS has been designated by the Government of the Russian Federation (RF) as the sole national technical counterpart for coordinating activities related to liaison, establishment and upgrade of infrastructure, installation, testing and evaluation, certification and post-certification activities for all IMS

Primary Seismic (PS) and a number of Auxiliary Seismic (AS) stations in Russian Federation, including PS34.

The Commission and SMS have agreed that in this project the role and responsibilities of the SMS shall be to coordinate activities between the Commission and the Contractor, to verify all documentation related to the project, to monitor, review and accept the reports and works for the installation of the Station, as well as to confirm whether the works have been performed in conformity with the national and local rules and regulations.

1.4 GENERAL DESCRIPTION OF THE STATION

The Station PS34 is located in in proximity of Kayerkan town, Norilsk, Krasnoyarsk region, Russian Federation.

The nearest airport is Norilsk, Alykel (IATA: NSK) in about 15 km from the Station's location. The Station coordinates (borehole site) are 69°23'36"N and 87°38'50"E. The Station can be reached from Norilsk at any time of the year by driving an off-road vehicle.

The Station will consist of two parts: a borehole site and a Central Recording Facility (CRF). The Station's CRF will be located inside the building of the IMS radionuclide station RN55 (69°20'42.00"N, 87°48'9.00"E), in the premises of a military base of SMS. The sensor and digitizer will be installed at the borehole site, located 8 km far from the CRF, on a slope of Lysukha mountain, as shown in Figure 1 (see chapter Figures).

The borehole enclosure will be installed above a 35-m deep borehole, which shall be drilled by the Contractor. At the borehole enclosure a rack shall be installed, containing a power supply unit, a back-up battery and a data acquisition unit. The 3-component seismometer shall be installed in the 35-m deep borehole. At the CRF building a rack with data acquisition computers and peripheral equipment, such as Ethernet switch, monitor, etc. shall be installed in a separate room.

Continuous data shall be transmitted by a 2.4 or 5.8 GHz radio link to the CRF. The equipment provided by the Commission shall be installed at the CRF to format and transmit data to the International Data Center (the "IDC") in Vienna through the Russian Federation Independent Subnetwork (RF ISN). The Commission's equipment shall also control various functions connected with authentication, command and control and system calibration.

Local AC mains power will be used to operate the Station's CRF and borehole site. The power supply system will also be connected to an AC generator, as a back-up autonomous power supply system for the CRF.

2. SCOPE OF WORK

The Work includes 6 (six) Work Tasks and the Optional Work in accordance with the requirements of these ToR as follows:

No.	Work Task
1.	Conceptual Design
2.	Final Design
3.	Construction of borehole site
4.	Upgrade of the CRF
5.	Dismantling and re-installation of NRIK equipment at the new PS34 CRF
6.	Logistic Support Services during Installation
	Optional (Miscellaneous) Work

The Work Tasks include the below mentioned activities to be completed by the Contractor and in accordance with the requirements as further described in Section 4 of the ToR:

(a) Fulfilment of all general obligations;

(b) Renovation of a room in the existing building in order to house the Station's CRF;

(c) Drilling and casing of borehole at the Station, in accordance with the Commission's technical requirements;

(d) Installation of a wellhead on the borehole casing pipe;

(e) Installation of a borehole enclosure;

(f) Construction of aerial 6 kV power line between the power connection point and the borehole enclosure;

(g) Provision and installation of 6/0.2 kV transformer at the borehole site;

(h) Provision and installation of the radio communication system at the Station between the CRF and borehole enclosure;

(i) Provision and installation of power supply unit and back-up battery at the borehole's enclosure according to the Commission's design;

(j) Provision and installation of the lightning and surge protection system in accordance to the Attachment A of this ToR;

(k) Provision and installation of an alarm and video surveillance system at the borehole site;

(l) Dismantling of the equipment, listed below, at existing PS34 NRIK station, transportation and installation of this equipment at the new CRF location;

(m) Provision of the support services to the Commission and the Commission's Supplier(s) during the installation period;

(n) Optional work as described in Section 6 below.

3. GENERAL OBLIGATIONS

(a) The Contractor shall obtain licenses, permits or authorizations needed to carry out the Work under this contract.

(b) The Contractor shall ensure that all Work is performed in compliance with any national, municipal or local regulations, laws, building codes, licensing or permitting requirements related to the implementation of the Work Tasks.

(c) The Contractor shall submit plans and reports as specified in Section 7of the ToR.

(d) The Contractor shall provide Station Specific Documentation set, as described in Attachment B to the ToR.

(e) The Contractor shall submit a work schedule for the site preparation and the completion of all works to the Commission. The Commission reserves the right to monitor/inspect field operations at any time by sending the Commission's representatives to the Station.

(f) The Commission and/or the Commission's Equipment supplier(s) will be responsible for the supply and installation of the data acquisition equipment (the Commission's Equipment) at the Station.

4. WORK TASKS

For all Work Tasks, the Contractor shall inform the Commission of the appropriate and current points of contact, including contacts for (1) technical matters, (2) logistics matters, and (3) commercial matters. If these points of contact change during any phase of the Work Tasks, the Contractor shall inform the Commission immediately in written format.

4.1 WORK TASK 1: CONCEPTUAL DESIGN

For this task, the Contractor shall gather all information related to the status of the site, infrastructure, facilities, and other equipment present at the Station, as well as the technical specifications, installation details, and operating requirements for the equipment to be updated and installed at the Station. Much of this information is contained within the TOR. There shall be close technical collaboration between the Contractor and the Commission to ensure that all requirements shall be met at this stage.

Under the Conceptual Design Task the Contractor shall complete the following items:

(a) Gathering of specifications for connections to existing infrastructure networks;

(b) Obtain all necessary information and technical specifications for the construction of medium-voltage line and its connection to the existing line next to the borehole site;

(c) Completing engineering and survey work at the borehole site;

(d) Gathering information of dismantling and removal of specific PS34 NRIK equipment at the current PS34 location and of specifications for later integration of this equipment into the new PS34 CRF infrastructure.

(e) Designing the repair and upgrade of existing facilities at the Station.

Upon completion of Task 1, the Contractor shall submit to the Commission a Conceptual Design Report in accordance with Section 7 below. The Report for Task 1 is subject to the Commission's acceptance in written format.

4.2 WORK TASK 2: FINAL DESIGN

Under Work Task 2 the Contractor shall finalize the design (Final Design) of the Station to be ready for the installation of the Commission's Equipment. This task shall include the preparation of detailed technical descriptions, plans, drawings, layout, and installation diagrams. The Contractor shall collaborate with the Commission and SMS in all activities associated with Work Task 2 to ensure the successful and timely completion of the Work.

The necessary work related to the Final Design of the Station shall allow the successful installation of the Commission's equipment. Additionally, the Final Design shall be feasible, cost-effective, and ensure that the resulting seismic equipment shall meet all the Commission's technical requirements, as outlined in the IMS Operational Manual for seismic monitoring facilities (CTBT/WGB/TL-11,17/15/Rev.7). Specifically, tasks associated with the Final Design shall include:

(a) Designing the equipment configuration for the station in order to satisfy the Commission's technical requirements for data collection and transmission;

(b) Acquisition of the precise coordinates for the borehole (within 10 m, WGS84 datum);

(c) Borehole specifications;

(d) Plans for installation of borehole enclosure, power and communication lines, grounding system and CRF building related to the Primary Seismic station;

(e) Coordinating the collection of specifications related to the Station for official approval;

(f) Completing an appraisal from a state expert, as required;

(g) Receiving approval from the State Architectural-Building Supervision (SABS), as required.

During the preparation of the Final Design for the Station, the Contractor shall take into consideration the following:

(h) Parameters and installation requirements of the equipment provided by the Commission;

(i) Mission capability requirements and minimum standards for the Station, as outlined in the IMS Operational Manual for seismic monitoring facilities;

(j) Assuring a lifetime of ~~at least~~ 25 years for all structures and for the Contractor's equipment, unless other is proven to be the maximum expected lifetime for the local conditions;

(k) Local environmental conditions, as well as standards and specific regulations within the Russian Federation;

(l) Approval and licensing requirements for all structures and equipment provided by the Contractor or the Commission;

(m) Feasibility and cost-effectiveness of implementing the design at the Station, as well as the viability of the design for future operation and maintenance;

(n) Availability and supply of spare parts, fuel, and other consumables;

(o) The Contractor shall submit the Final Design to all relevant authorities, applying any necessary adjustments to the Design. In case adjustments will be required, the Contractor shall submit the Final Design again to the Commission before submitting it to the Russian Federation authorities: once approved, the design shall become the Agreed Final Design. The Contractor shall submit the Agreed Final Design to the Commission immediately after obtaining all approvals.

Upon completion of Work Task 2, the Contractor shall submit to the Commission the Final Design Report

in accordance with Section 7 below. The Report for Task 2 is subject to the Commission's acceptance in written format.

4.3 WORK TASK 3: CONSTRUCTION OF THE BOREHOLE SITE

Under this task, the Contractor shall undertake and complete all activities related to the construction of the borehole site. Specifically, the Contractor shall complete the following:

(a) Drilling and casing of the borehole at the Station, in accordance with the Commission's technical requirements and the agreed-upon Design.

(b) Installation of the borehole enclosure.

(c) Provision and installation of aerial power line between the connection point of 6 kV line and the borehole enclosure.

(d) Provision and installation of the lightning protection and grounding system according to the Attachment A of this ToR and national rules and regulations;

(e) Construction of an access ~~unpaved category V~~ road connecting the existing gravel road and the borehole site.

(f) Provision and installation of double-perimeter security fence around the borehole enclosure.

(g) Provision and installation of video surveillance and alarm system at the borehole site.

The location of the borehole site is shown in the Figure 2.

4.3.1 Instrument Borehole

The Contractor shall drill and case a borehole at the borehole site with coordinates 69°23'36"N and 87°38'50"E. The borehole shall be 35-m deep after casing. The casing pipe internal diameter shall be 156-162 mm. The Commission recommends to use casing pipe of 178 mm nominal diameter with wall thickness 9.2 mm and internal diameter 159.4 mm according to GOST 632-80.

The Contractor shall be responsible for all works associated with the borehole drilling and casing, including the provision of the drilling equipment, materials, installation, cementation, testing and debris removal.

Upon completion of the drilling works, the Contractor shall install (weld) borehole well-head termination provided by the Commission.

The final requirements for the borehole are:

a) Final depth of the cased borehole will be 35 m below ground level.

b) The borehole must be dry, with no water leakage.

c) The space between the borehole walls and casing shall be cemented. The Contractor has the flexibility of selecting a preferred cementation method that will completely bond the casing to the rocks over their entire depth with no voids or shrinkage.

d) The angle of inclination from the vertical will not to exceed 2.5 degrees at any point in the borehole.

e) Steel casing with water-tight joints will be installed for the entire length of the borehole.

f) The top of the casing should be approximately 35 to 50 cm above ground level.

g) Inner diameter of the casing should be between 156 and 162 mm.

h) Casing must be completely round, with no elliptical shape; the inner surface of casing must be smooth with no irregularities such as welds or couplings, which would reduce the inner diameter.

i) A water-tight cement or metal plug shall be built at the bottom of the borehole.

j) The final cased borehole shall allow the insertion of a test gauge, to be provided by the Contractor, of dimensions similar to the equipment to be installed at the borehole: 150 cm in length and 150 mm in diameter.

k) The borehole shall be left dry after the leak test and sealed with a removable cap.

The following acceptance tests are applicable upon completion of the casing:

1. *Verticality Test:* A final verticality test must be performed in the interior of the casing after cementation. Measurements of the deviation from the vertical shall be made at 10 m depth intervals, as well as at the bottom of the borehole.

2. *Leak Test:* The final cased and cemented borehole must be checked against leaks by completely filling the casing with water, capped and pressurized to not less than 5 MPa, sealed off and allowed to stand. After one hour, the water level and pressure shall be recorded. A successful test will observe that no water has been lost and no more than 10% of the water pressure has been lost in the borehole. After the test, the water must be removed, the borehole blown dry and left clear over the total length of the borehole.

3. *Obstruction Test:* A test gauge 150 cm in length and 150 mm in diameter shall pass without obstruction to the bottom of the final borehole and then return to the surface.

4.3.2 Borehole Enclosure

The Contractor shall install a pre-fabricated enclosure at the borehole site to house the digitizer, breakout box, communications system, primary power supply, and backup power supply.

The borehole enclosure is provided by the Commission and stored at the new Station's CRF premises in Kayerkan. The enclosure is shown in Figure 3.

The borehole enclosure shall be installed on a proper foundation according to local construction rules and regulations. The foundation of the enclosure shall be decoupled from the borehole casing in order to avoid introducing seismic noise. The installation of the borehole enclosure on a lifted platform should be avoided in order to exclude wind noise distortion of the seismic signal.

The enclosure shall be equipped by appropriate electrical heating system (heat convectors) in order to maintain positive temperatures inside the enclosure in winter period.

The Contractor shall provide and install a suitable equipment enclosure (rack) at the borehole site to house the digitizer, breakout box, communications system (Ethernet switch and power insertion unit for the radio modem) and power supply with back-up batteries. Cable glands shall be provided in order to connect the following cables to the enclosure:

(a) AC Power cable;

(b) GNSS antenna cable;

(c) Cat 6 cable for radio modem.

The exact diameters of the cables will be provided by the Commission at the Design stage.

4.3.3 Communication equipment

The Contractor shall install radio communication equipment (see Section 5, **Contractor's equipment**, for details) on the top of the borehole enclosure. The radio modem to be installed on a 2-m mast, providing unobstructed view to the new CRF. The external parts of the communication equipment shall be rated for local environmental conditions with the minimum temperatures down to -50°C.

4.3.4 GNSS antenna mount

The Contractor shall provide a mounting fixture for the Global Navigation Satellite System (GNSS) antenna outside the borehole enclosure with a conduit for the running of the antenna cable. The maximum run of the GNSS antenna cable should not exceed 15 m from the antenna position to the equipment enclosure. The antenna shall be mounted outside the vault near the top of the structure with a clear view of the sky. The mount shall be threaded ¾" BSPP pipe.

4.3.5 Power Supply

The Contractor shall make all necessary provisions to ensure power supply at the borehole site.

The Contractor shall connect the borehole site to the connection point of a medium-voltage 6 kV line. The distance from the borehole site to the connection point is 165 m, the location of the connection point is shown in the Figure 4.

The Contractor shall obtain all necessary permits and technical specifications for the new line from the medium-line owner, Oboronenergo. The specifications shall be obtained during the Conceptual Design stage.

The estimated number of poles needed for the power line is 4, including the end-pole and anchor support at the beginning of the line.

The Contractor shall provide and install a single phase 6 / 0.2 kV, at least 5 kW transformer at the borehole site. The transformer shall be installed on the last pole of the new medium voltage line within the fence perimeter of the borehole site.

The anticipated load for the Commission's equipment is less than 30 W. The Contractor shall supply 24 VDC UPS K-307-10V or similar as a power supply, including back-up batteries, at the borehole site for the Commission's equipment. The capacity of back-up batteries shall be 2880-3600 Wh (120-150 Ah at 24 V). ~~The DC UPS shall have an external battery temperature sensor in order to optimize charging mode.~~

The Contractor shall be responsible to carry out all necessary tests for Contractor's supplied power equipment, according to local standards, including but not limited to:

- GOST R 50571.16-2019 and MEK 60364-6:2016 Low-voltage electrical installations, Part 6.4.3, Testing, in the part applicable for low-voltage installations at PS34, such as new cable, automatic switches, personal safety etc.;
- Rules for electrical installations, section 1, chapter 1.8, in the part applicable for low-voltage installations at PS34;
- Rules for electrical installations, section 1, chapter 1.8, paragraph 1.8.38 Batteries, 1.8.39 Grounding devices and 1.8.40 Power cable lines;
- Applicable rules for medium voltage line installation.

4.3.6 Lightning and surge protection

A lightning protection system of Level II according to IEC 62305-1 shall be designed and installed at the borehole site. The input of the AC cable to the borehole site shall be protected by appropriate combined Type 1 and 2 surge protection device. Detailed requirements for the lightning protection system design can be found in the Attachment A of this ToR. The Contractor shall also provide the 6 kV medium voltage side protection of the power line according to the applicable local rules and regulations.

4.3.7 Borehole site fencing

The borehole site must be surrounded with a double-perimeter security fence (2 m high, 10x10 m and 8.5x8.5 m) to prevent unauthorized access. The fence shall be designed and built in a way to withstand local climatic conditions.

4.3.8 Security System

The Contractor shall provide and install a security system transmitting alarm signals from tamper switches and video monitoring data from the borehole site to the CRF. The tamper switches shall be installed at the entry gate and at entrance to borehole enclosure. The system shall use the Contractor's supplied radio communication system, providing the transmission rate do not affect the seismic data transmission in normal and back-up mode.

The Contractor shall provide and install 4 (four) Ethernet video cameras at the borehole site, including cabling and mounting brackets. The cameras must be adopted to the local climatic conditions. The exact place of the installation of the cameras within the borehole site perimeter will be agreed prior to the installation of the Commission's supplied equipment.

A logger (workstation) shall be installed at the CRF to store the recorded information.

The power supply of the security system and cameras shall be independent of the main borehole site power supply and shall be provided by the Contractor.

The external parts of the security system shall be rated for local environmental conditions with the minimum temperatures down to -50°C.

4.3.9 Construction of a road at the borehole site

The Contractor shall construct an access road 4 meters wide, 35-40 centimetres high above the existing earth surface, backfilled with gravel (40-70 mm fraction), ~~unpaved category V road~~ The access road shall connect~~ing~~ the existing gravel road and the borehole site~~. The road shall be filled with crushed stone,~~ The estimated length of the road is 150 meters.

4.4 WORK TASK 4: UPGRADE OF THE CRF

The Contractor shall undertake and complete all activities related to the upgrade of the CRF infrastructure in order to accommodate the PS34 equipment. Specifically, the Contractor shall complete the following:

a) Refurbishment of the CRF premises inside existing building, as specified in these Terms of Reference and the agreed-upon in the Design phase.

b) Provision and installation of communication and power supply equipment described below.

The Contractor shall provide refurnishing of the CRF room inside the existing building, including repair / re-planning of the room, provision of necessary furniture, such as operator's desk, 2 chairs and 1 cabinet. The total area of the room to be renovated is expected to be 9 m^2. The renovation shall include re-painting of the whole area (walls, ceiling and floor) and installation of 1 new door, as well as replacement of electrical installations (sockets, cabling, lights). The room location is shown in Figures 5 and 6.

The room shall be equipped by a grounding bar connected to the common building's ground. The Contractor shall also ensure that the Station's equipment is protected against the power surges according to Lightning Protection System Level II according to IEC 62305-1.

The Contractor shall provide and install radio communication equipment at the CRF, a 5.8 GHz wireless Ethernet switch. The radio shall be installed on the roof of the CRF building next to the compressor's shelter of RN55 station, with a direct line-of-sight to the borehole site. The Contractor shall install inside the shelter a power insetion unit of the radio, surge protection Ethernet device and route a Cat 6 cables from the compressor's shelter to the CRF room. Estimated cable length will not exceed 50 m. The location of the radio equipment is shown in the Figure 7.

The Contractor shall ensure that the CRF is a suitable environment for the Commission's data acquisition computer. Included in this requirement are characteristics of temperature, humidity, power supply, and necessary connections to the independent network.

If feasible and cost-effective, then the Contractor shall use existing facilities at the Station site in order to meet the technical requirements of the Commission, as specified in the IMS Operational Manuals.

4.5 WORK TASK 5. DISMANTLING AND RE-INSTALLATION OF NRIK EQUIPMENT AT THE NEW PS34 CRF

The Contractor shall dismantle, transport to the new CRF location, and install there the following equipment from the current PS34 / NRIK location (69°20'30"N, 87°33'19"E):

- Diesel generator in a container enclosure;
- EATON main UPS unit with batteries;
- Surge protection devices (SPD) integrated into electrical distribution net of the NRIK building;
- 19" equipment rack accommodating the NRIK CRF equipment;

The Work Task 5 shall be performed only upon full completion of the Work Tasks 3 and 4. The NRIK station shall be fully operational until the NRSK station is completed (including the installation of the Commission's provided equipment) and stable data transmission to the RF National Data Centre (NDC) and to IDC is established. The equipment expected to be dismantled and re-installedat the new location is shown in the Figure 8.

4.5.1 Diesel generator in a container enclosure

The NRIK diesel generator shall be disconnected and moved to the new CRF location in Kayerkan. At the new CRF the generator shall be installed and integrated into the power supply system of the new CRF.

4.5.2 EATON UPS

The Contractor shall dismantle, transport to the new CRF location, install and integrate into the new CRF power supply system the main PS34 UPS (EATON 9390-60-U-4X0-MBS) and external battery bank.

4.5.3 19" equipment rack and NRIK data acquisition equipment

The Contractor shall disconnect, dismantle, and move the PS34 CRF data acquisition equipment (workstations, monitors, Ethernet switch) to the new CRF location.

4.6 WORK TASK 6: LOGISTIC SUPPORT SERVICES BEFORE AND DURING INSTALLATION

The Contractor shall complete all preparation and construction works at the site, as described in the ToR, prior to the installation of the Commission's Equipment by the Commission and/or the Commission's equipment supplier(s).

Regarding the Commission's Equipment, the Contractor shall provide the following logistic support services to the Commission before the installation period:

(a) Receipt of the Commission's Equipment at the Norilsk airport;

(b) Transportation of the Commission's Equipment from the airport to the Station (about 15 km);

(c) Arrange an off-loading work and a proper storage of the Commission's Equipment at the site;

(d) Arrange a proper insurance of the Commission's Equipment (valued at US$ 50,000.00) for at least six (6) months until the acceptance of the Final Report by the Commission. It should be noted that the insurance period may be additionally extended for up to six (6) months beyond the original period.

During the installation works, the Contractor shall provide the following support services:

(a) Transportation of the Commission's staff and staff from the Commission's contractors from/to Norilsk to/from the Station.

(b) Hands-on technical, logistical and administrative assistance in all of the activities associated with equipment installation and inspections.

(c) Interpretation between Russian and English during the entire duration of all visits of staff from the Commission and from the Commission's contractors.

(d) Adjustments of infrastructure and systems installed by the Contractor during site preparation and construction for allowing the fitting of the Commission's Equipment and connecting them to the power supply system.

The Contractor shall consider the following details:

- The total number of Commission's visits to the Station shall not exceed two (2);
- The period of one Commission's visit shall not exceed three (3) weeks. It should be noted that the cost of the visits will be borne by the Commission;
- The number of staff from the Commission and the Commission's equipment suppliers will not exceed four (4) persons.

Upon completion of Work Task 6 the Contractor shall submit to the Commission a Final Report/Revised Final Report in accordance with Section 7 below.

5. CONTRACTOR'S EQUIPMENT

The Contractor shall be responsible for supplying any equipment necessary to accomplish the tasks listed in Sections 4 and 5 of this ToR that is not supplied by the Commission, including but not limited to:

(a) Radio communication equipment: point-to-point wireless Ethernet bridge, 2.4 or 5.8 GHz, at least 10 Mbps Ethernet, 24 VDC power supply, 4 units (borehole site, CRF and spares) in total. The bridge must be designed to withstand local climatic conditions with the minimum temperatures of at least -50°C.

(b) Power supply: DC UPS of the type K-307-10V or equivalent, with over- and under voltage protection, short circuit protection, overheating protection. 2 units (borehole site and spare) in total.

(c) Back-up battery: AGM lead-acid battery, 24 V, 2880-3600 Wh;

(d) Data acquisition computers: 2 (two) rack-mount high-performance servers with the following specifications:

- 19" rack-mount chassis;
- Mainboard AIMB-505G2;
- CPU quad core 3.4 GHz;
- RAM 16 GB 2133 MHz DDR4;
- Disk 1 x SATA SSD 1 TB;
- 2 x LAN 10/100/1000;
- USB 4 x USB 3.0, 4 x USB 2.0;
- COM 2 x RS232;
- Operating temperature 0° to +40° C;
- OS Support: Linux CentOS 6.x/7.x;
- Warranty: at least 36 months.

(e) 10/100 Mbps 12-port rackmount Ethernet switch;

(f) Rackmount console (monitor & keyboard) with a switch between two data acquisition computers. Rackmount console shall have a functional capability to switch between the workstations;

(g) AC Uninterruptable power supply (UPS) for rack installation, with following specifications:

- Double-conversion
- Battery capacity: 2 kWh
- Voltage: 230 VAC
- Network Interface Card
- 19" rack – mounted

(h) Security system as described in the Section 4.3.8, and 2 (two) spare video cameras.

(i) 19" full-size equipment rack (42U);

(j) 3 kW petrol portable generator for emergency power supply of the borehole site;

(k) Surge protection devices (SPD): AC Type 1 and 2, for TN-S / TN-C-S networks, for installation at low-voltage end of AC power line to the borehole enclosure, AC Type 3 for protection of the CRF

equipment inside the equipment rack at the CRF, Ethernet SPDs for protection of the cable to the wireless bridges;

(l) Mechanical tamper switch for borehole enclosure entrance door and borehole site entrance gate;

(m) Cabinets, glands, cables and switches for the above.

6. OPTIONAL (MISCELLANEOUS) WORK

Upon the Commission's written notification, the Contractor shall investigate the need for Optional (miscellaneous) works at the Station and, if required, fully specify the optional works recommended to be done. The Commission will review the recommendation and inform the Contractor if the optional works should be added to this Contract and implemented via a contract amendment.

Upon completion of this activity, the Contractor shall submit to the Commission a Report for Optional (Miscellaneous) Work. The report for this Task is subject to the Commission's acceptance in writing.

7. DOCUMENTATION, PLANS AND REPORTS

The Contractor shall ensure that all the manuals and technical specifications received for the Station's equipment, including manuals for the operation and maintenance will be kept in a safe location at the Station.

Reports, plans and any other documentation shall be submitted as described in this Section. All reports and communications shall be in English and reports shall be submitted in original hard copy and two copies as well as in electronic version. The Commission will review and inform in writing if these reports have been accepted in order to confirm the completion of the relevant Work Task.

In case the Commission is not satisfied with a submitted report, the Commission is entitled to ask the Contractor to take any necessary remedial actions to comply with its obligations as stated in this Contract. The Commission shall give the Contractor reasonable time to remedy the defects and submit the Revised Report(s) within the timelines set out in the sections below.

The Contractor shall submit the following Reports to the Commission:

No.	Plans and Reports
1	***Work Task 1: Conceptual Design Report/ Revised Conceptual Design Report***
2	***Work Task 2: Final Design Report/Revised Final Design Report***
3	***Work Task 3-5: Upgrade of Infrastructure Report/Revised Upgrade of Infrastructure Report***
4	***Final Report/Revised Final Report***
5	***(if required by the Commission) Report for Optional (Miscellaneous) Work***

7.1 WORK TASK 1: CONCEPTUAL DESIGN REPORT

The Contractor shall prepare and submit to the Commission Conceptual Design Report/Revised

Conceptual Design Report regarding the completed Conceptual Design work for the installation of the Station. This report shall include:

- Review of existing infrastructure, and equipment at the existing seismic station;
- Input information to the design;
- Conceptual design of the site upgrade;
- Layout diagrams with approximate dimensions;
- Brief presentation of site upgrade;
- Justifications and explanations for design solutions included in the Conceptual Design Report.

7.2 WORK TASK 2: FINAL DESIGN REPORT

The Contractor shall prepare and submit to the Commission Final Design Report after the completion of the Design. This report shall contain all the designs, plans, and drawings and any other information necessary to evaluate the design. Additionally, this report shall contain drawings and specifications of equipment enclosure(s).

In case of the subsequent discussions between the Contractor and the Commission, which lead to modifications in the design, the Contractor shall submit a Revised Final Design Report incorporating the modifications within 4 (four) weeks of the Commission's request.

The Final Design Report/Revised Final Design Report shall include a section with all details of the permits and licensing requirements related to the Station, as well as the federal, municipal and local laws and regulations. The Contractor shall provide copies of all licenses, permits, or authorizations that have been obtained to carry out the Work.

7.3 WORK TASKS 3-5: STATION CONSTRUCTION REPORT

Within 4 (four) weeks of completion of Work Tasks 3 through 5, the Contractor shall submit the Station Construction Report to the Commission describing in details the required works at the Station undertaken by the Contractor. The report shall be comprehensive, and include, but not be limited to, the following information:

- A summary of work, including a description of the completion of all sub-tasks related to the site preparation and construction;
- Pictures of each stage of the upgrade work, including borehole enclosure, CRF and cable lines;
- A report on the seismometer borehole drilling, including information of the final depth of the borehole. Proof of the verticality and measurement methods must be included in the report;
- Description and pictures of grounding and lightning protection system;
- Final measured coordinates of the borehole location in WGS84 coordinate system with absolute accuracy to 100 meters;
- The elevations of the seismic site to within 20 m;
- A description of improvements at the CRF and at the Station related to operation of the IMS facility;

- A report of the power system installation including all required tests signed by authorized authorities;
- A description of the NRIK equipment dismantling and its installation at the NRSK/PS34 CRF;
- A description of the access road repair.

During the implementation of the Work Tasks 3 to 5, an inspection visit can be carried out by the technical representatives of the Commission. A representative from the SMS and the Commission's Equipment Supplier may participate in this inspection to confirm that the Station is ready for installation of the Commission's equipment.

If design or work tasks changes are necessary, the Contractor shall re-submit the report including all requested clarifications to the Commission for approval within 4 (four) weeks of the Commission's request. Work Tasks 3, 4 and 5 shall be considered completed upon approval by the Commission of the Station Construction Report /Revised Station Construction Report.

7.4 WORK TASK 5: FINAL REPORT

Within 4 (four) weeks after completion of all tasks referred to in Section 4, the Contractor shall prepare and submit to the Commission a Final Report.

The Final Report shall include a fully detailed description of the Work completed in accordance with Section 4 above. The Final Report shall contain a separate section "Station Specific Documentation Guidelines", prepared in accordance with Attachment B of this ToR.

In case the Commission, after the review of the Final Report, will require further information and/or more detailed description of actions taken, the Commission will inform the Contractor, asking to revise the Final Report to include such additional information and/or a more detailed description of the required remedial actions. The Contractor shall submit the Revised Final Report to the Commission within 4 (four) weeks from the reception of the instructions/requests for review and acceptance.

7.5 REPORT FOR OPTIONAL (MISCELLANEOUS) WORK

If requested by the Commission, the Contractor shall submit a Report for Optional (Miscellaneous) Work, in accordance with Section 5 of the ToR.

8. WORK SCHEDULE

- Work Task 1 shall be completed within 1 month after the signature of the Contract.
- Work Task 2 shall be completed within 2 months after the acceptance by the Commission of the Conceptual Design Report/Revised Conceptual Design Report.
- Work Task 3 shall be completed within 3 months after acceptance by the Commission of the Final Design Report/Agreed Final Design Report.
- Work Task 4 shall be completed within 3 months after acceptance by the Commission of the Final Design Report/Agreed Final Design Report

- Work Task 5 shall be completed within 3 months after the acceptance of the Final Design Report/Agreed Final Design Report.

9. LIST OF ATTACHMENTS

- Attachment A: CTBTO / IMS Earthing and Lightning Protection Minimum Standard
- Attachment B: Station Specific Documentation Guidelines
- Attachment C: Special Instructions for Contracts - IMS stations operated by the SMS of MoD RF

10. FIGURES

Figure 1. Station's location

Figure 2. View of the Station's location, borehole site, 10 x 10 m

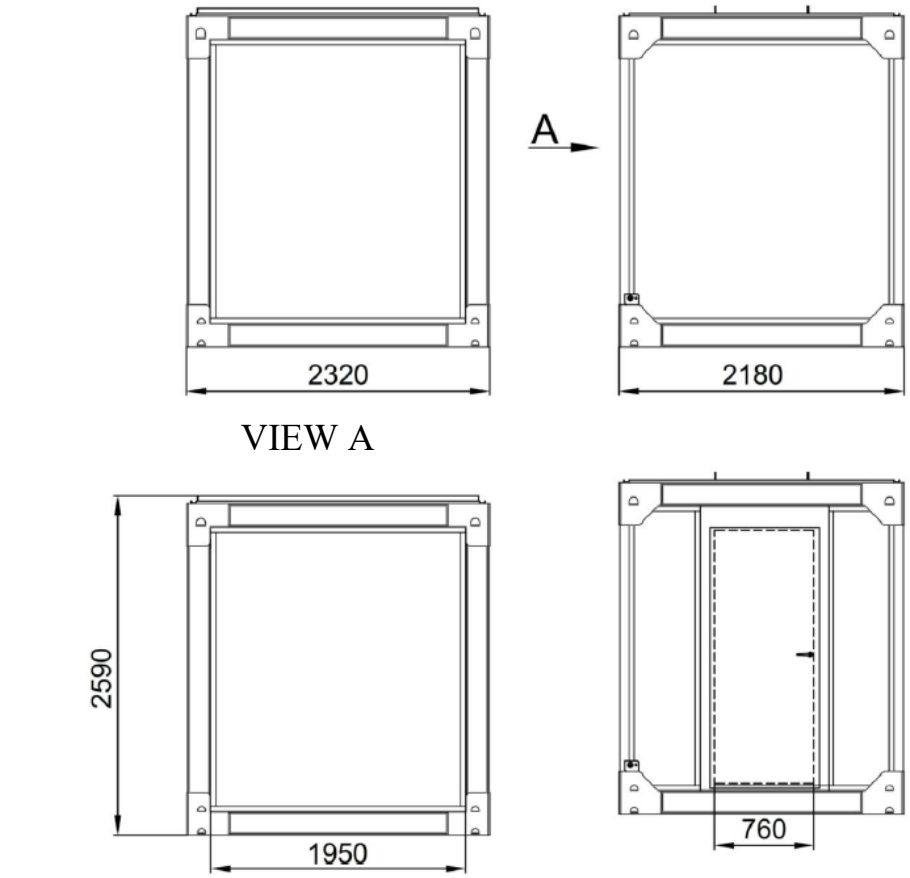
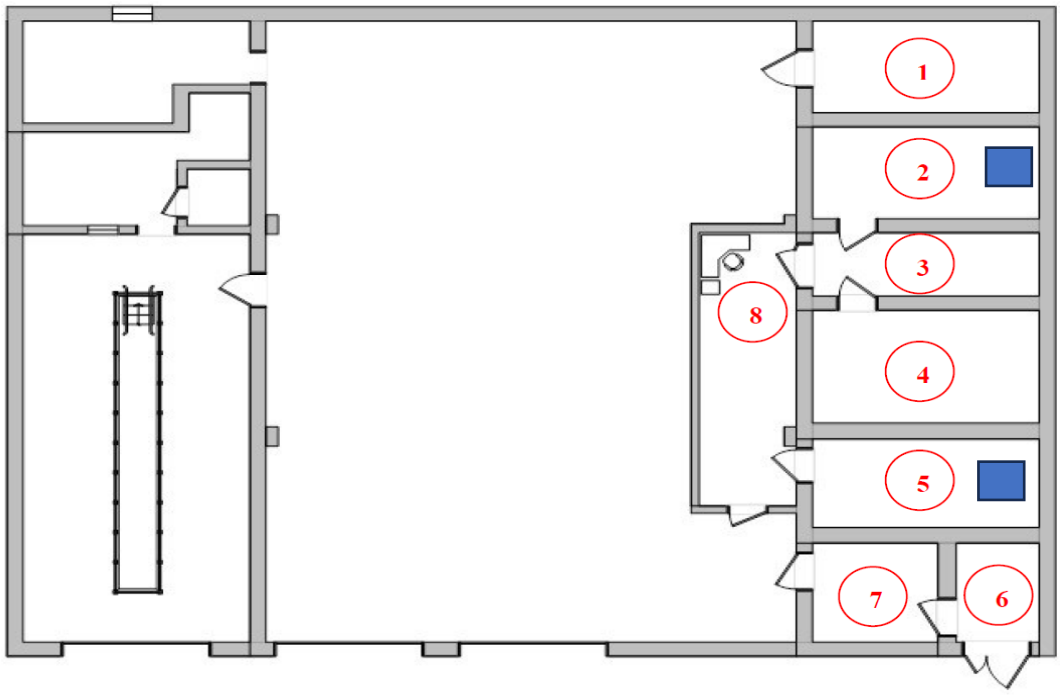


Figure 3. Borehole enclosure, drawings and photo. Dimensions in mm.

Figure 4. NRSK borehole site, view to the connection point of 6 kV line.



1. Heating and water supply room
2. RN55 detector room
3. Spare equipment room
4. RUX55 equipment room
5. Operators' room
6. Diesel generator
7. Electric panel room
8. PS34 equipment room

Figure 5. Floor plan of RN55. Possible locations of the NRSK CRF equipment rack are marked by blue rectangles.

Figure 6. Possible locations for PS34 equipment rack in the rooms number 2 (right) and 5 (left) of the floor plan.

Figure 7. External and internal place for radio equipment on the roof of the CRF building.

Figure 8. Diesel generator and EATON UPS at the NRIK location.

CTBTO/IMS Earthing and Lightning Protection Minimum Standard

(Version 3.0/2023)

Version changes:

Date		Version	Author / Reviewer
15.01.2010	Change IEC 62643 to IEC 61643		Diendorfer / Martysevich
10.01.2019	Revision of Version 1.0	Version 2.0	Diendorfer / Martysevich
19.06.2023	Revision of Version 2.0	Version 3.0	Diendorfer / Martysevich

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LIST OF ABBREVIATIONS

α	Protection angle of air-terminal (°)
A_D	Collection area of structure for direct strikes
A_I	Collection area of a line for nearby strikes
A_L	Collection area of a line for direct strikes
A_M	Collection area of structure for nearby strikes
CRF	Central Recording Facility
LPS	Lightning protection system
LEMP	Lightning electromagnetic impulse
LPZ	Lightning protection zone
N_D	Annual number of direct strikes to a structure
N_G	Ground flash density
N_M	Annual number of nearby strikes to a structure
N_I	Annual number of strikes nearby an incoming line
N_L	Annual number of direct strikes to an incoming line
N_{SG}	Ground Strike Point Density
PE	protective earthing conductor
PEN	PEN conductor is a conductor combining the functions of both a protective earthing conductor and a neutral conductor
R_A	Earth electrode resistance (Ω)
RCD	Residual Current Device
ρ	Specific earth resistivity (Ωm)
σ_E	Specific ground conductivity (Sm^{-1})
SPD	Surge protective device
T_D	Thunderstorm days per year
T_H	Thunderstorm hours per year
TOV	Temporary over voltage (V)
U_C	Maximum continuous operation voltage (V)
U_P	Voltage protection level of an SPD
$V_{OC\ STC}$	Open circuit voltage of a PV module at Standard Test Conditions (V)

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1 Introduction

The International Monitoring System (IMS) consists of a worldwide network of 321 stations, including primary and auxiliary seismic, hydroacoustic, infrasound and radionuclide monitoring stations supported by 16 radionuclide laboratories. The IMS facilities transmit data using a closed and secure satellite communications network via the Global Communications Infrastructure to the International Data Centre (IDC) in Vienna using very small aperture terminal technology.

The IMS network is required to be in continuous operation with high data availability requirements in the IDC, which can be summarized as 98% for seismic, hydroacoustic and infrasound stations and 95% for radionuclide monitoring stations.

Many stations are located in areas with high annual ground flash density and unreliable mains power. At those locations, the equipment is subject to damage caused by lightning, both direct strikes and surges from indirect flashes, and by electrical surges. This seriously affects the data availability requirements.

This document provides information about the lightning protection and installation of earth-termination system, lightning equipotential bonding and surge protection designated to minimize damage caused by these events.

In general, the cases which require lightning protection are the following:

(1) Existence of large crowds
(2) Necessity of service continuity
(3) Very high lightning flash frequency
(4) Tall isolated structures
(5) Buildings containing explosive or flammable materials
(6) Buildings containing irreplaceable cultural heritage

For CTBTO/IMS stations cases (2), (3) and (4) are applicable and hence proper lightning protection is needed in order to achieve the expected performance.

The main and most effective measure for protection of structures against physical damage is considered to be the Lightning Protection System (LPS). It usually consists of both **external** and **internal** lightning protection systems.

The **external** LPS is intended to intercept direct lightning flashes to the structure, including flashes to the side of the structure, and to conduct the lightning current from the point of strike to the ground. The external LPS is also intended to disperse this current into the earth without causing thermal or mechanical damage, nor dangerous sparking which may trigger fire or explosions.

An **internal** LPS prevents dangerous sparking within the structure using either equipotential bonding or a separation distance (and hence electrical insulation) between the external LPS components and other electrically conducting elements internal to the structure.

IEC Standard 62305, made up of four parts [1], [2], [3], and [4], provides all basic information for a proper lightning protection of objects and is also applicable to CTBTO/IMS stations.

At the time of writing the current revision of this guidelines a well advanced third edition Ed.3.0 of the above mentioned series of IEC 62305-x is in the final approval process ([5], [6], [7], [8]) and major changes to the second edition will be already included in this guidelines.

2 General Part

2.1 Lightning activity and exposure

The probability that a structure or object will be struck by lightning is the product of the equivalent collection area of the structure or object and the flash density for the area that the structure is located.

Lightning Flash Density (N_G), sometimes also called Ground Flash Density, is the average yearly number of flashes to ground per square kilometer. This value is available from lightning location networks in some areas of the world.

For installations in areas with N_G equal or higher than 4, lightning protection is strongly recommended.

More advanced information on the global lightning activity was collected in recent years by lightning location systems covering the entire globe. A map of global lightning activity from 2016-2021 was published by Vaisala and is shown in Figure 1. Vaisala is the operator of GLD360, a lightning location system covering the entire globe.

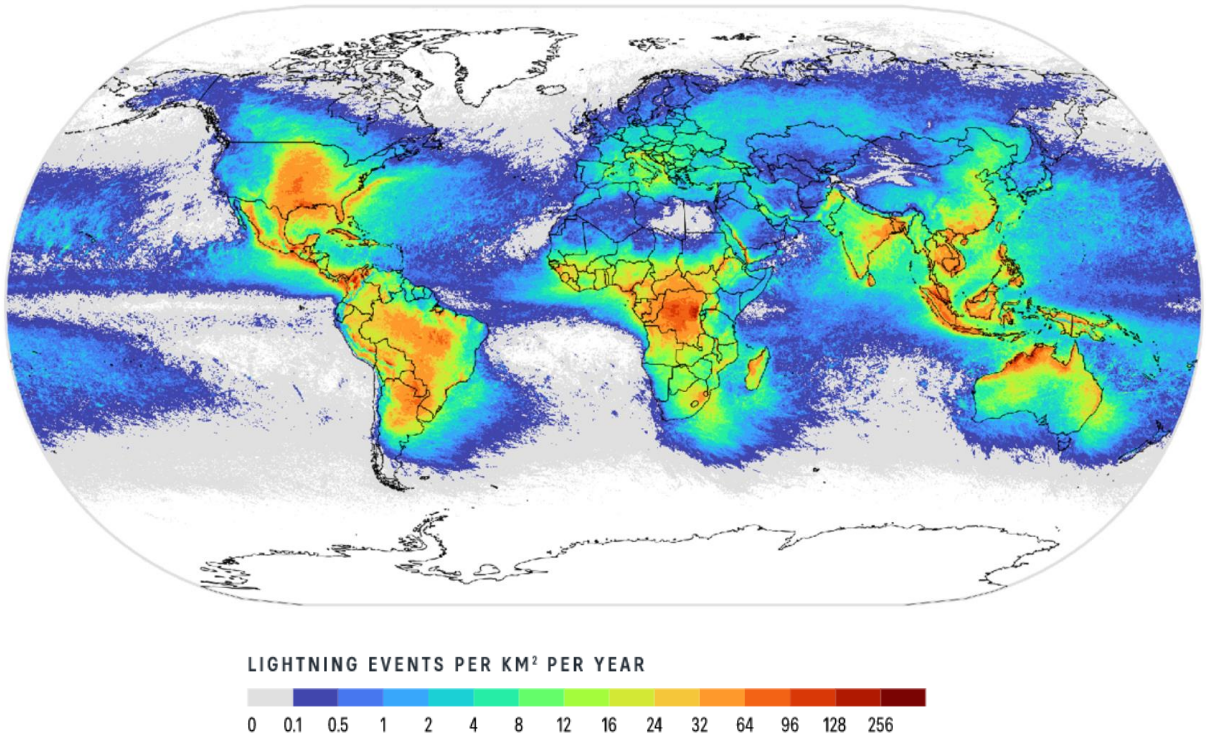


Figure 1: Stroke Density map of the Globe (see https://www.xweather.com/annual-lightning-report)

In areas without ground-based lightning location systems, the recommended estimate of ground flash density is:

$$N_G = 0{,}25 \times N_t$$

where N_t is the sum of cloud-to-ground (CG) and intracloud (IC) density of optical recorded flashes per km^2 per year, obtained through the NASA website http://lightning.nsstc.nasa.gov/data/data_lis-otd-climatology.html.

In the international standards for lightning protection there is a move from the Ground Flash Density N_G to the so-called Ground Strike Point Density N_{SG} defined in IEC 62858 entitled “Lightning density based on lightning location systems – General principles” [9].

N_{SG} takes into account, that about 50% of the lightning flashes exhibit multiple ground strike points. Based on various video studies an average of 1.7 ground strike points per flash was obtained. Based on high resolution lightning location data it became possible to identify almost all the different attachment points in a cloud-to-ground lightning flash and to obtain the regional N_{SG} value in some regions.

When N_{SG} values are not directly available, it is possible to account for flashes with multiple ground strike points based on the available N_G values [6].

$$N_{SG} = 2\ N_G$$

2.1.1 Frequency of lightning strikes

It is necessary to distinguish between the following frequencies of lightning strikes which can be relevant for a building or structure:

- N_D Frequency of direct lightning strikes to the building or structure;
- N_M Frequency of close lightning strikes with electromagnetic effects;
- N_L Frequency of direct lightning strikes in utility lines entering the building or structure;
- N_I Frequency of lightning strikes adjacent to utility lines entering the building or structure.

2.1.2 Direct lightning strikes to a structure

The yearly lightning strike frequency (N_D) to a structure (as e.g., a CTBTO/IMS site) is determined by the following equation:

$$N_D = N_{SG} \cdot A_D \cdot C_D \cdot 10^{-6}$$

where:

N_D is the yearly lightning strike frequency to the site
N_{SG} is the yearly average ground strike point density in the region where the structure is located (1/km^2 /year)
A_D is the collection area of the structure (m^2)
C_D is the Location Factor (see Table 1)

.

Table 1: Structure Location Factor C_d

Relative location	C_d
Structure surrounded by higher objects	0,25
Structure surrounded by objects or trees of the same height or smaller	0,5
Isolated structure: no other structures in the vicinity	1
Isolated structure on a hilltop or a knoll	2

The Collection Area (A_D) refers to the ground area having the same yearly direct lightning flash probability as the structure. It is an increased area for the structure that includes the effect of the height and location of the structure.

For isolated structures on flat ground, the collection area A_D is the area defined by the intersection between the ground surface and a straight line with 1/3 slope which passes from the upper parts of the structure (touching it there) and rotating around it (see Figure 2). Determination of the value of A_D may be performed graphically (Figure 3) or mathematically:

$$A_D = L \cdot W + 6 \cdot H \cdot (L+W) + 9 \cdot \pi \cdot H^2$$

with L, W and H expressed in meters. For the determination of A_D for more complex and non-rectangular structures see paragraph A.2.1 in [6].

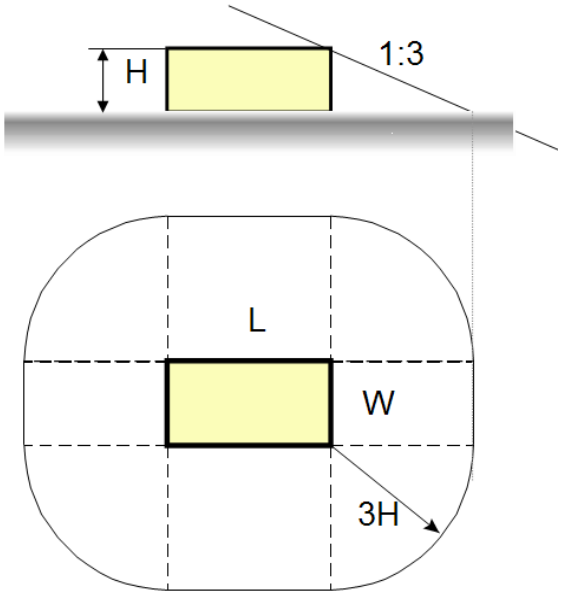


Figure 2: Calculation of the collection area A_D for a rectangular structure

In case of a typical CTBTO/IMS site with underground vaults, a surrounding fence of height H_F and a radio tower of height H_T the collecting area A_D can be estimated as shown in Figure 3.

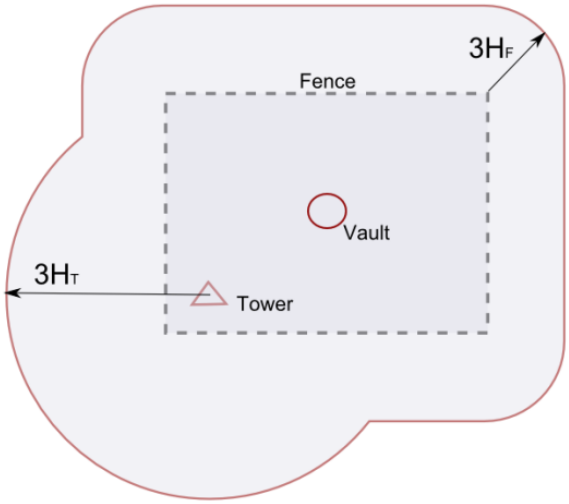


Figure 3: Collection area AD for a rectangular structure and a radio tower of height H_T

2.1.3 Assessment of the average annual number of dangerous events due to flashes near a structure N_M

Average annual number of dangerous events due to flashes near a structure N_M may be evaluated as the product:

$$N_M = N_G \cdot A_M \cdot 10^{-6}$$

where

N_G is the lightning ground flash density (1/km^2 /year);
A_M is the collection area of flashes striking near the structure (m^2).

The collection area A_M is extending to a line located at a conventional distance r_M from the perimeter of the structure (see Figure 4).

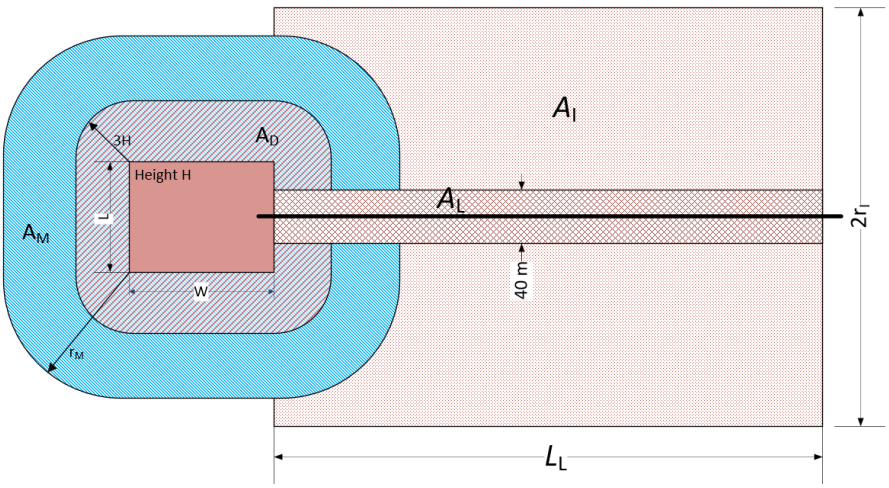


Figure 4: Equivalent collection areas A_D, A_M, A_L and A_I for a rectangular structure with a connected line (Note: areas are not drawn to scale)

For a rectangular structure of length L and width W the collection area A_M is given by:

$$A_M = 2 \cdot r_M \cdot (L + W) + \pi \cdot r_M{}^2$$

where $r_M = 350/U_W$ (m) with U_W being the equipment impulse rated voltage in kV of the equipment having the lowest insulation level. Typical values of U_W are given in Table 14 of this document.

2.1.4 Average annual number of dangerous events N_L due to flashes to a line

For each section of a line entering a building or a station, the value of N_L may be estimated by:

$$N_L = N_{SG} \cdot A_L \cdot C_I \cdot C_E \cdot C_T \cdot 10^{-6} \text{ (direct strikes)}$$

N_L is the number of overvoltages of amplitude not lower than 1 kV (1/year) on the line section
N_{SG} is the lightning ground strike-point density per km^2 per year,
A_L is the collection area for flashes striking the line in m^2,
C_I is the installation factor of the line (Table 2),
C_T is the line type factor (Table 3),
C_E is the environment factor (Table 4).

The equivalent collection area A_L for flashes to the line section of length L_L in meter is

$$A_L = 40 \cdot L_L$$

Note: a maximum total line length of 1 km is considered.

Table 2: Line installation factor C_I

Routing	C_I
Aerial	1
Buried	0,3
Buried cables running entirely within a meshed earth termination	0,01

Table 3: Line type factor C_T

Installation	C_T
LV power, telecommunication or data line or HV power line with HV/LV auto-transformer	1
HV power (with HV/LV transformer with separated windings)	0,2

Table 4: Line environmental factor C_E

Environment	C_E
Rural	1
Suburban	0,5
Urban	0,1
Urban with tall buildings (> 20m)	0,01

2.1.5 Average annual number of dangerous events N_I due to flashes near a line

The frequency of lightning nearby (N_I) a service line (power, data line, telecommunication, etc.) entering a building or a station can be estimated by:

$$N_I = N_G \cdot A_I \cdot C_I \cdot C_E \cdot C_T \cdot 10^{-6}$$

where

N_I is the number of overvoltages per year of amplitude not lower than U_W on the line section

N_G is the lightning ground flash density per km^2 per year,

A_I is the collection area for flashes striking the line in m^2,

C_I is the installation factor of the line (Table 2),

C_T is the line type factor (Table 3),

C_E is the environment factor (Table 4).

The equivalent collection area A_I for flashes near a line section of length L_L in meter is

$$A_I = 2 \cdot r_I \cdot L_L$$

where

L_L is the length of the line section (m),

$r_I = 2\,000/U_W$,

U_W is the equipment impulse rated voltage in kV, where typical values of U_W are given in Table 14 of this document.

2.2 Lightning Protection System (LPS)

a) Definitions:

The lightning protection system is the complete system used to reduce injury of human beings and physical damage caused by lightning to the structure and lightning induced surges to power and data lines [5].

The external LPS is intended to intercept direct lightning strikes to the structure and conduct the lightning current from the point of impact to the ground, and to dissipate the current into the ground without causing thermal or mechanical damage or dangerous sparking which may trigger fire or explosions.

In most cases, the external LPS is attached to the structure to be protected. An isolated external LPS should only be considered when the thermal and explosive effects at the point of strike, or on the conductors carrying the lightning current, may cause damage to the structure or to the contents (for more information on isolated LPS see paragraph 5.3.2 in [7]).

b) Lightning Protection Level Classification:

According to [1] (IEC 62305-1) there exist four Lightning Protection Levels (LPL): LPL I, II, III and IV. For each LPL a set of maximum and minimum lightning current parameters is defined. Only 2 % of lightning events will exceed the maximum values of the lightning current parameters specified for LPL I. For LPL II the parameters are reduced to 75% of the values of LPL I. These values are 50 % of LPL I for LPL III and IV.

The lightning protection classes I, II, III and IV refer to the LPL I, II, III and IV described above.

The lightning protection measures specified in this document are based on LPL II, which provides sufficient protection for the IMS installations.

The main components of an LPS are an air-termination system, down-conductors, an earth-termination system, equipotential bonding and surge protection based on the Lightning Protection Zone (LPZ) concept.

All connections within the LPS must provide a permanent galvanic and mechanical connection between the components. The method of connection depends on the materials used for the LPS and can be made by brazing, welding, pressing, screwing or riveting.

Material and its dimensions shall be chosen considering the effects of corrosion either of the structure to be protected or of the LPS and shall comply with the requirements and tests according to [10] and [11].

2.2.1 Air-termination system

The probability of lightning penetrating a structure is considerably reduced by the presence of a properly designed air-termination system.

Air-termination systems may consist of any combination of the following elements (see Figure 5 for examples):

a) rods (including free-standing masts);

b) catenary wires;

c) meshed conductors.

Note: IEC 62305 does not consider any of the so called “active lightning rods”, also often called ESE-devices, as their claimed efficiency is still controversially discussed among scientists. Therefore, this type of active lightning rods shall not be used for CTBTO IMS stations.

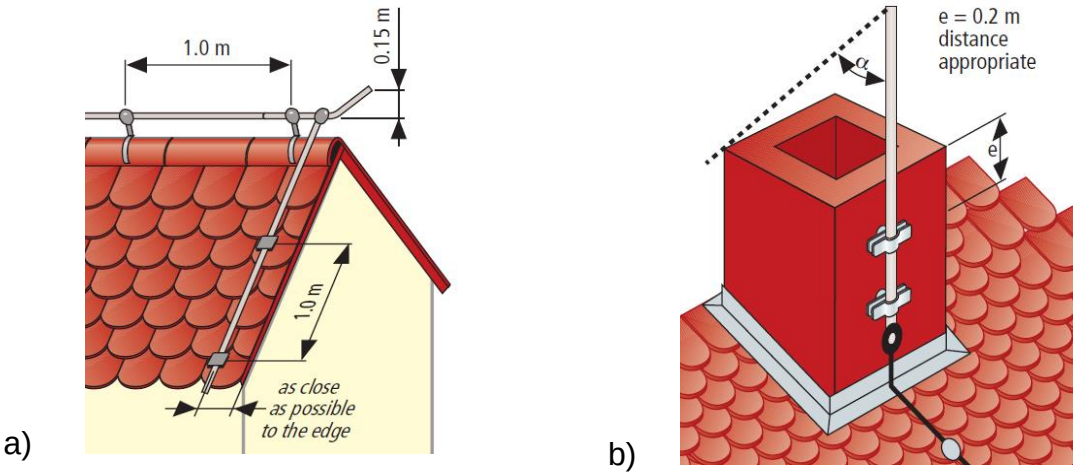


Figure 5: Two examples of air-termination systems on buildings. a) Roof with air termination conductor; b) air-termination rod for a chimney (adapted from [12])

Air-termination components installed on a structure shall be located at corners, exposed points and edges in accordance with one or more of the following methods:

– the protection angle method;

– the rolling sphere method;

– the mesh method.

The values for the protection angle, rolling sphere radius, and mesh size values for each class of LPS are given in Table 5.

Table 5: Maximum values of rolling sphere radius and mesh size corresponding to the class of LPS

Class of LPS	Rolling Sphere Radius *r* (m)	Mesh Size *W* (m)
I	20	5 x 5
II	30	10 x 10
III	45	15 x 15
IV	60	20 x 20

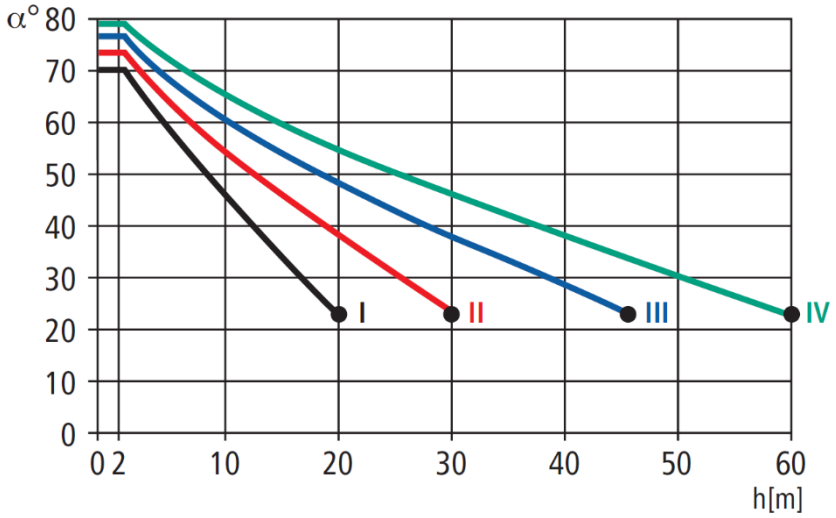


Figure 6: Protection angle α corresponding to the class of LPS as a function of the height H of air-termination above the reference plane

– The mesh method is an appropriate form of protection where plane surfaces are to be protected.
– The protection angle method is suitable for buildings of simple shape, but it is subject to limitations of air-termination height *H,* as indicated in Figure 6.
– The cone-shaped protected zone provided by a single vertical rod of height *h* and the corresponding angle *α* (*α* is a function of *h* and the class of LPS) is shown in Figure 7.

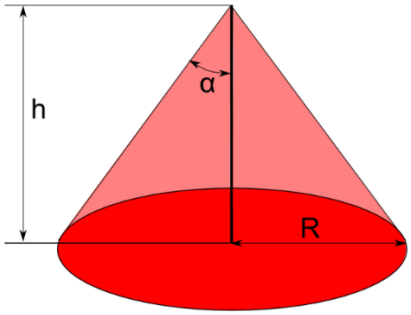


Figure 7: Protected zone of a single vertical rod for a protection angle *α*

For class II LPS, the protection angle *α* and radius *R* of protected area at the reference plane are given in Table 6.

Table 6: Protective angle α and distance R in Figure 7 as a function of height h for class II LPS

Height h of air termination rod	Protection angle α	Distance R in m
1	74	3.49
2	74	6.97
3	71	8.71
4	68	9.90
5	65	10.72
6	62	11.28
7	60	12.12
8	58	12.80
9	56	13.34
10	54	13.76
11	52	14.08
12	50	14.30
13	49	14.95
14	47	15.01
15	45	15.00
16	44	15.45
17	42	15.31
18	40	15.10
19	39	15.39
20	37	15.07
21	36	15.26
22	35	15.40
23	36	16.71
24	32	15.00
25	30	14.43
26	29	14.41
27	27	13.76
28	26	13.66
29	25	13.52
30	23	12.73

2.2.1.1 Shadowing of photovoltaic modules by lightning rods or other structures

In order to harvest a maximum of the available solar energy using solar panels, it is necessary to avoid any shadowing of the solar panels by lightning rods or other

mechanical structures (e.g., guy wires of the towers, where the solar panels are mounted). Even a small shade on a solar panel will reduce the power output significantly.

The appearance of an umbra on the solar cell or the PV module, respectively, should be avoided in any case. To do this, a minimum distance of the lightning rod or any other object from the panel is 108 times the diameter of the object (see Annex A in [13]). For a 10 mm lightning rod, the minimum distance is 1,08 meters.

The final effect of a shade on a solar panel on the power output depends on many parameters (e.g., panel orientation, wiring scheme of solar cells on the panel, bypass diodes). In any case shades on the solar panels should be avoided whenever possible. Partial shading of the PV array(s) causes multiple local maxima that affect the proper functioning of an MPP tracker and this leads to considerable power loss.

2.2.2 Down-conductors

Down conductors must be arranged so that there are several parallel paths from the point of impact to earth. The length of these paths should be kept to a minimum. Equal spacing of down conductors around the perimeter of a structure is preferred. Typical values for the spacing of the down conductors are given in Table 7.

Table 7: Typical preferred values of the distance between down-conductors according to the class of LPS

Class of LPS	Typical Distance (m)
I	10
II	10
III	15
IV	20

A down-conductor should be installed at each exposed corner of the structure, where this is possible.

Figure 8: Example of down-conductor mounted on a brick wall

2.2.3 Earth-termination system

Electrical installations require an earthing arrangement for several reasons, independent of the lightning protection [14]. For lightning protection, it may be that requirements beyond this must be met, which are specified in [3].

The main tasks of the earth-termination system are to:

- efficiently dissipate the lightning surge energy that may arrive via down-conductors of the lightning protection system;
- efficiently dissipate electrical surges and faults in order to minimize the chances of human injury from either “step potentials” or “touch potentials”;
- provide a stable reference for electrical and RF circuits at the facility in order to minimize noise during normal operation;
- be properly bonded to provide an equipotential plane under fault or lightning strike conditions;
- be electrically and mechanically robust to assure performance over the “life” of the facility (nominally tens of years from the date of construction).

The shape and dimensions of the earth-termination system are the most important criteria in dealing with the dispersion of the high frequency lightning current into the ground. In general, a low earthing resistance is recommended [3], with values lower than 10 Ω when measured at low frequency.

From a lightning protection standpoint, a single integrated earthing system is preferable and suitable for all purposes (i.e., lightning protection, power systems, and telecommunications systems). Underground metallic piping and any other existing earthing system shall be bonded together to form a single integrated earthing system.

The earth-termination system shall have low electrical impedance, with conductors large enough to withstand high electrical fault and lightning currents. In addition, in highly corrosive environments, the size of the electrodes should be large enough to provide sufficient life time (minimum 20 years for IMS applications). The lower the impedance of the earth electrode, the more effectively the earth electrode system can dissipate high energy current impulses into the ground.

2.2.3.1 Earthing electrodes

The earthing electrodes are the conductive elements used to connect electrical systems and/or equipment to the earth. The earthing electrodes are placed into the soil to maintain electrical equipment at the potential of the earth and to dissipate currents into the soil. Earthing electrodes can be earthing rods, metal plates, in concrete encased conductors, earthing ring conductors, electrolytic earthing rods or the metal frame of buildings and includes also foundation earth electrodes. Typical earthing electrodes and examples of installation are shown in Figure 9.

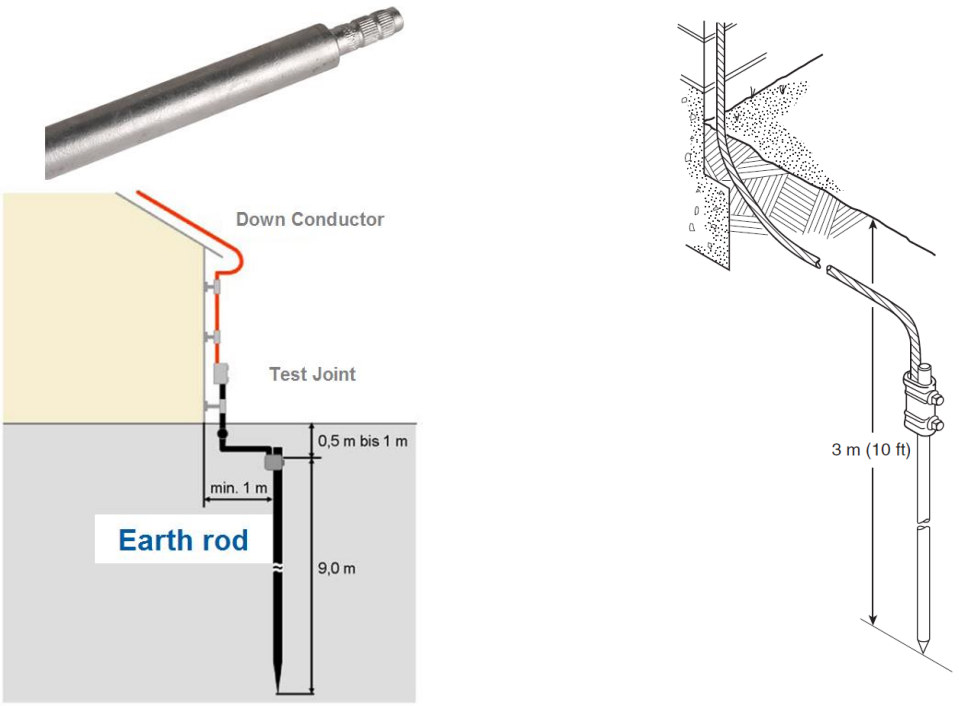


Figure 9: Typical vertical earth electrodes and their installation

The requirements for earthing electrodes are:

- The material and dimensions used for earth electrodes should conform to the materials listed in Table 8.
- The corrosion behavior of the metal in soil and in combination with other metals should always be considered (see 0).
- The vertical earth electrodes shall have a minimum length of 3 m. The actual diameter, length, and number of rods required may vary with site dimensions and/or as determined by an engineering study based on the soil resistivity profile of the site.
- Where multiple connected earth electrodes are used, the separation between any two electrodes shall be at least the sum of their driven depths (where practicable).
- The method of bonding earthing conductors to earth electrodes shall be compatible with the types of metals being bonded (see Table 19 in Annex D).
- Earth electrodes shall be free from paint or other non-conductive coatings.
- Where applicable, the earth electrodes shall be buried below the permanent moisture level.
- Earth electrodes shall be buried, where practicable, to a minimum depth of 0.8 m below finished grade or below the frost line, whichever is greater.
- Earth electrodes that cannot be driven straight down, due to contact with rock formations, may be driven at an oblique angle of not more than 45 degrees from the vertical or may be buried horizontally in a trench at least 0.8 m deep perpendicular to the building.

Table 8: Material, configuration and minimum dimensions of earth electrodes (Table 7 in [7])

Material	Configuration	Dimensions		
		Earth rod diameter mm	Earth conductor mm^2	Earth plate mm
Copper [g] Tin plated copper	Stranded		50	
	Solid round	15	50	
	Solid tape		50	
	Pipe	20		
	Solid plate			500 × 500
	Lattice plate[c]			600 × 600
Hot dipped galvanized steel	Solid round	14	78	
	Pipe	25		
	Solid tape		90	
	Solid plate			500 × 500
	Lattice plate[c]			600 × 600
	Profile	[d]		
Bare steel[b]	Stranded		70	
	Solid round		78	
	Solid tape		75	
Copper coated steel [f, g] Tin-plated copper coated steel	Solid round	14[e]	50	
	Solid tape		90	
Stainless steel [f]	Solid round	15[e]	78	
	Solid tape		100	

NOTE In the United States, only copper, copper coated steel and stainless steel are acceptable for direct burial.

[a] Mechanical and electrical characteristic, as well as corrosion resistance properties, shall meet the requirements of IEC 62561-2.

[b] Shall be embedded in concrete for a minimum depth of 50 mm.

[c] Lattice plate constructed with a minimum total length of the conductor of 4,8 m.

[d] Different profiles are permitted with a cross-section of 290 mm^2 and a minimum thickness of 3 mm, e.g., cross profile.

[e] In some countries the diameter may be reduced to 12,7 mm

[f] Chromium ≥ 16%, nickel ≥ 5%, molybdenum ≥ 2%, carbon ≤ 0,08%.

[g] An earth electrode of copper material buried in the soil shall not be used in contact with the steel members, steel pipes and steel piles related to the building structures because of corrosion considerations.

NOTE: In some areas, bare steel is also allowed to be used in the soil, not embedded in concrete.

In [15] a corrosion weight loss of 7.6% after 7 years was determined for bare steel electrodes in soil (electrodes were 2.4 m long and 16 mm in diameter). Since the actual corrosion of bare steel is determined by the local soil conditions, periodic measurements of the earthing resistance of such electrodes should be made to ensure proper earthing conditions and to initiate improvements if necessary. Corrosion is a phenomenon that can occur at the boundaries between two distinct soil layers. Therefore, whenever possible, earthing electrodes of sufficient corrosion resistivity (e.g., stainless steel, copper) shall be used. See Annex D for more details on corrosion when dissimilar materials are connected.

2.2.3.2 Earthing conductor

An earthing conductor is a conductor connecting the system component to be earthed to an earth electrode and which is installed above the ground or insulated in the ground.

2.2.3.3 Minimum site earthing requirements

Since the earthing system is used for several functions in a structure (e.g., signal reference ground and lightning protection), the requirement for a minimum earthing resistance may have different reasons.

For lightning and overvoltage protection the absolute value of the earthing system resistance is not as important as ensuring that all equipment and conducting services are connected to a more or less equal potential plane (equipotential bonding is a must). The need to ensure an equipotential plane becomes obvious by the following simple calculation:

When a typical lightning current of 10 kA is injected into an earthing system of 10 Ω, there will be a potential rise of 100 kV relative to the reference earth ($U = I \cdot R$ = 10.000 A · 10 Ω = 100.000 V) at the striking point, causing flashover and equipment damage if bonding is not done properly.

A mesh of earth conductors with a mesh-size of approximately 5 m x 5 m, in which towers, objects and equipment vaults are integrated, is suitable for limiting potential differences between the installations and at the surface (risk of step-voltages) to acceptable values.

Since IEC 62305-3 [7] assumes a systematic lightning equipotential bonding, no specific value is required for the earth electrode resistance. In this IEC standard the minimum length l_1 of the earthing electrode is a function of the class of lightning protection system (see Figure 10). For LPL II, being applicable to CTBTO/IMS stations, Table 9 shows l_1 as a function of the soil resistivity in Ωm.

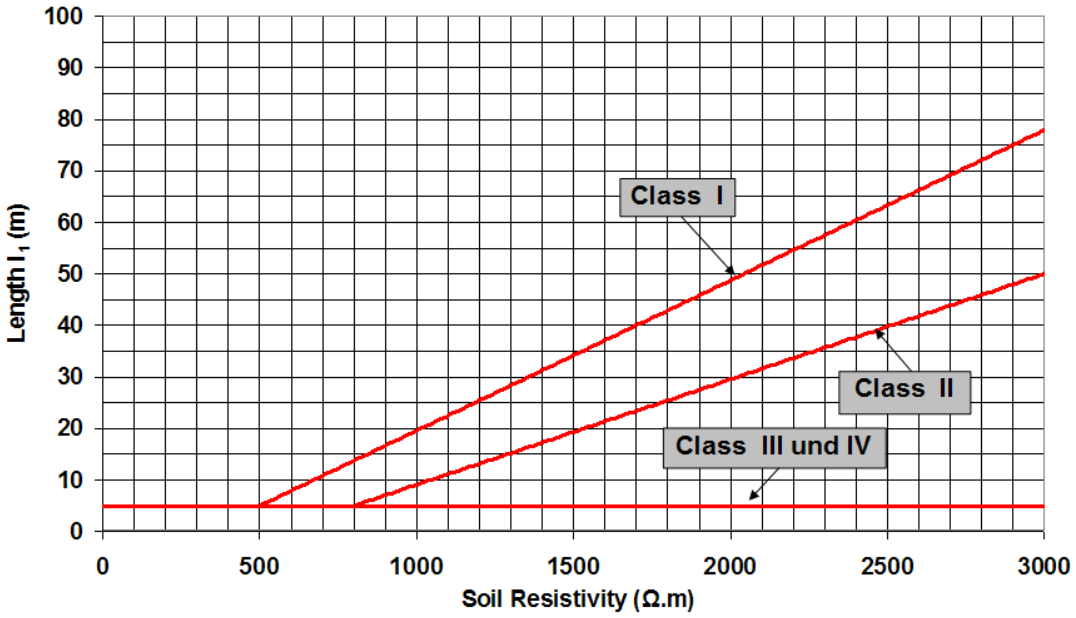


Figure 10: IEC 62305-3 specified minimum length l_1 of each horizontal earth electrode according to the class of the LPS

Table 9: Minimum length l_1 of each horizontal earth electrode as a function of ground resistivity in Ωm according to LPL II

Ω.m	l_1	Ω.m	l_1	Ω.m	l_1	Ω.m	l_1	Ω.m	l_1	Ω.m	l_1
0	5,0	500	5,0	1000	9,1	1500	19,3	2000	29,5	2500	39,8
10	5,0	510	5,0	1010	9,3	1510	19,5	2010	29,8	2510	40,0
20	5,0	520	5,0	1020	9,5	1520	19,7	2020	30,0	2520	40,2
30	5,0	530	5,0	1030	9,7	1530	19,9	2030	30,2	2530	40,4
40	5,0	540	5,0	1040	9,9	1540	20,1	2040	30,4	2540	40,6
50	5,0	550	5,0	1050	10,1	1550	20,3	2050	30,6	2550	40,8
60	5,0	560	5,0	1060	10,3	1560	20,5	2060	30,8	2560	41,0
70	5,0	570	5,0	1070	10,5	1570	20,8	2070	31,0	2570	41,2
80	5,0	580	5,0	1080	10,7	1580	21,0	2080	31,2	2580	41,4
90	5,0	590	5,0	1090	10,9	1590	21,2	2090	31,4	2590	41,6
100	5,0	600	5,0	1100	11,1	1600	21,4	2100	31,6	2600	41,8
110	5,0	610	5,0	1110	11,3	1610	21,6	2110	31,8	2610	42,0
120	5,0	620	5,0	1120	11,5	1620	21,8	2120	32,0	2620	42,2
130	5,0	630	5,0	1130	11,8	1630	22,0	2130	32,2	2630	42,4
140	5,0	640	5,0	1140	12,0	1640	22,2	2140	32,4	2640	42,6
150	5,0	650	5,0	1150	12,2	1650	22,4	2150	32,6	2650	42,8
160	5,0	660	5,0	1160	12,4	1660	22,6	2160	32,8	2660	43,0
170	5,0	670	5,0	1170	12,6	1670	22,8	2170	33,0	2670	43,3
180	5,0	680	5,0	1180	12,8	1680	23,0	2180	33,2	2680	43,5
190	5,0	690	5,0	1190	13,0	1690	23,2	2190	33,4	2690	43,7
200	5,0	700	5,0	1200	13,2	1700	23,4	2200	33,6	2700	43,9
210	5,0	710	5,0	1210	13,4	1710	23,6	2210	33,8	2710	44,1
220	5,0	720	5,0	1220	13,6	1720	23,8	2220	34,0	2720	44,3
230	5,0	730	5,0	1230	13,8	1730	24,0	2230	34,3	2730	44,5
240	5,0	740	5,0	1240	14,0	1740	24,2	2240	34,5	2740	44,7
250	5,0	750	5,0	1250	14,2	1750	24,4	2250	34,7	2750	44,9
260	5,0	760	5,0	1260	14,4	1760	24,6	2260	34,9	2760	45,1
270	5,0	770	5,0	1270	14,6	1770	24,8	2270	35,1	2770	45,3
280	5,0	780	5,0	1280	14,8	1780	25,0	2280	35,3	2780	45,5
290	5,0	790	5,0	1290	15,0	1790	25,3	2290	35,5	2790	45,7
300	5,0	800	5,0	1300	15,2	1800	25,5	2300	35,7	2800	45,9
310	5,0	810	5,2	1310	15,4	1810	25,7	2310	35,9	2810	46,1
320	5,0	820	5,4	1320	15,6	1820	25,9	2320	36,1	2820	46,3
330	5,0	830	5,6	1330	15,8	1830	26,1	2330	36,3	2830	46,5
340	5,0	840	5,8	1340	16,0	1840	26,3	2340	36,5	2840	46,7
350	5,0	850	6,0	1350	16,3	1850	26,5	2350	36,7	2850	46,9
360	5,0	860	6,2	1360	16,5	1860	26,7	2360	36,9	2860	47,1
370	5,0	870	6,4	1370	16,7	1870	26,9	2370	37,1	2870	47,3
380	5,0	880	6,6	1380	16,9	1880	27,1	2380	37,3	2880	47,5
390	5,0	890	6,8	1390	17,1	1890	27,3	2390	37,5	2890	47,8
400	5,0	900	7,0	1400	17,3	1900	27,5	2400	37,7	2900	48,0
410	5,0	910	7,3	1410	17,5	1910	27,7	2410	37,9	2910	48,2
420	5,0	920	7,5	1420	17,7	1920	27,9	2420	38,1	2920	48,4
430	5,0	930	7,7	1430	17,9	1930	28,1	2430	38,3	2930	48,6
440	5,0	940	7,9	1440	18,1	1940	28,3	2440	38,5	2940	48,8
450	5,0	950	8,1	1450	18,3	1950	28,5	2450	38,8	2950	49,0
460	5,0	960	8,3	1460	18,5	1960	28,7	2460	39,0	2960	49,2
470	5,0	970	8,5	1470	18,7	1970	28,9	2470	39,2	2970	49,4
480	5,0	980	8,7	1480	18,9	1980	29,1	2480	39,4	2980	49,6
490	5,0	990	8,9	1490	19,1	1990	29,3	2490	39,6	2990	49,8
500	5,0	1000	9,1	1500	19,3	2000	29,5	2500	39,8	3000	50,0

The minimum length of each earth electrode is:

- l_1 in Figure 10 for horizontal earth electrodes
- l_1 x 0.5 for vertical or inclined earth electrodes (with a minimum length of 3 m)

The determined values of l_1 apply to each individual earth electrode. For meshed earth electrodes and foundation earth electrodes the average radius r of the area enclosed by the earth electrode shall not be less than the given minimum length l_1 given in Figure 10 according to the selected class of LPS. To determine the average radius r, the area under consideration is transformed into an equivalent circular area and the radius is determined as shown in Figure 11.

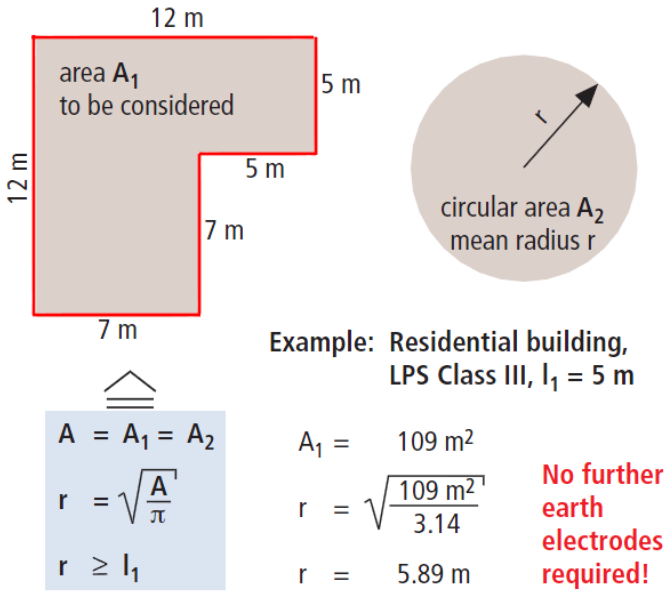


Figure 11: Equivalent radius of a residential building in order to compare with minimum length l_1 of each horizontal earth electrode according to the class of LPS

In the example shown in Figure 11, the calculated equivalent radius of 5.89 m for the given ring electrode around the buildings area A_1 is greater than the minimum length of 5 m (see Figure 10 for LPS class III) and hence no additional earth electrodes are required.

2.2.3.4 Calculation of earth electrode resistances

Table 10 shows some formulas for estimating the earth electrode resistance of the most common types of earth electrodes. In practice, these approximate formulas are quite sufficient, when keeping in mind all the variable parameters of the ground sub-surface (soil humidity, temperature, homogeneity of soil, etc.).

Table 10: Formulas for the calculation of the earth electrode resistance R_A for different earth electrodes (from [12]*)*

Earth electrode	Approximate formula	Auxiliary
Surface earth electrode (radial earth electrode)	$R_A = \frac{2 \cdot \rho_E}{l}$	–
Earth rod	$R_A = \frac{\rho_E}{l}$	–
Ring earth electrode	$R_A = \frac{2 \cdot \rho_E}{3 \cdot d}$	$d = 1.13 \cdot \sqrt[2]{A}$
Meshed earth electrode	$R_A = \frac{\rho_E}{2 \cdot d}$	$d = 1.13 \cdot \sqrt[2]{A}$
Earth plate	$R_A = \frac{\rho_E}{4.5 \cdot a}$	–
Hemispherical / foundation earth electrode	$R_A = \frac{\rho_E}{\pi \cdot d}$	$d = 1.57 \cdot \sqrt[3]{V}$

R_A Earth resistance (Ω)
ρ_E Earth resistivity (Ωm)
l Length of the earth electrode (m)
d Diameter of a ring earth electrode, the area of the equivalent circuit or a hemispherical earth electrode
A Area (m^2) of the enclosed area of a ring or meshed earth electrode
a Edge length (m) of a square earth plate. In case of rectangular plates: a is substituted by $\sqrt{b \cdot c}$, where b and c are the two sides of the rectangle
V Volume of a single foundation earth electrode

2.2.3.5 Special earthing situations

The earthing resistance of the total earthing systems should be as low as possible, nevertheless it is always most important to ensure minimum potential differences within the protected area including towers, buildings and equipment vault with cables (e.g., for power supply and data communication) interconnecting these structures. Regardless of the actual earthing conditions (e.g., on a mountain top, in arctic regions or in a coral environment) safe equipment operation can be achieved if all equipment is at more or less the same potential and all lines entering the equipotential area are well bonded and protected by SPDs. Some examples are given below:

Towers with limited space for an earthing ring

Towers located close to buildings may not have adequate space for a complete tower earthing ring or for earthing rods spaced properly to achieve the resistance requirements of the site. The tower earthing shall be integrated with the earthing system of the adjacent buildings and an earthing mesh (with optional earthing rods) shall be installed across the available space (see example in Figure 12).

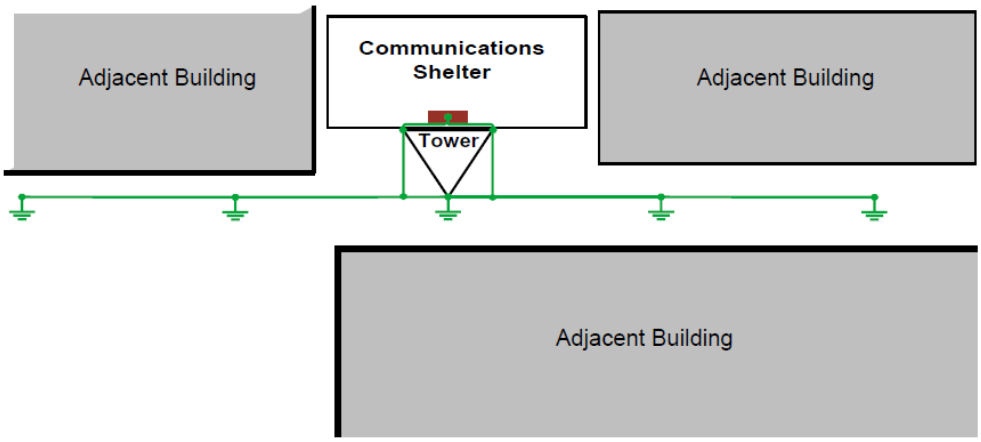


Figure 12: Linear earthing electrode system in case of limited space (typically one rod every 5 m or twice the length of the rod)

Earth electrodes in rocky soil, sand, coral, limestone, arctic ice or mountain tops

Some sites are located on mountaintops or in areas with rocky soil. In the instances where there is no soil or very little soil at the site (shallow topsoil environment, arctic regions, sand, coral, or limestone environments, etc.) special designs will be needed. During construction, a foundation earth electrode should be built into the concrete foundation. Even where a foundation earth electrode has a reduced earthing effect in rocky soil, it still acts as an equipotential bonding conductor.

Surface earth electrodes, such as ring or star-type earth electrodes, are often the only way to create an earth-termination system. When installing the earth electrodes, the flat strip or round material is laid on the stony ground, on the ice or on the rock. If the earth electrode cannot be installed in the soil and has to be mounted on the surface, it should be protected against mechanical damage. Radial earth electrodes lying on or near the earth surface should be covered by stones or embedded in concrete for mechanical protection. The clamped points should be installed with special care and be protected against corrosion (anti-corrosion tape).

Under the conditions described above, the primary goal is to achieve an earth termination system that provides a sufficient equipotential plane. The achievement of a low grounding resistance is a secondary goal.

An example for extending a tower earthing system to nearby areas with lower resistivity soil is shown in Figure 13.

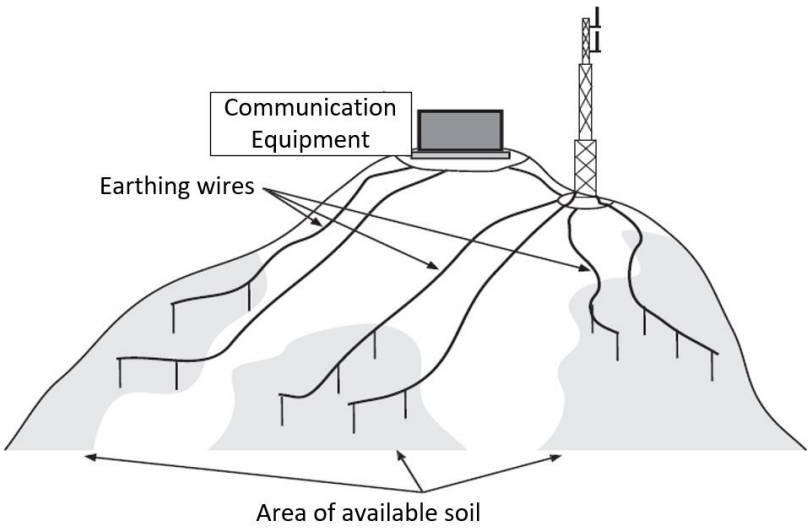


Figure 13: Example of site on mountain top with earthing wires from the tower to nearby areas with low soil resistivity (adapted from [16])

Earthing in permafrost regions

Permafrost is defined as ground, including rock or soil, at temperatures below the freezing point of water 0° C for two or more years. Most permafrost regions are located at high latitudes (in and around the Arctic and Antarctic regions), but at lower latitudes alpine permafrost occurs at higher elevations.

Areas of permafrost do not provide acceptable grounding conditions due to the high resistance of the frozen ground. In these locations, all electrically conductive station elements, including electrical wiring, piping, metal structures, etc., must be interconnected to form a single large network on the same potential. This network is then connected to a ground rod that does not penetrate the permafrost. This provides a floating ground with everything at the same electrical potential, which is the most important part for a save and proper operation of the equipment.

The direct burial of cables in the active layer in frost-susceptible soils must be avoided. Freezing and expansion of these soils will cause structural failure of the cable or severe mechanical damage. Buried conduits or ducts must be placed in non-frost-susceptible backfill materials. If a buried system is required, prime consideration shall be given to placing a gravel and non-frost-susceptible material pad on the existing ground surface in which the cables will be buried.

2.2.4 Separation Distance

To avoid dangerous sparking, a separation distance *S* must be maintained between the lightning protection system and the electrical installation and other structural metal parts in the protected object.

If the lightning current or part of it flows through the lightning down-conductor, a voltage is induced in open loops which can lead to uncontrolled, dangerous flashovers at the point of proximity. Figure 14 shows an example of a loop formed by the lightning down-conductor and the neutral conductor to a lamp.

The voltage occurring at the point of proximity can also be seen as an inductive voltage drop along the lightning conductor. With a current slope of the lightning current of 100 kA/µs and an inductance of the lightning down conductor of L=1µH/meter, a voltage drop of 100 kV per meter is built up. At a height of 6 meters, this results in a voltage stress of 600 kV, which will lead to flashover if the separation distance *S* is not maintained.

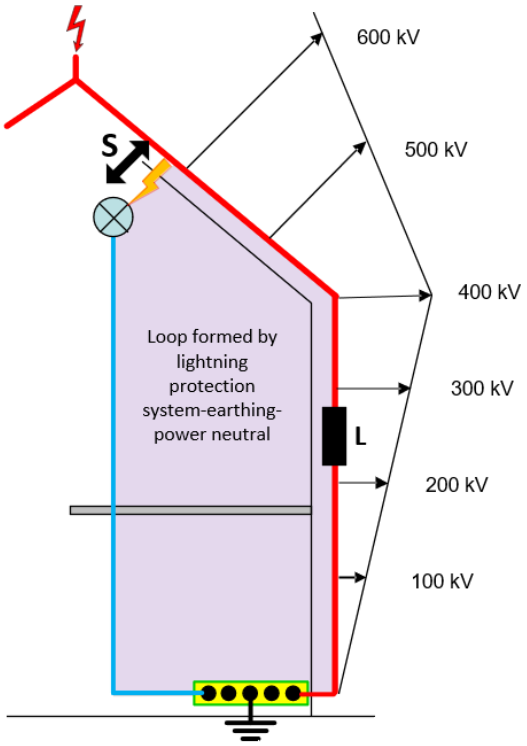


Figure 14: Example of separation distance "*S*" for an installed lamp in a building

The required distance *S* depends on the selected lightning protection level (k_i), the electrical insulation material (k_m), the partial lightning current flowing on the air-termination and the down-conductor (k_c) and the length (l), in meters, along the air-termination and the down-conductor from the point where the separation distance is to be considered, to the nearest equipotential bonding point or the earth termination. Approximate values for k_c are given in Table 11.

Table 11: Separation distance – Approximated values of coefficient k_c

Number of down-conductors	k_c
1 (only in the case of an isolated LPS)	1
2	0,66
3 and more	0,44

For simple arrangements, where the same fraction of lightning currents flows along the entire length l, the separation distance s is calculated by the following simplified formula:

$$s = \frac{k_i}{k_m} . k_c . l$$

where k_i =0,06 for LPL II and 0,08 for LPL I, k_m = 1 for air and k_m = 0,5 for concrete, bricks, or wood as the material between down-conductor and the metal structure. For more complex situations (e.g., multi-story buildings), more precise calculations of the separation distance can be found in [3].

Assuming two down-conductors (k_c =0,66), an LPL II installation (k_i =0,06) and bricks as material, the minimum separation distance the example shown in Figure 14 is S = (0,06/0,5).0,66.6 = 0,47 m.

2.2.5 Equipotential Bonding

Lightning strikes can give rise to harmful potential differences in and on a building/structure. The main concern in protecting of a building/structure is the occurrence of potential differences between the conductors of the lightning protection system and other grounded metal bodies and wires belonging to the building. These potential differences are caused by resistive and inductive effects and can result in dangerous sparking or damage of electronic equipment.

2.2.5.1 Bonding to the earth termination system

Equipotential bonding is required to eliminate or reduce potential differences between different installations. Bonding prevents e.g., hazardous touch voltages between the protective conductor of the low voltage electrical power consumer's installations and metal, water, gas and heating pipes.

The equipotential bonding consists of a main equipotential bonding bar (MBB) to which the following extraneous conductive parts shall be directly connected (see Figure 15):

- Main equipotential bonding conductor
- Foundation earth electrodes or lightning protection earth electrodes
- Conductive parts of the building structure (e.g., elevator rails, steel skeleton, ventilation and air conditioning ducting)
- Metal drain pipes
- Internal gas pipes
- Earthing conductor for antennas
- Earthing conductor for telecommunication systems
- Protective conductors of the electrical installation (PEN conductor for TN systems and PE conductors for TT systems or IT systems)
- Metal shields of electrical and electronic conductors
- Metal cable sheaths of high-voltage current cables up to 1000 V

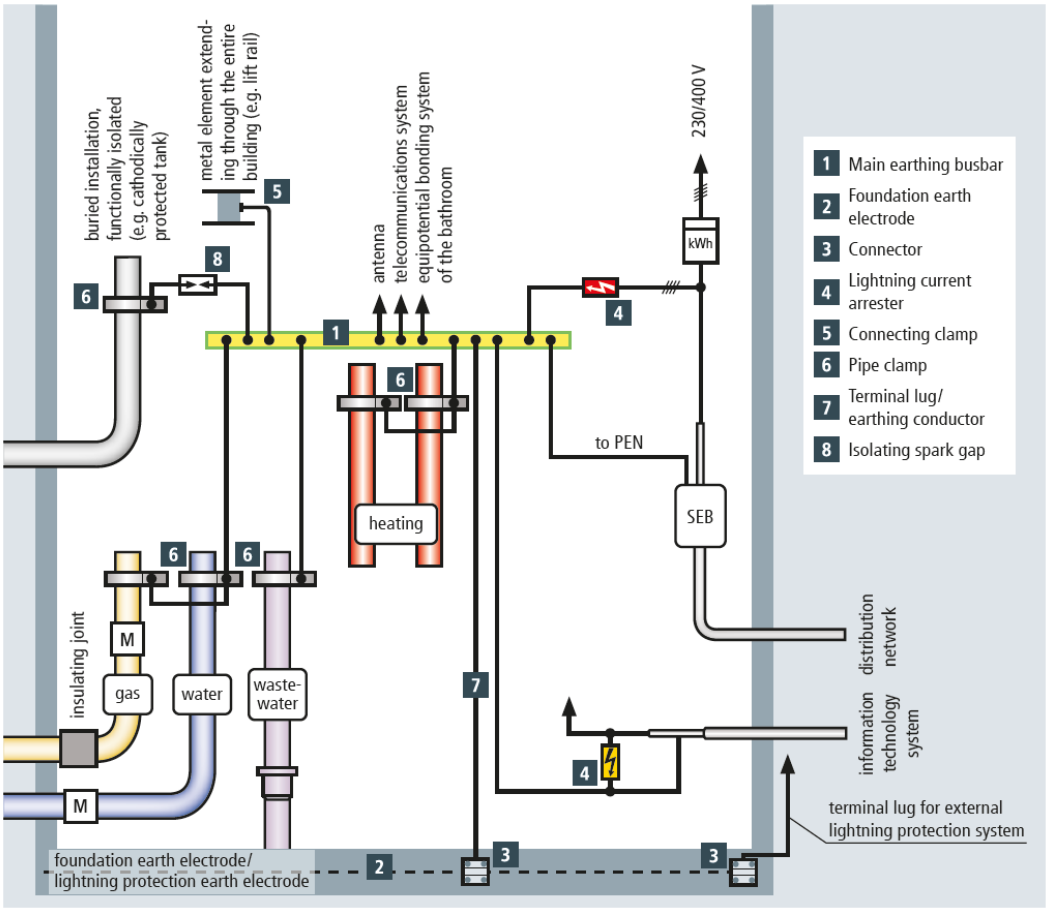


Figure 15: Principle of lightning equipotential bonding consisting of lightning and main equipotential (Figure 6.1.1 in[12])

Different types of equipotential bonding bars and their installation are shown in Figure 16.

In case where direct connection to the bonding bar is not possible, the installation components must be indirectly connected to the main equipotential bonding through isolating spark gaps (e.g., measuring earth in laboratories, if they have to be separate from the protective conductors). During normal operation the spark gap will keep the circuits isolated, and whenever lightning strikes, the spark gap will provide a short-time interconnection.

Lightning equipotential bonding connections shall be made as direct and straight as possible. For external conductive parts, lightning equipotential bonding shall be provided as close as possible to the point of entry into the structure to be protected.

Figure 16: Examples of practical design an installation of equipotential bonding bars

The minimum cross-section values of the bonding conductors connecting different bonding bars and of the conductors connecting the bars to the earth-termination system are listed in Table 12.

Table 12: Minimum dimensions of conductors connecting different bonding bars or connecting bonding bars to the earth-termination system (Table 8 in [3])

Material	Cross-section mm²
Cooper	16
Aluminum	25
Steel	50

The minimum cross-section values of the bonding conductors connecting internal metal installations to the bonding bars are listed in Table 13.

Table 13: Minimum dimensions of conductors connecting internal metal installations to the bonding bar (Table 9 in [3])

Material	Cross-section mm²
Cooper	6
Aluminum	10
Steel	16

According to [17] the minimum cross-section for earthing conductors of antennas is also 16 mm^2 Cu insulated or bare, 25 mm^2 Al insulated or 50 mm^2 steel as they have to withstand lightning currents of up to 100 kA. Fine-wire conductors shall not be used as earthing conductors.

In order to minimize the induction loops within buildings the following is recommended:

- Cables and metal pipes shall ideally enter the building at the same point;
- Power lines and data lines shall be laid spatially close and have to be shielded;
- Avoid unnecessarily long cables by laying lines directly;
- Integration of the cable shields into the equipotential bonding by bonding the shield at both ends. In case when a permanent bonding of the cable shield at both ends is not possible, the shield may be bonded with a spark gap.

2.2.5.2 Sub-system Equipotential Bonding Bar (EBB)

Sometimes supplementary local equipotential bonding is useful. The reason behind is to interconnect all simultaneously accessible parts as well as the stationary operating equipment and also extraneous conductive parts. The goal is to keep any voltage differences between systems as low as possible.

The difference from the main equipotential bonding is the fact that the cross sections of the conductors can be chosen to be smaller, and also this supplementary equipotential bonding can be limited to a specific location. See Table 13 for the minimum cross-section of conductors connecting internal metal installations to the bonding bar. All connections to the bonding bar should be as short as possible and without loops.

2.2.5.3 Internal perimeter earthing bus conductors

Enclosures and racks of electronic equipment and systems should be integrated into the equipotential bonding network with short connections. This requires a sufficient number of equipotential bonding bars and/or ring equipotential bonding bars in the building or structure. The busbars, in turn, must be connected to the equipotential bonding network (Figure 17, Figure 18).

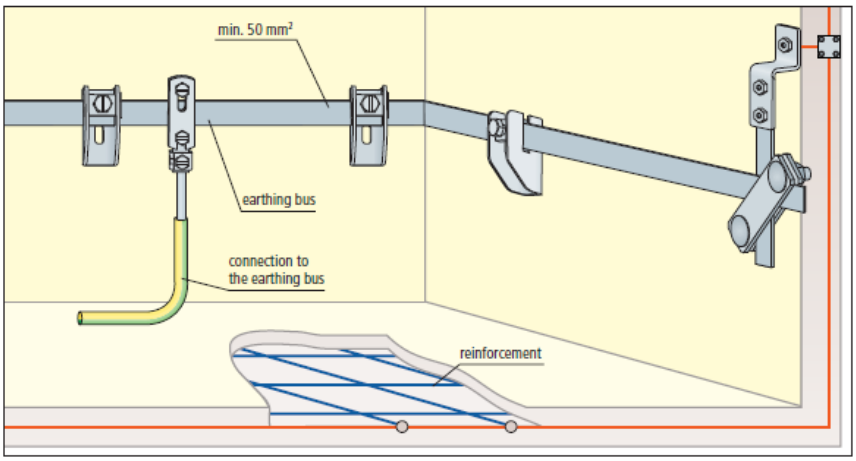


Figure 17: Example of earthing bus going around a room

Figure 18: Connection of the ring equipotential bonding bar with the equipotential bonding network via fixed earthing point

2.2.5.4 Equipment earthing

Protective conductors (PE) and cable shields of the data links of electronic devices and systems must be integrated into the equipotential bonding network in accordance with the system manufacturer's instructions. The connections can be made either of a star-shaped or mesh-shaped (see Figure 19 and Figure 20).

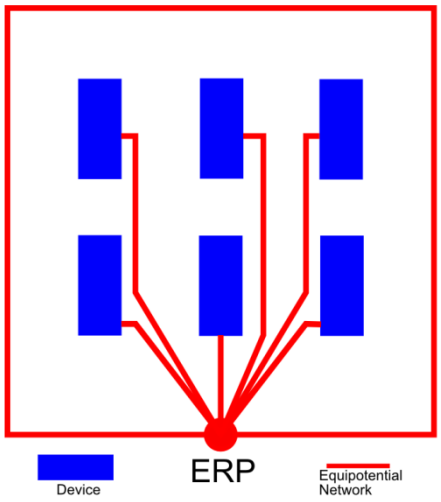


Figure 19: Star-shaped integration of electronic systems into the equipotential bonding network (ERP is the earthing reference point)

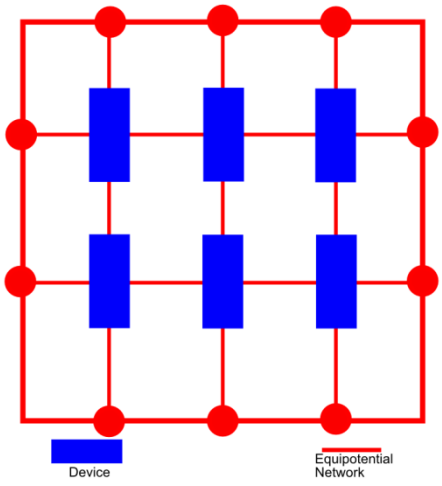


Figure 20: Mesh-shaped integration of electronic systems into the equipotential bonding network

When using a star-shaped arrangement (Figure 19), all metal components of the electronic system must be suitably insulated against the equipotential bonding network. A star-shaped arrangement is therefore usually limited to applications in small, locally confined systems, such as IMS stations. In such cases, all lines must enter the building or structure, or a room within the building or structure, at a single point. The star point arrangement must be connected to the equipotential bonding network at one single earthing reference point (ERP) only.

Proper earthing is also necessary for noise reduction in the electric power system and star shape earthing is recommended. To avoid coupling between power and data lines keep as much physical distance as possible between power and data line cables (install in separate routes or cable trays).

Using shielded cables is very advisable to avoid or reduce electromagnetic interferences. But it is only effective if the cable shield is properly connected to ground on both ends of the cable. So called “Pigtailing” of shields shall be avoided as it may reduce the shielding effect significantly.

When using filters, it is important to identify the source (frequency) of the interference and select or design a filter according to the given source and load impedances. Filter data sheets typically show the attenuation for a 50 Ω source and load impedance. For other values of source or load impedance, the attenuation of a filter may be completely different.

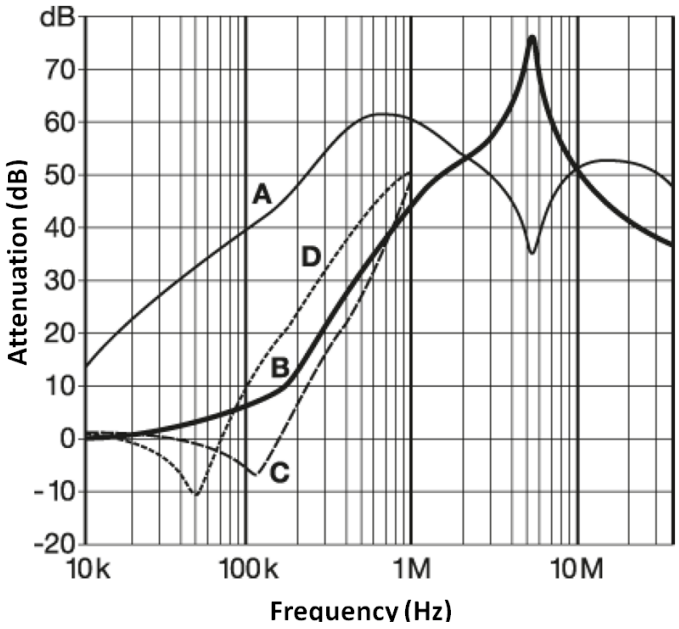


Figure 21: Example of a filter for suppressing common and differential-mode noise on a DC voltage line. Curve A is for 50 Ω/50 Ω sym; B = 50 Ω/50 Ω asym; C = 0.1 Ω/100 Ω sym; D = 100 Ω/0.1 Ω sym

Obviously, this filter would actually amplify (attenuation -10dB) the noise at 50 kHz in configuration D (100 Ω/0.1 Ω sym), demonstrating the need for careful selection of filters in the power supply.

2.2.5.5 Equipotential bonding of AC power service connection and data lines

Equipotential bonding of AC power service connection and data lines as part of the internal lightning protection is an extension of the main equipotential bonding. In addition to all conductive systems, it also integrates the supply conductors (“hot wires”) of the low voltage consumer’s installation and data lines into the equipotential bonding. The special feature of this equipotential bonding is the fact that a tie-up to the

equipotential bonding is only possible via suitable surge protective devices (SPDs). Similar to the equipotential bonding for metallic installations (see section 2.2.5.1), the equipotential bonding for AC power and data line shall also be carried out immediately at the point of entry into the structure.

If the step-down transformer from medium to low voltage is located in the vicinity of the IMS installation the earthing of the medium voltage and low voltage systems shall be interconnected, unless this is contrary to local regulations.

2.2.6 Surge Protection

The protection of electrical and electronic systems in a structure against surges resulting from the Lightning Electro-Magnetic Pulse (LEMP) is based on the principle of Lightning Protection Zones **(LPZ)** [8]

According to this principle, the building or structure to be protected must be divided into a number of internal lightning protection zones according to the level of threat posed by LEMP (Figure 23). This allows categorizing areas of different LEMP risk levels and to adjust protection measures to the immunity of the electronic system.

2.2.6.1 Lightning Protection Zones

Depending on the type of threat caused by the lightning, the following lightning protection zones are defined (see also Figure 23):

External

LPZ 0 Zone where the threat is due to the unattenuated lightning electromagnetic field and where the internal systems may be subjected to full or partial lightning surge current. LPZ 0 is subdivided into:

LPZ 0_A Zone where the threat is due to direct lightning flash and the full lightning electromagnetic field. The internal systems may be subjected to full lightning surge current.

LPZ 0_B Zone protected against direct lightning flashes but where the threat is the full lightning electromagnetic field. The internal systems may be subjected to partial lightning surge currents.

Internal

LPZ 1 Zone where the surge current is limited by current sharing and isolating interfaces and/or by SPDs at the boundary. Spatial shielding may attenuate the lightning electromagnetic field.

LPZ 2…n Zone where the surge current may be further limited by current sharing, isolating interfaces and/or by additional SPDs at the boundary. Additional spatial shielding may be used to further attenuate the lightning electromagnetic field.

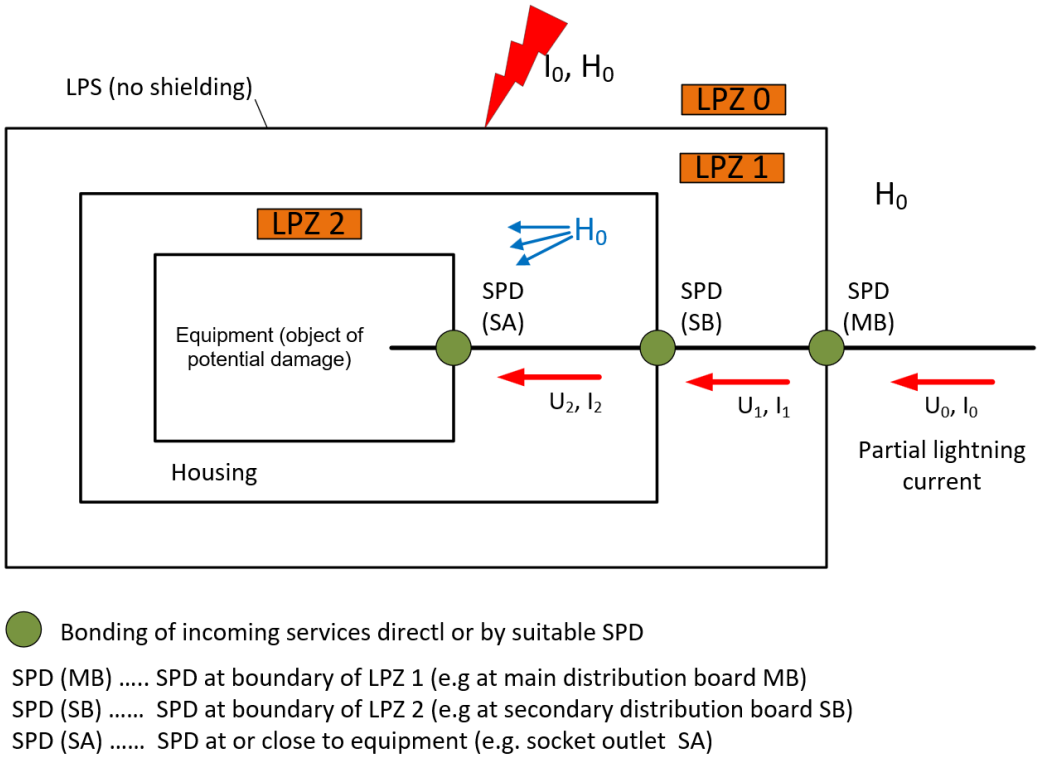


Figure 22: Concept of surge protection using a coordinated SPD system only – Equipment is protected against conducted surges (U_2 << U_0 and I_2 << I_0), but not against radiated magnetic field (H_0)

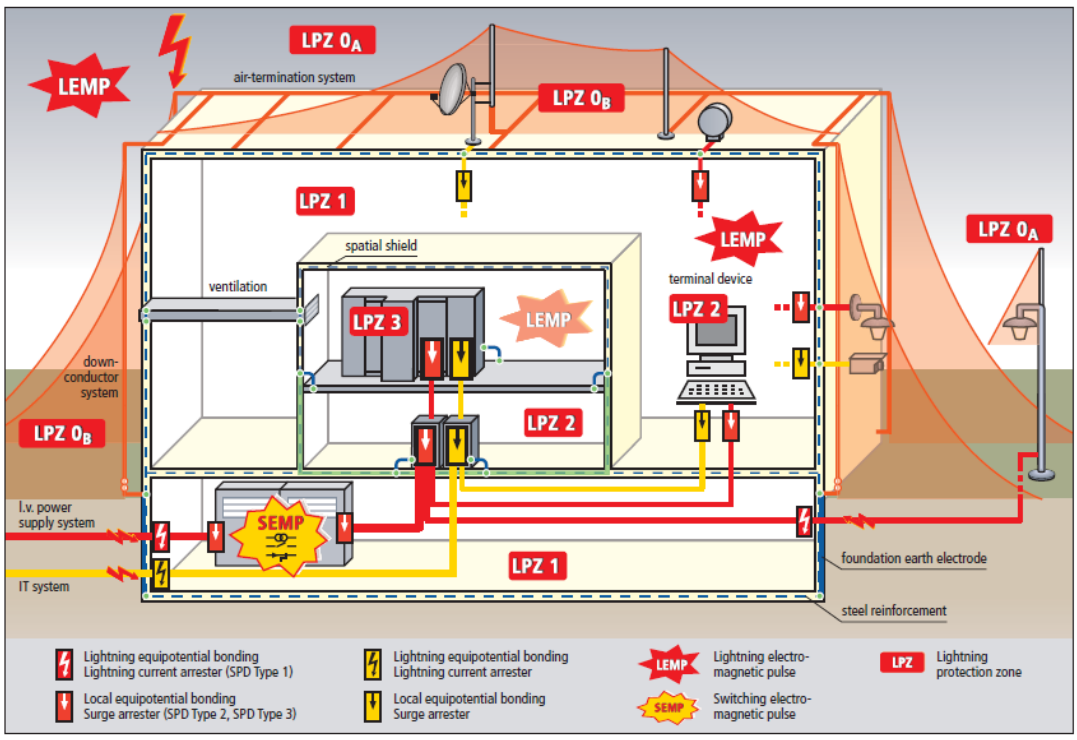


Figure 23: Example of lightning protection zones concept according to IEC 62305-4 (figure adapted from DEHN)

In general, the lightning current arrester from LPZ 0 to LPZ 1 acts as a kind of wave breaker and dissipates a large part of the interference energy, thus protecting the installation in the building from damage. Additional surge protective devices are installed at the LPZ boundary from LPZ 1 to LPZ 2 to ensure a sufficiently low level of residual interference adjusted to the immunity of the terminal device.

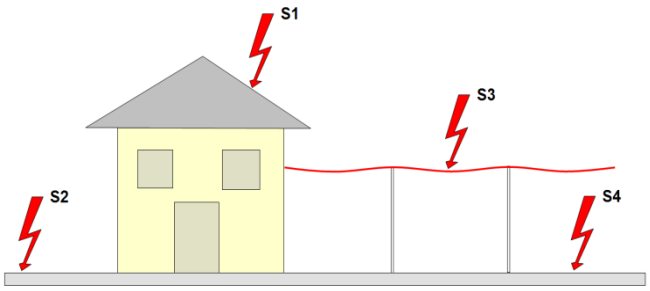
2.2.6.2 Types of overvoltages

Overvoltages (surges) in low-voltage systems are caused by several types of events or mechanisms:

(1) Lightning overvoltages

Lightning overvoltages are the result of a direct strike to or near the power system, structures (with or without lightning protection system) or to the ground. Distant lightning flashes can also induce overvoltages in the circuits of an installation.

Lightning is a natural and unavoidable event that affects low-voltage systems (power systems and signal/communication systems) through several mechanisms. The obvious interaction is a flash to the power system, but other coupling mechanisms can also cause overvoltages (see Figure 24).



S1: flashes to the structure

S2: flashes near the structure

S3: flashes to the services connected to the structure

S4: flashes near the services connected to the structure

Figure 24: Different lightning flash coupling mechanisms to a structure

For a given flash, the severity of the magnitude of overvoltage experienced at the end-user's facility reflects the characteristics of the coupling path, such as the distance and type of system between the strike point and the end-user's facility, earthing practices and earth connection impedance, presence of surge-protective devices (SPDs) along the path, and branching out of the distribution system. All of these factors vary widely based on general utility practices and local configurations.

(2) Switching overvoltages

Switching overvoltages are the result of intentional actions on the power system, such as the switching of loads, inductors or capacitors in the transmission or distribution system by the utility, or in the low-voltage system by end-user

operations. They may also be the result of unintentional events such as power system faults and their correction.

(3) Temporary overvoltages (TOV)

Temporary overvoltages occur in power systems, as the result of a wide range of system conditions, both normal operation and abnormal conditions. Their occurrence is relevant to the selection of suitable surge-protective devices.

TOVs are power frequency overvoltages of relatively long duration (several seconds) and can be caused by faults in the medium and low-voltage networks. The SPD's temporary overvoltage specification (U_T) must be greater than any expected temporary overvoltage of the network. Otherwise, the SPD will be destroyed due to an overload when TOVs occur.

2.2.6.3 Expected surge currents due to lightning flashes

For direct lightning strikes to connected services, the distribution of the lightning current in both directions of the service and the breakdown of the insulation must be taken into account. For example, a 2-wire 0.5 mm^2 cross section data cable will not be able to carry a 100 kA lightning current into a building. Insulation breakdown (cable damage) will occur along the data cable.

When dealing with such complexities, one must keep in mind that the most important aspect when selecting an SPD is its voltage limiting performance during the expected surge event and the energy withstand (I_{imp}, I_{max}, I_n, V_{OC}) that it can handle.

2.2.6.4 Impulse voltage withstand categories of installed equipment

So-called "overvoltage categories' or "impulse withstand categories" I, II, III, and IV are specified in the standards for testing of equipment taking into account the characteristics of the system to which it is intended to be connected.

- Equipment of overvoltage ***category IV*** is for use at the origin of the installation (e.g., electricity meters and primary over-current protection equipment).
- Equipment of overvoltage ***category III*** is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements (e.g., switches, distribution boards, electric wall mounted sockets in the fixed installation and equipment for industrial use with permanent connection to the fixed installation).
- Equipment of overvoltage ***category II*** is energy-consuming equipment to be supplied from the fixed installation (e.g., appliances, portable tools and other household and similar loads. If such equipment is subjected to special requirements with regard to reliability and availability, overvoltage category III applies).
- Equipment of overvoltage ***category I*** is equipment for connection to circuits where measures are taken to limit transient overvoltages to an appropriately low level (e.g., PCs).Table 14 shows the rated impulse voltages for equipment energized directly from the low-voltage mains. Therefore, the installation of appropriate (and coordinated) SPDs shall limit the overvoltages to the values shown in Table 14. For example, on a typical 230/400 V three-phase network,

overvoltage limitation of to 1500 V is required for Category I equipment such as PCs or other sensitive electronic devices.

Table 14: Rated impulse voltage for equipment energized directly from the low-voltage mains (adapted from Table B.1. in [18]*)*

Nominal voltage of the supply system		Voltage line to neutral derived from nominal voltages a.c. or d.c. up to and including (V)	Rated impulse voltage in (V)			
			Overvoltage category			
Three-phase (V)	Single-phase (V)		**I**	**II**	**III**	**IV**
		50	330	500	800	1500
		100	500	800	1500	2500
	120-240	150	800	1 500	2 500	4 000
230/400 277/480		300	1 500	2 500	4 000	6 000
400/690		600	2 500	4 000	6 000	8 000
1 000		1 000	4 000	6 000	8 000	12 000

2.2.6.5 Surge Protection Devices

A ***Surge Protective Device*** (SPD) is a device designed to limit transient overvoltages and divert surge currents and it contains at least one non-linear component.

2.2.6.6 SPD selection

The primary function of SPDs is to protect downstream terminal devices. They also reduce the risk of cable damage. The selection of SPDs depends on the following considerations, among others:

- Lightning protection zones of the installation site (see 2.2.6.1)
- Energy to be dissipated
- Arrangement of the protective devices
- Immunity of the terminal devices
- Protection against differential- and/or common-mode interferences
- System requirements, e.g., transmission parameters
- Compliance with product or user-specific standards, where required
- Adaptation to the environmental conditions / installation conditions.

2.2.6.7 SPD Technologies

SPDs are installed external to the equipment to be protected and are designed to limit overvoltages to levels below the test voltages of equipment listed in Table 14. Under normal conditions, the SPD has no significant influence on the operating characteristics of the systems to which it is applied. Under abnormal conditions (the occurrence of a surge), the SPD responds to surges by lowering its impedance, thereby diverting the surge current through it to limit the voltage to its protective level.

Upon return to normal conditions, the SPD will recover to a high impedance value after the surge and any possible power follow current.

An SPD can fail or be destroyed when surges are greater than its designed maximum energy and discharge current capability. SPD failure modes are roughly divided into ***open-circuit mode*** and ***short-circuit mode***.

In ***open-circuit mode,*** the protected system is no longer protected. In this case, a failure of the SPD is usually difficult to detect because it has almost no effect on the system. To ensure that failed SPD is replaced before the next surge, an indicating device of the SPD failure may be required.

In a ***short-circuit mode,*** the system is severely affected by the failed SPD. Short-circuit current flows through the failed SPD from the power source. Thermal energy can be generated, creating a fire hazard prior to burnout and open circuit. In case the system to be protected has no suitable device to disconnect the failed SPD from its circuit, a suitable, additional disconnecting device may be required for a SPD with short-circuit failure mode.

The main components of SPDs belong to two categories:

(1) Voltage-limiting type, such as varistors, avalanche or suppressor diodes, etc. These SPDs are sometimes referred to as "clamping type" SPDs. Figure 25 shows the response of a typical voltage-limiting SPD to an impulse current (e.g., lightning current) applied via a combination wave generator.

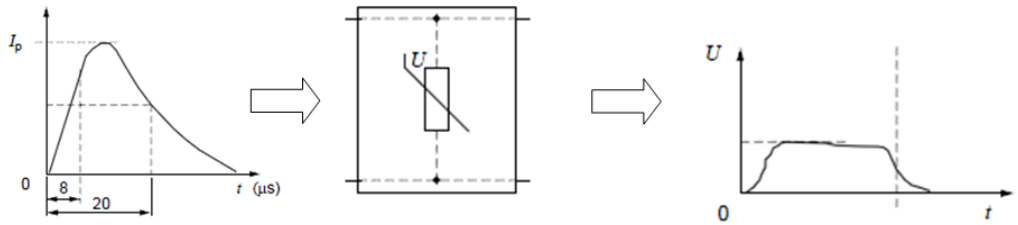


Figure 25: Typical response of a voltage-limiting type SPD such as a varistor

(2) Voltage-switching type such as air-gaps, gas discharge tubes, thyristors, etc. Figure 26 shows the response of a typical voltage-switching SPD to an impulse current applied through a combination wave generator.

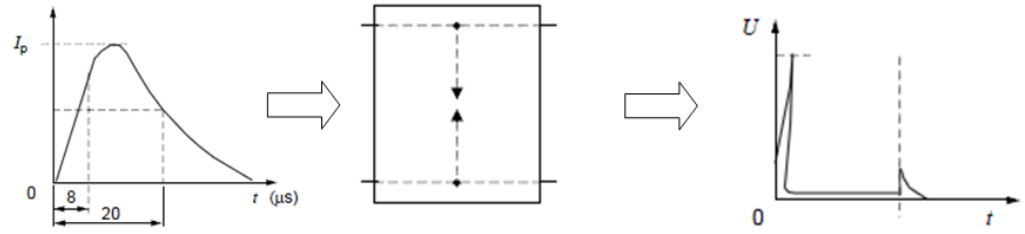


Figure 26: Typical response of a voltage-switching type SPD such as a spark-gap

In practice, combination type SPDs, which include both voltage-switching type components and voltage-limiting type components, are often used.

2.2.6.8 SPD classification (Type 1, 2 and 3)

SPDs used as part of a fixed installation are classified as Type 1, 2 and 3 surge protection devices according to the requirements and stress on the places of installation and they are tested according to [19].

- The highest requirements (Class I test in [19]) in terms of discharge capacity are placed on **Type 1 SPDs**. The Class I test is intended to simulate partial conducted lightning current impulses. Type 1 SPDs are generally recommended for locations at points of high exposure, such as line entrances to buildings protected by lightning protection systems. These protective devices must be capable of carrying partial lightning currents, waveform 10/350 µs, many times without consequential damage to the equipment. Type 1 SPDs are also called ***lightning current arresters*** and the function of these protective devices is to prevent destructive partial lightning currents from penetrating the electrical installation of a structure.

- SPDs tested to Class II or III test methods are subjected to impulses of shorter duration. **Type 2 SPDs** are generally recommended for locations with less exposure to direct impulses. SPDs Type 2 are called ***surge arresters*** and are used to protect against surges resulting from induced voltages in open or closed loops. Their discharge capacity is around some 10 kA (8/20 µs).

- SPDs Type 3: The main function of a **Type 3 SPD** is to protect against overvoltages occurring between L and N in the electrical power system. They can be installed in supply networks where Type 1 and/or Type 2 SDPs are already present. They can be installed in fixed or moveable sockets.

Type 1 SPD | Type 2 SPD | Type 3 SPD

Figure 27: Examples of Type 1, Type 2, and Type 3 Surge Protection Devices for AC power

2.2.6.9 SPDs for information technology systems, RF receivers and GPS

Unlike surge protective devices for AC power supply systems, where uniform conditions can be expected with respect to voltage and frequency in 230/400 V systems, the types of signals to be transmitted in information technology (IT), control and data networks differ in terms of:

- Voltage (e.g., 0 – 10 V)
- Current (e.g., 0 – 20 mA, 4 – 20 mA)

- Signal reference (balanced, unbalanced)
- Frequency (DC, NF, HF)
- Type of signal (analogue, digital)
- etc.

Therefore, the signal must not be influenced intolerably by the use of lightning current and surge arresters in measuring and control installations. Manufacturers of SPDs offer a wide range of surge protection elements with appropriate specifications for many applications (Ethernet, telephone, RS232, RS442, ISDN, etc.).

When selecting SPDs, the following aspects must be especially taken into consideration:

– Protective performance (discharge capacity and protection level)
– System parameters (system voltage, nominal current and transmission parameters)
– Installation environment (design, conditions of connection and certifications)

Guidelines for the selection and testing of surge protective devices connected to telecommunications and signaling networks are given in [20], [21], and in the manufacturers' specifications. IEC 61643-21 [20] specifies test procedures and parameters for IT system SPDs and they must be tested with at least one of the pulses listed in Table 15.

The maximum protection level of a given SPD arisen during these tests is expressed as the voltage protection level U_p measured at the output of the device.

So-called Category C tests represent especially disturbing pulses with a fast rate of rise and less energy (surge arrestors), opposite to the disturbing pulses of category D, which is supposed to simulate high energy loads due to induced partial lightning currents (lightning current arrestors). The category is also indicated in the technical data sheet of the SPDs – both in the description of the discharge capacity (I_n, I_{imp}) and protection level (U_p).

Table 15: Voltage and current impulses for determining the impulse-limiting voltage characteristics of SPDs for IT systems adopted from [20]

Category	Type of test	Impulse voltage	Impulse Current	Minimum number of impulses
C1	fast rate of rise	0.5 kV to 2 kV 1.2/50μs	0.25 kA to 1 kA 8/20 μs	300
C2		2 kV to 10 kV 1.2/50 μs	1 kA to 5 kA 8/20 μs	10
C3		≥ 1 kV, 1 kV/μs	10 A to 100 A 10/1000 μs	300
D1	high energy	≥ 1 kV	0,5 kA to 2,5 kA 10/350 μs	2
D2		≥ 1 kV	0,6 kA to 2,0 kA 10/250 μs	5

Immunity of IT terminal devices to be protected

As part of the electromagnetic compatibility (EMC) tests, electrical and electronic equipment (devices) must have a specified immunity to conducted pulse disturbances (surges). Requirements for immunity and test designs are specified in EN 61000-4-5 [22].

Different electromagnetic environments place different demands on the immunity of equipment. EN 61000-4-5 divides the test levels into four different levels. Test level 1 contains the minimum requirements for the immunity of the terminal equipment. In general, the test level can be found in the equipment documentation or can be obtained from the manufacturer.

Table 16: Test levels of devices according to EN 61000-4-5 [22]

Test levels according to EN 61000-4-5	*Open-circuit test voltage ±10%*
1	*0.5 kV*
2	*1 kV*
3	*2 kV*
4	*4 KV*

SPDs for use in IT systems need to limit conducted and induced interferences to safe values to ensure that the immunity of the terminal device is not exceeded.

Depending on the structure of the building and the protection requirements of the Lightning Protection Zones Concept (see 2.2.6.1), it may be necessary to install lightning current and surge arresters locally separated from each other or in one point of the installation.

Examples of different types of SPDs applicable for coaxial cables (e.g., GPS signals), Ethernet, and low voltage signal lines (e.g., meteorological sensors) are shown in Figure 28.

Coaxial cable (e.g., GPS) Ethernet IT system

Figure 28: Typical SPDs for coaxial cables, Ethernet and IT data lines

2.2.6.10 Protection of GPS receiver

The antenna of the GPS receiver shall be placed within the area protected by a lightning rod or a structure (LPZ 0_B) to avoid any direct lightning strikes to the antenna.

Appropriate SPD for coaxial lines shall be placed at the antenna cable entry into the equipment vault or the building. Alternatively, the SPD can be placed directly at the GPS clock interface. The connection to the common ground of the GPS clock and the SPD should be as short as possible.

Note: Check with the GPS clock manufacturer compatibility of the SPD with the GPS clock specifications to avoid unacceptable signal distortion.

Figure 29: Example of an SPD for coaxial cable with N-connectors

2.2.6.11 Surge protection of photovoltaic (PV) installations

Photovoltaic systems inevitably represent a connection to the electrical installation of a building or technical infrastructure. There are some special features to be considered in the surge protection of PV systems. On the one hand, especially with larger PV systems, a comparatively high open-circuit voltage (> 1000 V) can occur, which depends on the current temperature and solar radiation, and which must not lead to destruction of the SPD. On the other hand, large DC currents, as they occur when the SPD responds to dangerous overvoltages, are much more difficult to interrupt compared to AC currents, since there is no natural zero crossing as with AC currents. PV current sources with their very specific voltage-current characteristics are very different from the source in AC circuits. Special SPDs are therefore needed to protect the DC side of a PV system. The requirements and test procedures for SPDs for PV systems are given in IEC 61643-31[23] and main suppliers of SPDs offer an appropriate set of SPDs for DC applications.

As PV panels are typically installed on locations exposed to lightning (building roof, communication tower, etc.) special attention needs to be given to the surge protection of the inverter or charge controller [24].

Based on the presence or absence of a lightning protection system for the building where the PV panels are installed, three basic situations must be considered:

(1) PV installation without external lightning protection system

(2) PV installation with external lightning protection system and maintained separation distance *S*

(3) PV installation with external lightning protection system and separation distance *S* cannot be maintained

The basic concept of surge protection in case of a PV installation, where separation distances *S* cannot be maintained (e.g., PV panels on a radio tower) is shown in Figure 30. Due to the direct connection of the lightning protection system (radio tower structure) with the PV system, all SPDs are exposed to direct lightning currents and therefore need to be Type 1 SPDs. In other cases, when separation distance *S* is maintained some of the SPDs can be of Type 2.

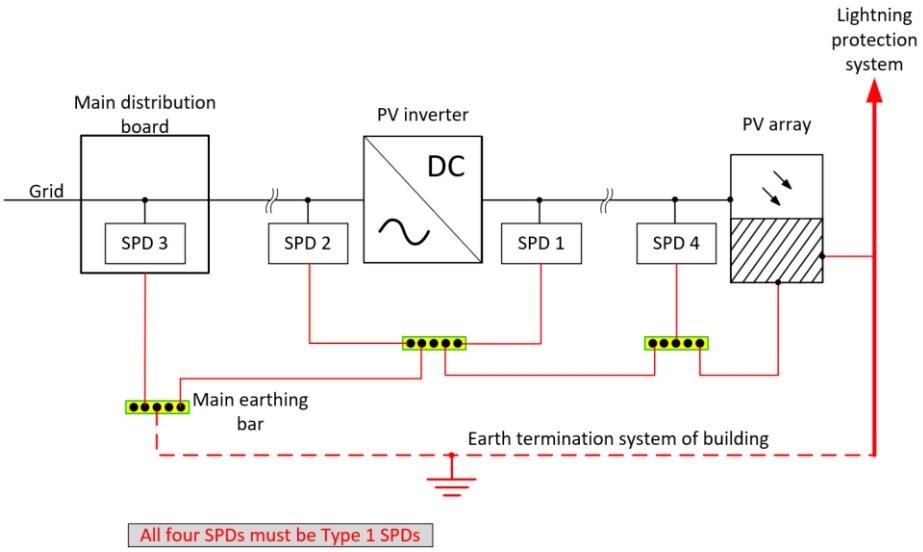


Figure 30: Example of installation of SPDs in the case of a PV-installation with an external LPS where the separation distance (*S*) cannot be maintained (adapted from [24])

NOTE: SPD 2 is not required, if the inverter is installed inside the main distribution board and connected to the same earthing bar

More details on selection and installation of SPDs in photovoltaic installations, either on top of buildings or in the open field, are given in [13].

2.2.6.12 SPD Installation Requirements

- It is highly recommended that the power and signaling networks enter the structure to be protected close to each other and are bonded together at a common bonding bar. This is especially important for structures made of non-shielding materials (wood, brick, concrete, etc.).

- SPD leads and any external connectors connected in series with the SPD should be as short as possible. The residual voltage transferred to the equipment is the sum of the residual voltage of the SPD and the inductive voltage drop along the connecting leads, as shown Figure 31.

  When the SPD in the conductor branch responds, the discharge current flows through further elements (lead conductors, fuses) causing additional dynamic voltage drops U_{dyn1} and U_{dyn2}, respectively, across these impedances (Figure 31), and the protected equipment is exposed to the voltage U_{total}, given by

$$U_{total} = U_{dyn1} + U_{SPD} + U_{dyn2}$$

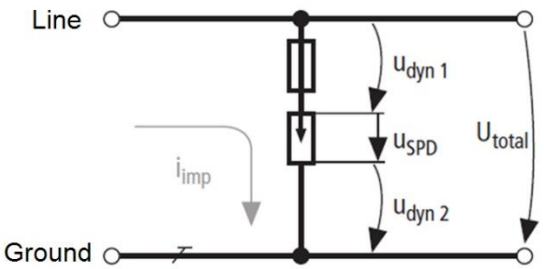


Figure 31: Connection of surge protective devices in cable branches with connecting leads

For a high frequency event as a lightning flash, the resistive component is negligible compared to the inductive component and U_{dyn} is determined by:

$$U_{dyn} = L \ x \left(\frac{di_{imp}}{dt} \right)$$

where L is the inductance of the lead conductor. As a general rule, the lead inductance is assumed to be 1 µH/m. This inductive voltage drop, when caused by an impulse with a rate of rise of 1 kA/µs, will be approximately 1 kV per meter of lead length. Furthermore, if the steepness of di/dt is greater, this value will be increased. To keep this dynamic voltage drop low, the inductance of the connecting cable, and therefore its length, must be kept as short as possible (less than 0.5 m). A preferred connection method is shown in Figure 32.

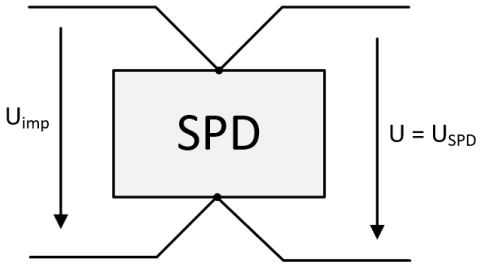


Figure 32: Preferred scheme for SPD connection

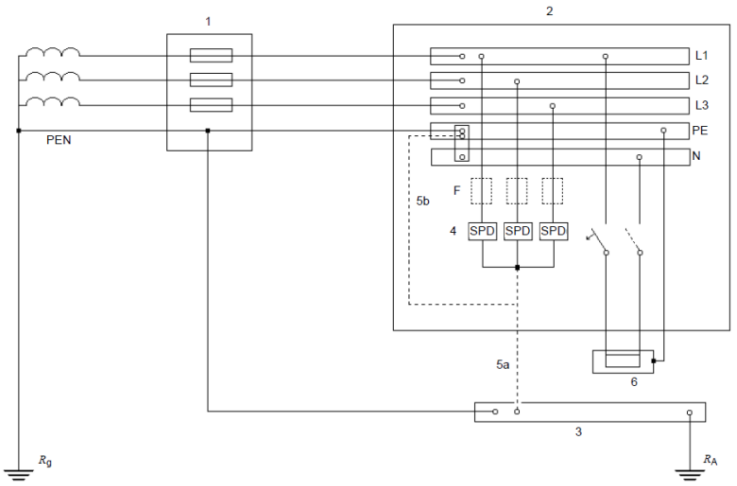
2.2.7 Installation of SPDs in the AC power systems

Due to the short distance between the cable entry point and the equipment in the vault, **combined lightning current and surge arresters** (Type 1 +Type 2 SPD in a single unit) are recommended if low impedance equipotential bonding from the protective device to the terminal device can be assured (e.g., use shielded cable from the combined arrestor to the terminal device).

When using separate Type 1 and Type 2 SPDs in series, coordination of the SPDs is essential to ensure proper share of the surge energy among the SPDs involved. SPD manufacturers offer coordinated product lines and provide information on installation requirements (e.g., minimum cable length between Type 1 and Type 2

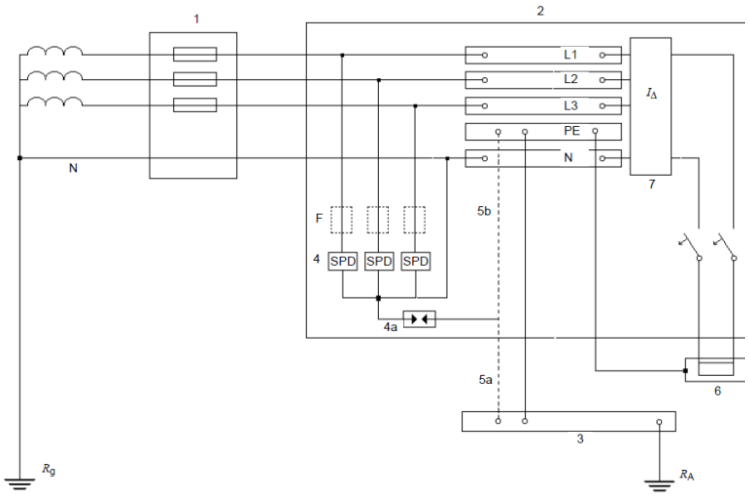
units). Coordination with the local power distribution network operator is required to ensure installation of surge protection devices in line with local regulations and conditions (e.g., before or after the meter or different solutions are applicable in TN, TT or IT distribution network systems).

With respect to system earthing (TT, TN, IT) and position of Residual Current Device (RCD) the SPDs shall be installed as shown in Figure 33, Figure 34, and Figure 35, respectively [25], unless it contradicts local regulations. The main target is to ensure proper operation of the RCD even in case of a damaged SPD.



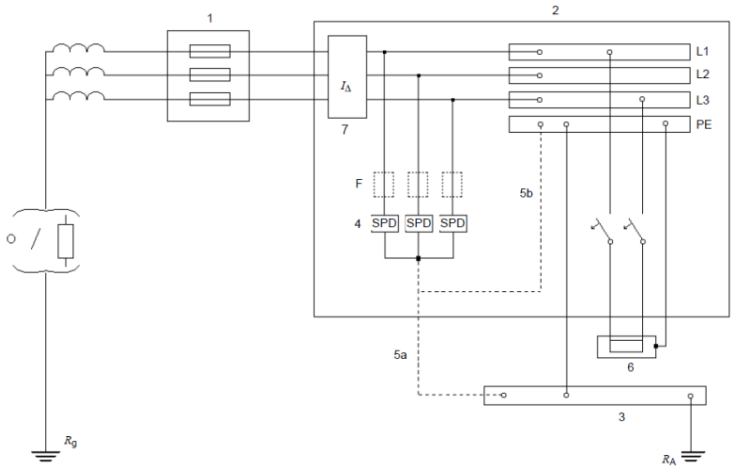
1 Origin of the installation
2 Distribution board
3 Main earthing terminal or bar
4 Surge protective devices
5 Earthing connection of surge protective devices, either location 5a or 5b
6 Equipment to be protected
F Protective device indicated by the manufacturer of the SPD (for example, fuse, circuit-breaker, RCD)
R_A Earthing electrode (earthing resistance) of the installation
R_g Earthing electrode (earthing resistance) of the supply system

Figure 33: Installation of SPD in TN-system



1 Origin of the installation
2 Distribution board
3 Main earthing terminal or bar
4 Surge protective devices
4a Surge protective device in accordance with IEC 60364-5-53 (2.3.2) or spark gap
5 Earthing connection of surge protective devices, either location 5a or 5b
6 Equipment to be protected
7 Residual current protective device (RCD)
F Protective device indicated by the manufacturer of the SPD (for example, fuse, circuit-breaker, RCD)
R_A Earthing electrode (earthing resistance) of the installation
R_g Earthing electrode (earthing resistance) of the supply system

Figure 34: Installation of SPD in TT-system



1 Origin of the installation
2 Distribution board
3 Main earthing terminal or bar
4 Surge protective devices
5 Earthing connection of surge protective devices, either location 5a or 5b
6 Equipment to be protected
7 Residual current protective device (RCD)
F Protective device indicated by the manufacturer of the SPD (for example, fuse, circuit-breaker, RCD)
R_A Earthing electrode (earthing resistance) of the installation
R_g Earthing electrode (earthing resistance) of the supply system

Figure 35: Installation of SPD in IT-system

2.2.8 Installation of SPDs in Telephone/Control/Data Network Circuits and RF communication systems

Lightning equipotential bonding requires that all metal conductive components, such as cable conductors and cable shields, must be incorporated into the equipotential bonding at the entrance to the building to achieve the lowest possible impedances. Examples of such components include antenna lines, telecommunication and control lines with metal conductors. The active lines are connected with the help of elements capable of carrying lightning current (arresters and shielding terminals). A convenient installation site is the point where cabling enters the building. Both the arresters and the shielding terminals must be selected according to the expected lightning current parameters.

The individual cables must be integrated into the equipotential bonding as follows:

- Unshielded cables must be connected by SPDs which are capable of carrying partial lightning currents (the expected partial lightning current per wire is the partial lightning current of the line divided by the number of individual wires).
- If the cable shield is capable of carrying lightning currents, the lightning current will flow through the shield. However, capacitive/inductive interference can penetrate the shield and reach the wires and make it necessary to use surge arresters.
    - The shield must be connected to the main equipotential bonding at **both ends** to be able to carry lightning currents.

Figure 36: Shield connection system capable of carrying lightning currents

Whenever possible all external equipment (antennas, sensors, etc.) should be installed within LPZ 0_B, i.e., they should be placed within the protected area of some lightning protection rods or protected areas provided by structural components (e.g., radio tower).

When implementing measures for the protection against disturbances resulting from direct, nearby, and distant lightning strikes, it is recommended to apply a multi-stage coordinated protection concept. This reduces step-by-step the high energy interference (partial lightning current) because an initial energy absorbing stage (LPZ 0/LPZ 1) prevents the main part of the interference from reaching the downstream system. The subsequent stages (LPZ 1/LPZ 2) serve to reduce the interference to levels that the system can handle.

As fiber optic links are immune to any electromagnetic interferences it is recommended to use this type of data link whenever possible.

3 CTBTO/IMS Specific Part

This part complements Section 2 and describes specific requirements for the protection of IMS field installations. The protection of the Central Recording Facility (CRF) and the remote elements is discussed, as well as some technology specific issues.

3.1 Classification of CTBTO/IMS stations

3.1.1 Classification in terms of lightning exposure

The CTBTO/IMS stations are installed at geographical locations with different exposure to lightning. With respect to their location, the stations can be separated in two classes, Class A and Class B.

Class A: **Lightning Exposed**

Lightning is not an uncommon event in the region and therefore all protection measures (SPDs, equipotential bonding, etc.) should consider direct lightning at the site or to an incoming service (e.g., use SPD Type I at the entry points of service lines and install a lightning protection system).

With regards to the Lightning Protection Level (LPL) defined and used in IEC 62305, an LPL II should be considered as the standard for CTBTO/IMS Class A stations, since there is no risk of explosion and loss of human life involved in a typical unmanned IMS stations.

Class B: **None or very little lightning activity**

Lightning is not expected in the region or is an exceptional event. External lightning protection is not required, but typical surge protection and equipotential bonding measures as for Class A sites are recommended, with the only difference that the installation of Type 2 SPDs (see section 2.2.6.8) at the entry point of the service lines is sufficient.

Because reliable data on ground flash density or annual thunderstorm days are not publicly available for many locations, the classification should also be based on information from local authorities.

Class B should only be used, when the local authorities confirm the absence of any lightning activity. The budget differences in the protection measures for Class A and Class B stations are relatively small compared to the total value of installed equipment. The consequences of increased failure rates and repair costs do not justify accepting any lightning risk.

3.1.2 Classification in terms of Lightning Protection Zones

For a typical CTBTO/IMS site application of LPZ 0_A, LPZ 0_B, LPZ 1 seems sufficient with the following specifications:

- LPZ 0_A: Exterior of the site
- LPZ 0_B: Outside areas protected against direct lightning strikes either by extra lightning rods or by IMS station construction elements (e.g., radio tower)
- LPZ 1: Inside the equipment vault or the CRF

At the boundary between LPZ 0_A and LPZ 1, lightning current arrestors (Type 1 SPDs) shall be used, while at the boundary between LPZ 0_B and LPZ 1, surge arrestors (Type 2 SPDs) shall be used.

If the expected lightning strike rate is very high, the implementation of an additional zone LPZ 2 inside the CRF building is highly recommended.

3.2 Mains power supply of CRF and elements

3.2.1 Surge protection of MV transformer

The electrical energy for the CRF can either come directly from the local 110 V, 220 V, or 230 V power supply network, or it can be supplied from the medium-voltage (MV) network (e.g., 6 kV, 10 kV) with its own transformer at the CRF site.

In the case of a MV transformer, the transformer is typically specified, owned, operated and maintained by the local power utility. It is always advisable to install arresters on both sides of transformers, especially in areas with high thunderstorm activity.

The earthing arrangement at the transformer depends on the type of transformer installed, and the treatment of the MV star point connection (earthing and LV earthing (PEN)) needs to be arranged with the local power utility and according to local regulations.

Metal Oxide (MO) surge arresters are typically used in MV networks. For the correct choice of MO surge arresters, the treatment of the transformer neutral and the fault conditions in the system determine the continuous operating voltage U_c. MO surge arresters are specified in [26] and as they are part of the insulation coordination of the MV network, they should always be specified either by the local power utility itself or approved by the MV line operator if installed by the customer. Examples of MV surge arresters are shown in Figure 37.

U_c Continuous operating voltage	U_r Rated voltage	Residual voltage U_{res} in kV peak at specified impulse current									
		wave 1/…µs		wave 8/20 µs					wave 30/60 µs		
kV	kV	5 kA	10 kA	1 kA	2.5 kA	5 kA	**10 kA**	20 kA	125 A	250 A	500 A
rms	rms	peak	peak	peak	peak	peak	**peak**	peak	peak	peak	peak
4	5.0	14.5	16.0	11.7	12.4	13.1	**14.0**	15.9	10.4	10.8	11.1
6	7.5	21.7	24.0	17.5	18.5	19.6	**21.0**	23.9	15.6	16.1	16.6
8	10.0	28.9	32.0	23.3	24.7	26.1	**28.0**	31.8	20.8	21.5	22.2
10	12.5	36.1	39.9	29.1	30.8	32.6	**35.0**	39.8	25.9	26.8	27.7
12	15.0	43.3	47.9	34.9	37.0	39.1	**42.0**	47.7	31.1	32.2	33.2
14	17.5	50.5	55.9	40.7	43.2	45.6	**49.0**	55.7	36.3	37.5	38.8
16	20.0	57.7	63.9	46.5	49.3	52.1	**56.0**	63.6	41.5	42.9	44.3
18	22.5	64.9	71.9	52.3	55.5	58.6	**63.0**	71.6	46.7	48.2	49.8
20	25.0	72.1	79.8	58.1	61.6	65.1	**70.0**	79.5	51.8	53.6	55.3
22	27.5	79.4	87.8	64.0	67.8	71.7	**77.0**	87.4	57.0	59.0	60.9
24	30.0	86.6	95.8	69.8	74.0	78.2	**84.0**	95.4	62.2	64.3	66.4
26	32.5	93.8	103.8	75.6	80.1	84.7	**91.0**	103.3	67.4	69.7	71.9
28	35.0	101.0	111.8	81.4	86.3	91.2	**98.0**	111.3	72.6	75.0	77.5
30	37.5	108.2	119.7	87.2	92.4	97.7	**105.0**	119.2	77.7	80.4	83.0
32	40.0	115.4	127.7	93.0	98.6	104.2	**112.0**	127.2	82.9	85.7	88.5
34	42.5	122.6	135.7	98.8	104.8	110.7	**119.0**	135.1	88.1	91.1	94.1
36	45.0	129.8	143.7	104.6	110.9	117.2	**126.0**	143.1	93.3	96.4	99.6

Figure 37: Examples of a MV surge arresters (POLIM-D from ABB™) with its technical specifications regarding electrical data available for different operating voltages ranging from 4 kV to 36 kV

3.2.2 Buried cables

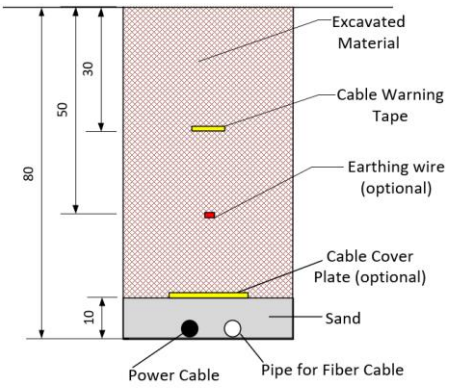
If buried cables are used for the power connection between the CRF and the elements, the following points should be considered;

- Wire cross sections must be sufficient to ensure a maximum voltage drop of 5% at the end of the cable under normal load.

- Only cables suitable for direct burial in the ground should be used. Figure 38 shows an example of a very reliable installation of power cables and ducts for fiber optic cables in the ground. The final installation of cables along extended routes between the CRF and elements depends on local conditions (soil consistency) and electrical codes and power utility regulations, as well as the method used to bury the cable (e.g., using a cable-laying plow).

- Cables with a proper shield of concentric conductors of copper wires and overlapping copper tape, with the shield connected to the local earthing system at both ends, will reduce the risk of lightning surges and other electromagnetic interferences. The cross-section of the cable shield must be sufficient to carry the lightning current in the event of a direct strike to the cable. An example of such a cable is e.g., the E-XYCY type cable with a 16 mm^2 shield shown in Figure 39.

- The cable shield must be connected to ground at BOTH ends to the local main bonding bar (MBB), ideally in the most direct way as shown in Figure 40.

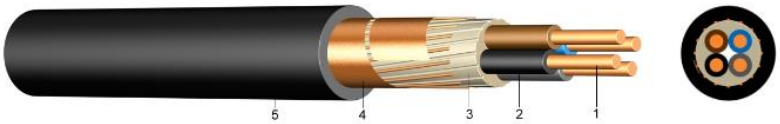


- The floor of the tilt must be free of stones.
- For road crossings, the cables must be laid in a cable conduit of a diameter of 100 mm at a depth of one meter.
- Cable cover plates provide extra protection and should be used in urban areas, where there are high chances of excavations along the cable route.

Figure 38: Best practice for buried power line cables and ducts for fiber optic cables

E-XYCY **PVC Insulated Cable with Concentric Conductor Screen Cross Section 16 mm² and Coppertape**

Application: In dry, humid and wet locations, cable ducts, outdoors, underground and in water.



Construction:
1 ..... solid (RE) or stranded (RM/SM) bare copper
2 ..... core insulation of polyvinylchloride (PVC)
3 ..... PVC core covering or taping
4 ..... concentric conductor of copper wires and overlapping copper tape
5 ..... outer sheath of polyvinylchloride (PVC) black , UV-resistant

Figure 39: Example of a shielded power cable with a 16 mm^2 screen

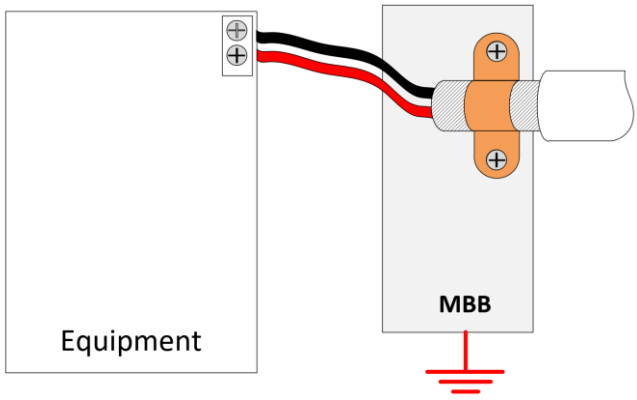


Figure 40: Connecting cable shields to main bonding bar (MBB)

3.3 Protection of the Central Recording Facility

The CRF is usually located in a separate building or in a dedicated room of an existing building. The design of the LPS for the CRF installation shall comply with standard IEC 62305, LPL II.

3.3.1 Air Termination system and down-conductors

A typical air termination and down conductor system design for a small office building with two down conductors placed at diagonal corners is shown in Figure 41.

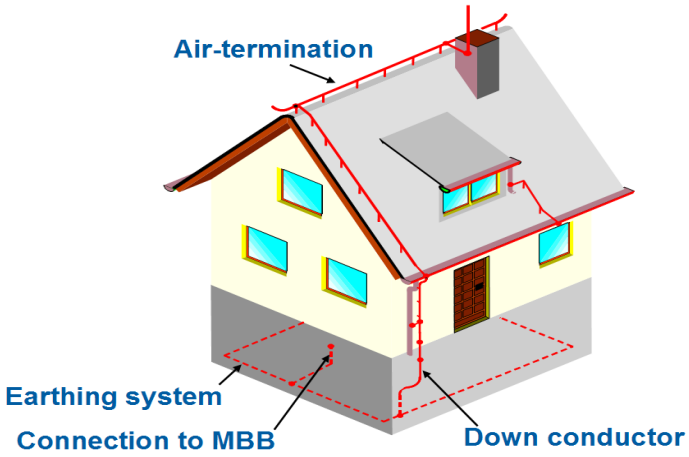


Figure 41: Typical external LPS of a small office building

As an alternative to the system of horizontal air-termination conductors on the roof of the building shown in Figure 41, protection may be provided by vertical lightning rods of a sufficient height to place the building within the protected volume.

3.3.2 Earth termination system

Foundation earth electrodes shall be the preferred earth electrode system for buildings. When properly installed, the electrodes are encased in concrete on all sides and are therefore corrosion resistant. Due to the large area covered by this type of electrode, low earth resistance can be achieved. The hygroscopic properties of concrete generally produce a sufficiently low earth electrode resistance.

The foundation earth electrode must be installed as a closed ring in the strip foundation or the bed plate and thus also acts as the primarily equipotential bonding (Figure 42, Figure 43). For larger buildings (exceeding dimensions of 20 m in size), it is necessary to divide the earthing into meshes ≤ 20 m x 20 m. The required connection lugs for connecting the down conductors of the external lightning protection and the main equipotential bonding to the earthing system must be taken into account.

Figure 42: Preparation of foundation earth electrode (spaces ensure that electrodes are enclosed on all sides by concrete)

Figure 43: Foundation earth electrode in use

Terminal lugs from the outside into the soil must have additional corrosion protection at the point where it enters the soil. Suitable materials are, for example, plastic sheathed steel wire high-alloy stainless steel, Material No. 1.4571, or fixed earthing terminals.

If a foundation earth electrode is not possible, a ring electrode should be installed. When selecting the material of the earth electrode with regard to corrosion, the local conditions must be taken into account. It is advantageous to use stainless steel.

If the CRF is installed in a dedicated room of an existing building where the earth termination system does not comply with LPL II requirements, the earth termination system must be upgraded to comply with LPL II.

3.3.3 Equipotential bonding system

Equipotential bonding shall be done according to section 2.2.4.

3.3.4 Surge protection

All incoming and outgoing cables must be protected by appropriate SPDs at the entrance to the building (LPZ $0_{A,B}$ / LPZ 1 – boundary).

If LPZ 2 is required, the CRF equipment must be installed in a metal rack that defines the volume of the LPZ 2. Appropriate SPDs must be installed on all lines crossing this boundary

Special attention should also be paid to equipment that is not part of the IMS station but is connected to the IMS station equipment by power or signal connections.

In the case of a dedicated room, the room boundaries define the LPZ 1 volume and appropriate SPDs shall be installed on all lines crossing this boundary.

3.4 Protection of the remote elements

The remote elements shall be protected against direct lightning and lightning induced surges according to the concept of lightning protection zones. The main equipment shall be located in the LPZ 1. Some outdoor equipment (antennas and radio modems) shall be located in LPZ 0_B and no equipment shall be installed in the LPZ 0_A.

The protection zones at remote elements are shown in Figure 44 and Figure 45. The boundary between LPZ 0_A and LPZ 0_B is defined by the protection zones, calculated for the LPL II, provided by the communication towers, power transmission line poles or installed lightning attractors. The boundary between LPZ 0_B and LPZ 1 is defined by the SPDs at the entrance to the equipment vault.

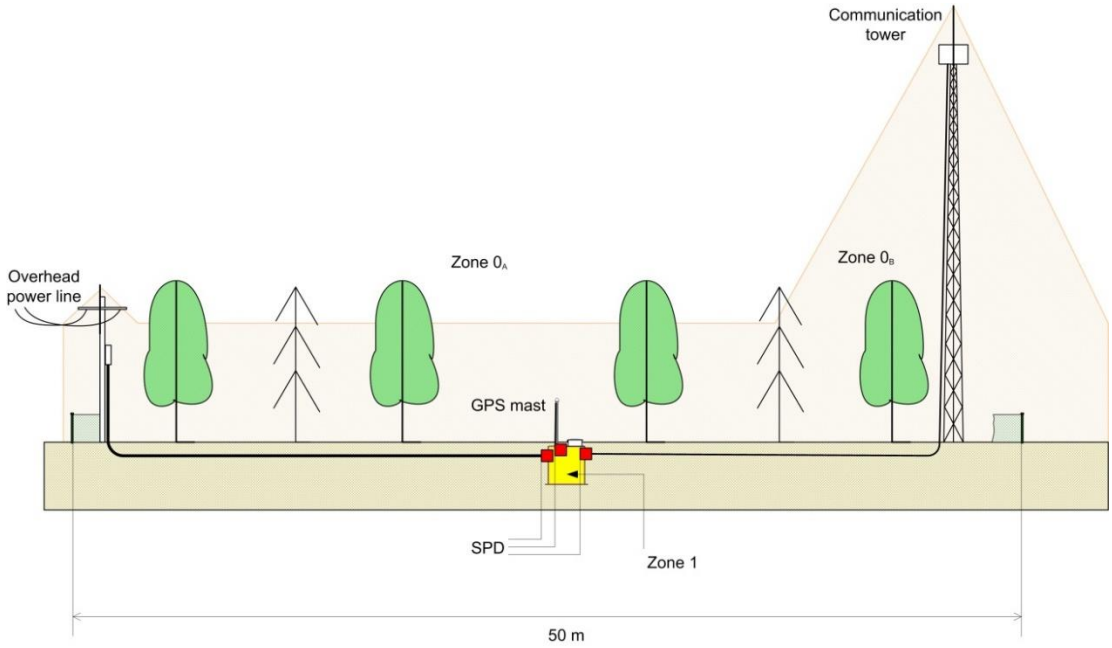


Figure 44: Example for LPZ for an infrasound remote element (Note: it is assumed in this example that trees provide certain protection against direct strikes to installations at ground level)

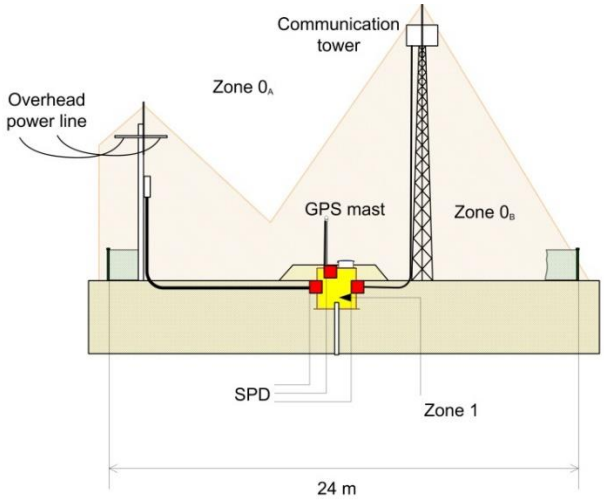


Figure 45: Example of LPZ for a seismic remote element

A schematic LPZ concept and corresponding SPD installations for a remote element is shown in Figure 46. All lines entering the equipment vault are protected by SPDs and the GPS antenna and meteorological sensors are located in LPZ 0_B.

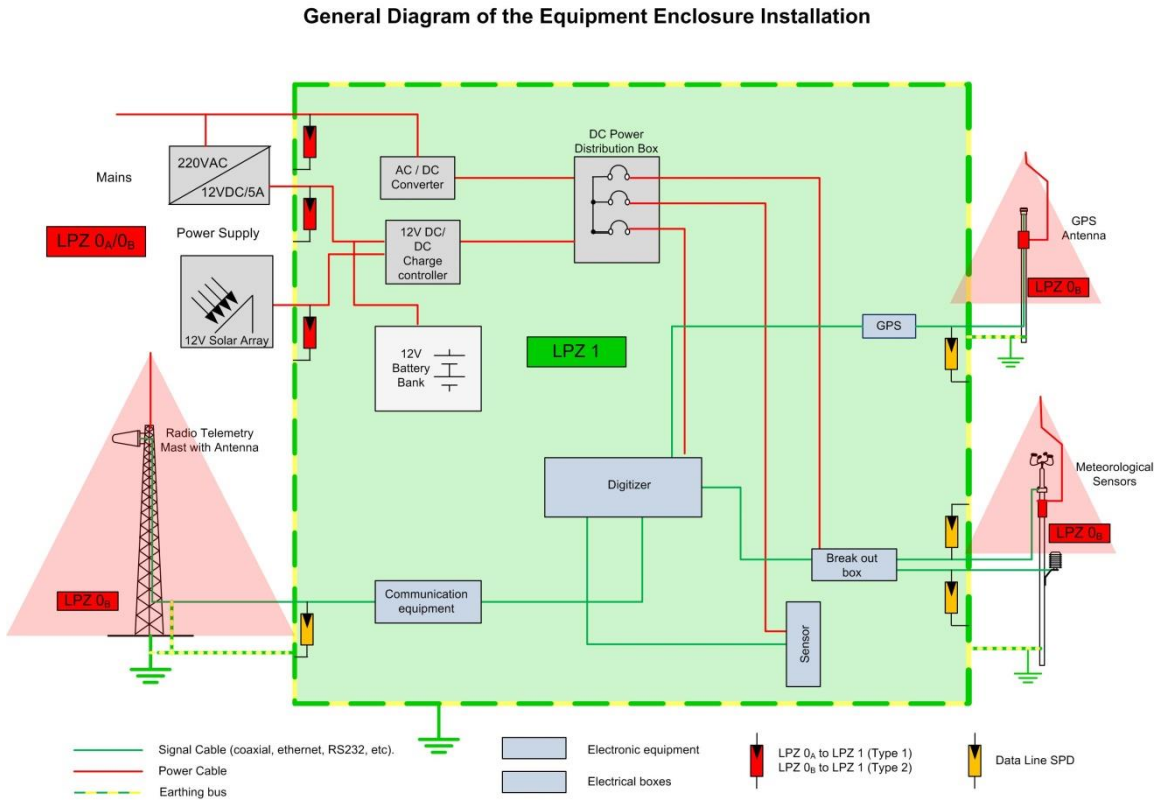


Figure 46: Lightning protection concept of an IMS station (schematic)

3.4.1 Air termination system

All electronic equipment, including solar panels, GPS and RF antennas, and meteorological stations, installed at remote elements shall be located within LPZ 0_B. This zone LPZ 0_B is provided either by existing installations (e.g., radio tower) or additionally installed lightning rods. Protection angles are applied according to LPL II (see section 2.2.1).

Figure 47: Example of air-termination for RF antenna at an IMS station

3.4.2 Down-conductors

Down-conductors on radio towers are not required except in case of lightning air-termination installed on non-conductive structures (e.g., wooden or fiber glass masts). When such non-conductive structures are used, the size and material of the down conductor shall meet the requirements of section 2.2.1.1.

In typical IMS installations, the required separation distance between the lightning current carrying metal structure of the tower and the installed equipment (solar panels, antennas, etc.) is not maintained. Therefore, SPD Type 1 should be installed at the entry of antenna lines or other cables into the interior of the station.

3.4.3 Earth-termination system

The earthing of the remote elements should be designed in order to provide (a) an equipotential plane and (b) low resistance to ground. Figure 48 and Figure 49 show two examples of a recommended design of the earthing system for CTBTO/IMS array elements. As the size, the distances and the relative position between the tower, the equipment vault and the fences may vary from site to site, the following main aspects should be considered:

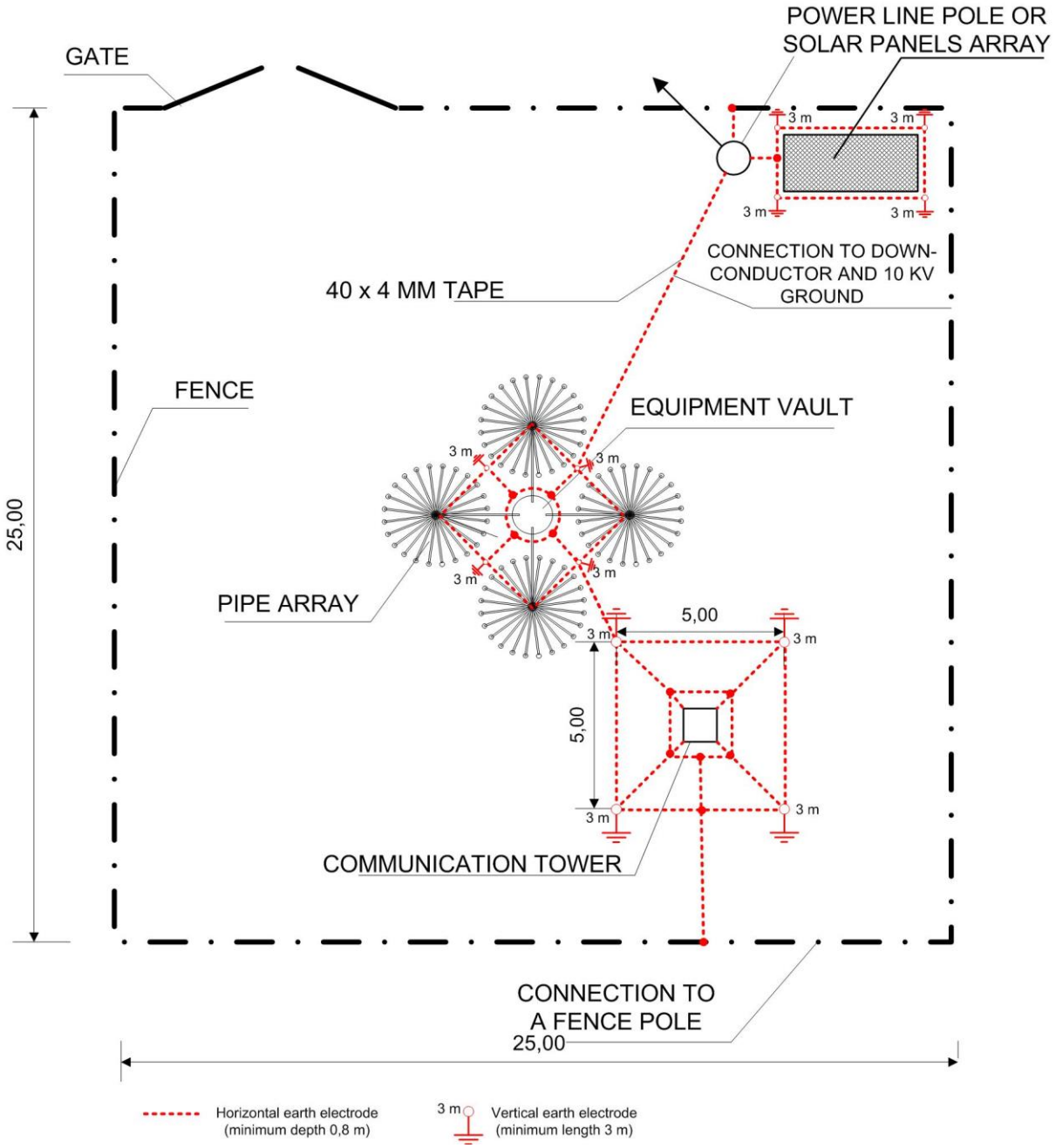


Figure 48: Example of schematic design of earth termination system for an IMS infrasound array element with noise reduction system made of metal. A minimum of 4 earthing rods per structure (communication tower, equipment vault, and solar panel array) shall be installed

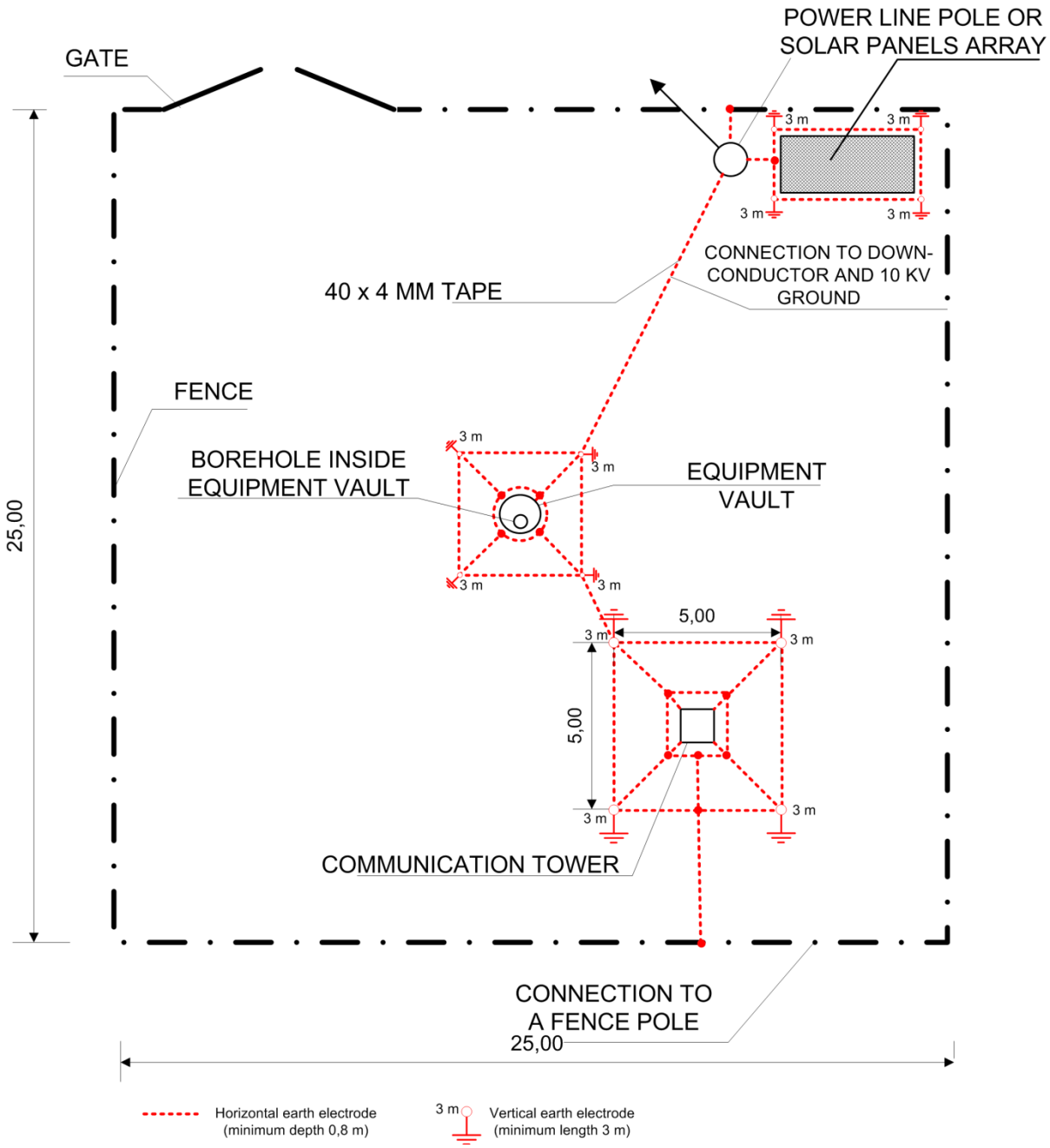


Figure 49: Example of schematic design of earth termination system for an IMS seismic array element. A minimum of 4 earthing rods per structure (communication tower, equipment vault, and solar panel array) shall be installed

Create a single integrated earthing systems for the tower and equipment vault (about 5 m x 5 m mesh)

- Ring conductors (distance about 1 m) around the tower and the equipment vault shall be used to control step voltages in the vicinity of the structures
- Vertical ground rods shall be used when they will provide a significant and cost-effective reduction in earthing resistance (e.g., when they reach the ground water level or other well conducting soil layers).

Ensure a low impedance connection between the tower and the vault and/or building parallel to the cables.

To minimize potential differences all metal parts on the IMS site (e.g., tower base, guy wires, GPS and meteorological mast, solar panel frames, conductive fences, borehole casing, etc.) shall be connected to the earth termination system.

Selected material and dimensions for the earthing system according to section 2.2.3.1.

3.4.4 Equipotential Bonding system

Equipotential bonding at the remote elements shall be provided in accordance with section 2.2.5 by installing SPDs on all incoming and outgoing cables and properly connecting cable shields at the cable entry point, as well as by interconnecting the equipment chassis.

To reduce the potential difference between the tower and the vault, the following may be used:

- Several parallel bonding conductors running in the same paths as the electrical cables, or the cables enclosed in grid-like reinforced concrete ducts (or continuous bonded metal conduit) integrated into both of the earth-termination systems.
- Shielded cables with shields of adequate cross-section and bonded at both ends to the separate earthing systems.
- Cables should be routed within the tower structure whenever possible (reduces induction effects).

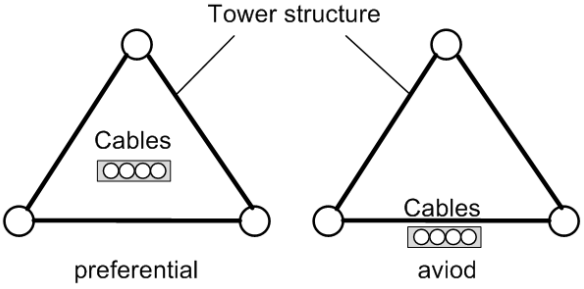


Figure 50: Preferential cable routing along a tower of triangular cross profile

3.4.5 Surge Protection

The Surge Protective Devices (SPD) shall be installed according to section 2.2.6 at the entrance of all incoming cables to the equipment vault (boundary of the LPZ 0_B to LPZ 1). Examples are shown in Figure 46 and Figure 51.

Figure 51: Example of SPDs installed at the entrance of incoming cables to the equipment vault

3.5 Technology Specific Situations

3.5.1 Seismic Monitoring Stations

The main specific part of the seismic monitoring station is the presence of the borehole (up to a depth of 60 m or more) at the remote elements. The casing of this borehole must be integrated with the earth termination system. The borehole casing will provide a perfect earthing electrode and defines the achievable earthing resistance at the site. It should be noted, that this casing does not completely replace the earth termination system described above as the earthing system (e.g., ring electrode around the IMS station) supports potential control (reduction of step and touch voltages) at the surface adjacent to the object.

Figure 52: Borehole at an IMS seismic monitoring station with earthing conductor

3.5.2 Infrasound Monitoring Stations

The main specific part of the infrasound monitoring station is the presence of a wind noise reducing pipe array (see Figure 53) at the remote elements. In the case of an electrically conductive pipe array, it must be integrated with the earth termination system. It should be noted, that this does not replace the earth termination system described above.

Figure 53: Pipe array at an infrasound station, partly filled by soil

To prevent electrical sparking between a WNRS (Wind Noise Reduction System) made of metal pipes and the micro-barometer or cables crossing the incoming pipes, all four metal pipes entering the equipment vault shall be bonded to the Main Bonding Bar (MBB) with an earthing wire according to Table 12 (e.g., 16 mm^2 copper).

3.5.3 Hydroacoustic Monitoring Stations

There are two types of hydroacoustic stations, using different sensing techniques: hydrophone and T-phase.

Hydrophone sensors are underwater microphones at depths of 600 to 1200 m that convert changes in water pressure caused by sound waves into electrical signals that can then be measured.

T-phase stations are located on oceanic islands with steep slopes. They use seismic sensors to detect waterborne acoustic energy, which is converted to seismic waves (T-phases) when hitting land.

No specific situation is foreseen for T-Phase Monitoring Stations. The protection requirements for Hydroacoustic (Hydrophone) stations are covered by the protection requirements for the CRF.

3.5.4 Radionuclide Monitoring Stations

There are no specific requirements for radionuclide monitoring stations. All buildings and objects shall be protected by a lightning protection system of LPL II according to

IEC 62305-3 standard. Air samplers and meteorological sensors shall be located in the protected area of the air termination system or protected structure (LPZ 0_B) to avoid any direct strikes to the technical equipment. Surge protection for power and data lines must be installed at the interfaces of the LPZs. An example of a lightning protection system for a radionuclide monitoring station is shown in Figure 54.

Figure 54: Lightning protection of a radionuclide monitoring station by a metallic tower providing protected volume for the satellite antenna and equipment container

3.5.5 Digital meteorological stations

When installing a meteorological station (either analog or digital), the need for lightning and surge protection for the met-station must be considered.

External lightning protection:

(a) If there is a risk of direct lightning strikes to the met-station, it is advisable to find a location for the met-station within the lightning protected area of another object at the site (building, radio tower, etc.). As long as the met-station is within the protected area, there is no need for additional measures against direct lightning strikes to the met-station.

(b) If the met-station is exposed to direct lightning strikes, it should be protected by an additional lightning rod as shown in Figure 55.

Figure 55: Examples of lightning rods providing sufficient area of protection for a met sensor

For GMX500, the manufacturer recommends that the GMX digital & signal ground be isolated from the cable shield. Shielded twisted pair cable (data and power) must be run in a metal pipe or metal conduit that is connected at BOTH ends to the local earthing.

To prevent damage to the digitizer input or other equipment (power supplies, data modems, etc.), the cables entering the vault must be protected by SPDs.

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Annex A *Maintenance and inspection of the Lightning Protection System*

A.1 General

The purpose of the LPS inspections is to ascertain that:

- the LPS conforms to the originally specified design;
- all components of the LPS are in good condition and capable of performing their intended functions, and that there is no corrosion;
- any recently added services or constructions are properly incorporated into the LPS.

Inspections should be performed:

- during the construction of the structure, in order to check the embedded electrodes that will become inaccessible;
- after the installation of the LPS;
- periodically at intervals determined by the nature of the structure to be protected, i.e., corrosion problems and the class of LPS;
- after alterations or repairs, or when it is known that the structure has been struck by lightning.

During the periodic inspection, it is especially important to check for the following:

- deterioration and corrosion of air-termination elements, conductors and connections;
- corrosion of earthing electrodes;
- earthing resistance value for the earth-termination system;
- condition of connections, equipotential bonding and fixings.

A.2 Recommended frequency of inspection

For class II LPS, IEC 62305-3 recommends a visual inspection at least annually. A full inspection (including measurements and component tests) is recommended every 2 years.

A.3 Visual inspection

Visual inspections should be performed to ensure that:

- the LPS is in good condition;
- there are no loose connections and no accidental breaks in the LPS conductors and joints;
- no part of the system has been weakened by corrosion, especially at ground level;
- all visible earth connections are intact (functional);
- all visible conductors and system components are fastened to the mounting surfaces and components providing mechanical protection are intact (functional) and in the right place;

- there have been no additions or modifications to the protected structure that would require additional protection;
- there is no evidence of damage to the LPS, to SPDs or failure of fuses protecting SPDs;
- proper equipotential bonding has been established for any new services or additions which have been made to the interior of the structure since the last inspection, and that continuity tests have been performed for these new additions, and that bonding conductors and connections within the structure are present and intact (functional);
- separation distances are maintained;
- bonding conductors, joints, shielding devices, cable routing and SPDs have been inspected and tested.

A.4 Testing

Visual inspections should be supplemented by the following actions:

- Perform continuity tests, especially continuity of those parts of the LPS that were not visible for inspection during the initial installation and are not available for subsequent visual inspection;
- Perform earth resistance tests on the earth-termination system. The following isolated and combined earth measurements and tests should be performed and the results recorded in an LPS inspection report:

(1) The earth resistance of each local earth electrode and, to the extent reasonably practicable, the earth resistance of the entire earth-termination system.

Each local earth electrode should be measured in isolation with the test point between the down conductor and earth electrode in the disconnected position (isolated measurement).

If the resistance to earth of the entire earth-termination system exceeds 10 Ω, it should be verified that the electrode meets the minimum length requirements of Figure 10.

If there is a significant increase in the value of the earth resistance, additional investigations should be made to determine the cause of the increase and measures should be taken to remedy the situation.

For earth electrodes in rocky soils, the requirements of section 2.2.3.5 should be followed. The 10 Ω requirement is not applicable in this case.

(2) The results of a visual inspection of all conductors, connections and joints, or their measured electrical continuity.

Annex B *Soil resistivity measurements*

B.1 Specific earth resistance ρ_E

ρ_E is the specific electrical resistance of the soil. It is typically expressed in units of Ohm·m (Ωm) and represents the resistance between two opposite sides of a cube of soil with edges 1 m long (see Figure 56).

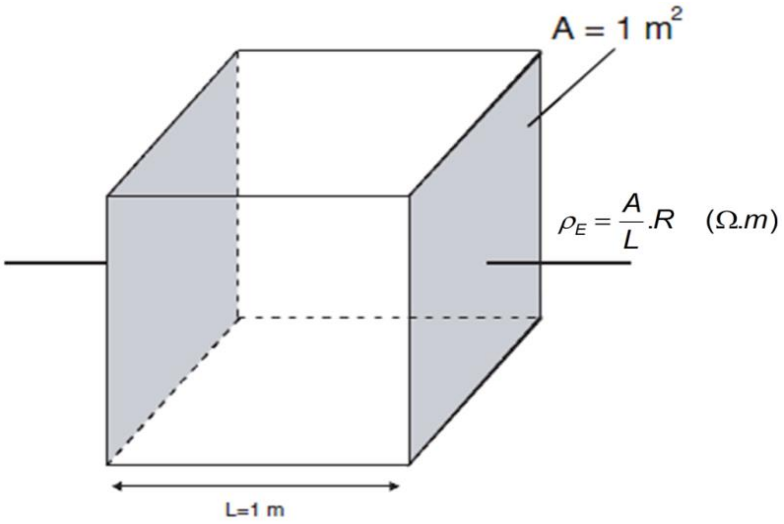

Figure 56: Definition of specific ground resistivity ρ_E

Note: Some documents use the term ground conductivity σ_E, expressed in units of Siemens per meter ($S.m^{-1}$), which is defined as the inverse of the ground resistivity $\sigma_E = 1/\rho_E$.

The specific earth resistance ρ_E, which determines the value of the earth electrode resistance R_A of an earth electrode, depends on the composition of the soil, the amount of moisture in the soil and the temperature. It can vary within wide limits. Values and fluctuation ranges of the specific earth resistivity ρ_E for different soil types are given in Figure 57.

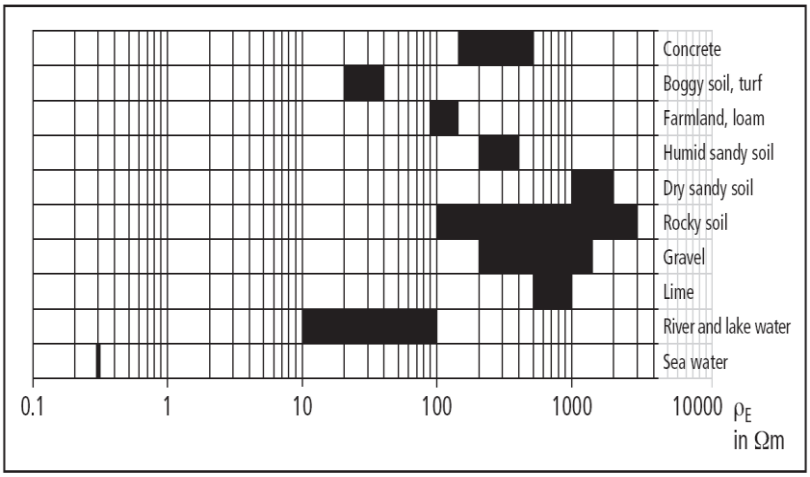

Figure 57: Specific earth resistance ρ_E of different ground types

B.2 Seasonal fluctuations

Extensive measurements have shown that the specific earth resistance varies significantly depending on the burial depth of the earth electrode. Due to the negative temperature coefficient of the ground (α = 0.02 ... 0.004), the specific earth resistance reaches a maximum in winter and a minimum in summer. Therefore, it is advisable to convert the measured values obtained from earth electrodes to the maximum prospective values, since even in unfavorable conditions (very low temperatures) the permissible values must not be exceeded. The curve of the specific earth resistance ρ_E as a function of the season (ground temperature) can be very well approximated by a sinusoidal curve with a maximum in the northern hemisphere around mid-February and a minimum around mid-August. Investigations have also shown that, for earth electrodes buried no deeper than about 1.5 m, the maximum deviation of the specific earth resistivity from the mean is about ± 30 % (see Figure 58).

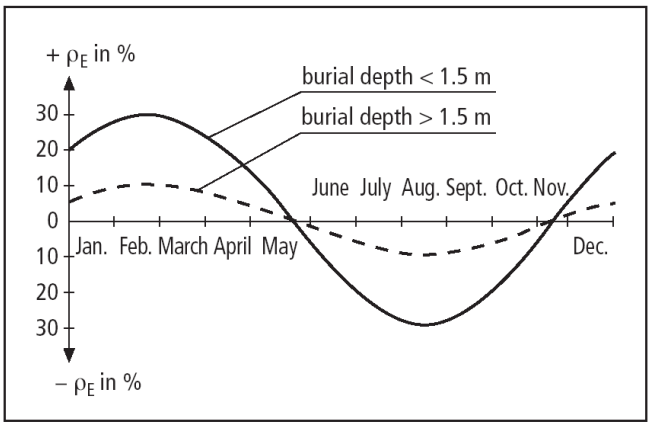

Figure 58: Specific earth resistance ρ_E as a function of the seasons without the influence of precipitation (burial depth of the earth electrode < 1.5 m). Note: This figure is valid for mid latitudes in the northern hemisphere. By shifting the x-axis by six months, it can also be applied to the southern hemisphere

For deeper buried earth electrodes (especially for vertical earth rods), the fluctuation is only ± 10 %. From the sinusoidal curve of the specific earth resistivity in Figure 58, the earthing electrode resistance R_A of an earth-termination system measured during a particular season can be converted to a maximum prospective value.

B.3 Measurement of specific earth resistance ρ_E

The specific earth resistance ρ_E is determined using an earthing measuring bridge with 4 clamps. Figure 59 illustrates the measurement setup for this method named after WENNER. The measurement is made from a fixed central point M, which is maintained for all subsequent measurements. Four measuring probes (earthing spikes 30 ... 50 cm long) are driven into the soil along a line a – a' pegged out in the ground. From the measured resistance *R,* the specific earth resistivity ρ_E of the soil can be determine:

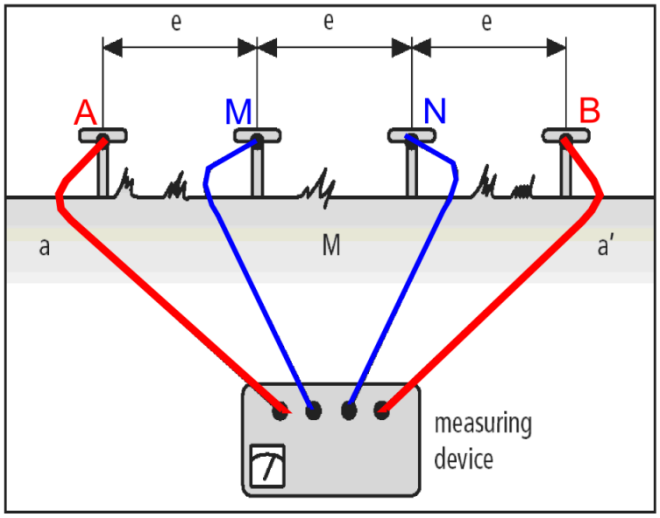

Figure 59: Determination of the specific earth resistivity ρ_E using a four-terminal measuring bridge according to the WENNER method. Current *I* is applied electrodes A, B and voltage drop *U* along the central earth section between electrodes M and N is picked off by electrodes M, N

$$\rho_E = 2\pi \cdot e \cdot R$$

R measured resistance (*R=U/I)* in Ω
e probe distance in m
ρ_E average specific earth resistance in Ωm down to a depth corresponding to about the probe distance *e*

By increasing the probe distance e (e.g., stepwise from 2 m to 30 m) and re-tuning the earthing measuring bridge, the curve of the specific earth resistance ρ_E as a function of the depth can be determined (see Figure 60 for examples).

- Curve 1: A decrease of ρ_E with increasing depth (see line “1” in Figure 60) indicates existence of good conductive soil layer (ground water) at greater depth and a deep earth electrode is advisable.
- Curve 2: As ρ_E decreases only down to point *Z*, an increase in the depth deeper than *Z* does not improve the values.
- Curve 3: With increasing depth ρ_E is not decreasing: a strip conductor electrode is advisable.

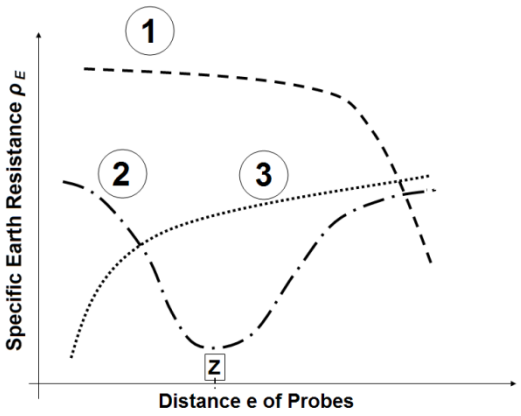

Figure 60: Specific earth resistivity ρ_E as a function of probe distance “*e*”

Because measurement results are often distorted and corrupted by underground pieces of metal, underground aquifers etc, a second measurement, in which the spike axis is turned by an angle of 90°, is always advisable (see Figure 61).

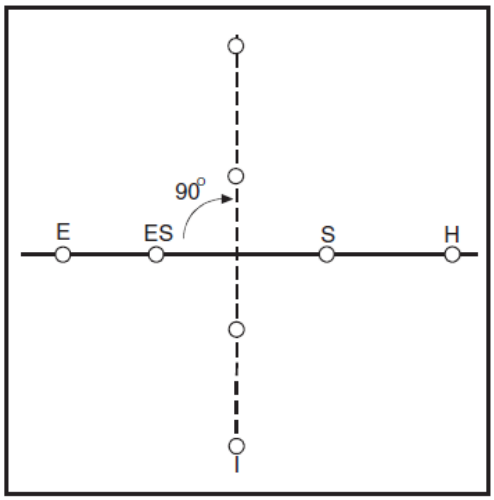

Figure 61: 90° turned positions of earth electrodes to check for any underground pieces of metal

Annex C *Earthing Electrode System Testing/Verification*

Procedures in this section shall not be performed by untrained or unqualified personnel, nor are any procedures herein intended to replace proper training. It is required that personnel attempting to measure the resistance of an earthing electrode system receive prior formal training on the subject and on its associated safety hazards. All applicable laws, rules and codes regulating the work on electrical systems shall be complied with at all times.

This section provides procedures for performing resistance testing of the site earthing electrode system. The resistance of an earthing electrode system shall be measured after it is installed and **before** it is connected to the power company neutral wire or any other utility, such as the telephone ground or metal pipes.

Periodic testing should be performed at the site regularly whenever the site earthing system can be safely disconnected from the power company neutral. Suggested best practice is to perform the test at least annually, with tests being performed in alternate seasons to verify results under varying soil moisture/temperature conditions.

NOTE: Test the earthing electrode system any time there is suspicion that the site has been directly struck by lightning.

C.1 Overview

Testing **shall** be performed using one of the methods which are described in this chapter. The methods are:

C.2 3-pole/4-pole Measurement of Earthing Resistance

This is the most widely accepted method. However, performing the test may require access to areas that may be beyond the site's property lines.

The current voltage measurement method is based on the block diagram circuit shown in Figure 62 below.

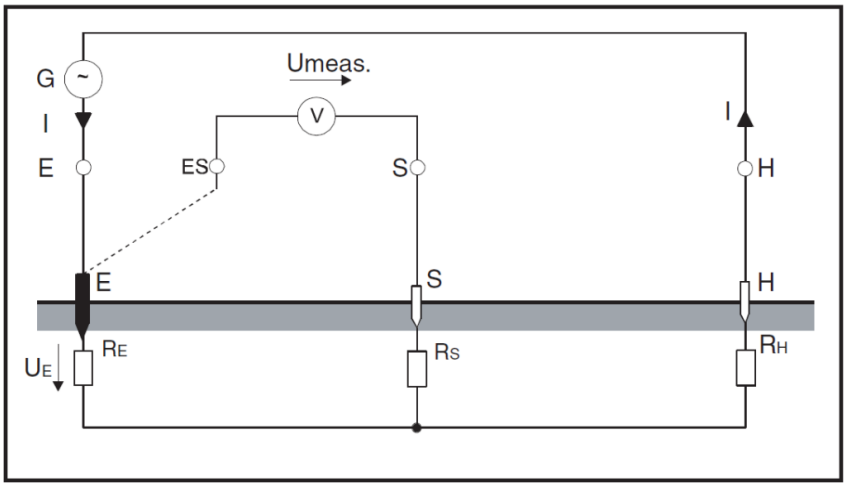

Figure 62: Earthing Resistances Measurement - Method

An AC generator G feeds current *I* through the earth electrode E (earth electrode resistance R_E) and auxiliary earth electrode H (auxiliary earth electrode resistance R_H).

A voltage U_E drops on earthing resistance R_E (U_E proportional to R_E.) This voltage is picked up and measured by the probe S. With the so-called three-wire circuit, the instrument sockets E and ES are connected to each other.

In a four-wire circuit a separate cable is used to connect socket ES with the earth electrode and with that, the voltage drop of the cable between socket E and earth electrode is not measured. Since the voltage measuring circuit has such a high impedance, the influence of the probe resistance R_S is negligible within certain limits.

This results in the earthing resistance R_E

$$R_E = \frac{U_{meas}}{I}$$

and is independent from the resistance of the auxiliary earth electrode R_H. The generator typically runs at a frequency between 70 and 140 Hz.

A probe positioned inside a potential gradient area leads to incorrect measuring results. For this reason, it is advisable to repeat each measurement with the probes repositioned, and to consider a measurement successful and accurate only if several subsequent measurements give the same values. Normally, a distance of 20 m to the earth electrode and between the probes is sufficient (see Figure 63).

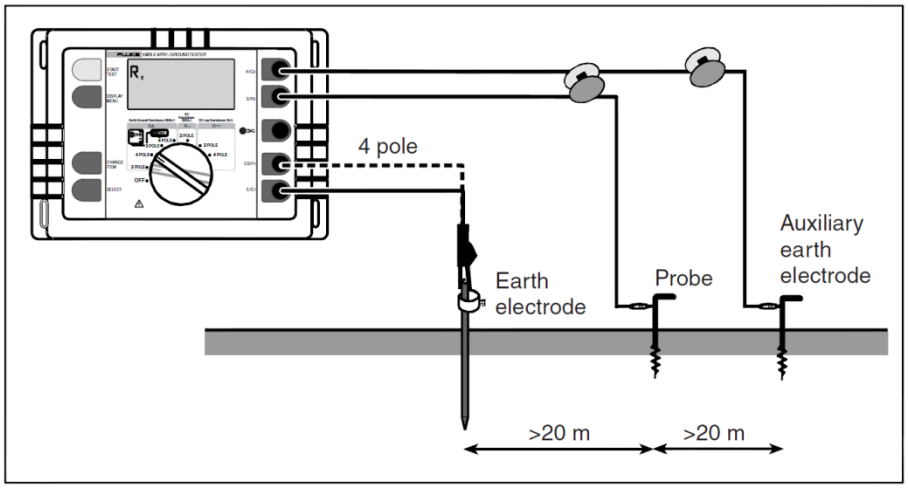

Figure 63: 3-pole/4-pole Measurement of Earthing Resistance - Process

To verify the accuracy of the results, take another reading after repositioning the auxiliary ground electrode or probe. If the value remains approximately the same, the distance is sufficient. If the reading changes, the probe or auxiliary earth electrode must be repositioned until the reading R_E remains constant. Spike wires should not be placed too close together.

C.3 Clamp-on Ohmmeter

This method **shall** be used when access to the space required for the ***3-pole/4-pole Measurement of Earthing Resistance*** is not available. However, the clamp-on ohmmeter test can only be performed after the AC utilities have been connected to the site and various feed conductors are accessible.

The Clamp-on Ohmmeter works by applying a known voltage *U* to the earthing electrode system to produce a current flow whose value is a function of the earthing electrode system resistance. The test current flows from the earthing electrode system through the earth, returning to the earthing electrode system via the power company's multi-grounded neutral wire.

The meter then measures this current and converts the measurement to a resistance reading using Ohm's Law ($R = U/I$). As such, the meter displays a resistance of the earthing electrode system in Ohms. Since the power company's earthing system is so extensive, the meter considers it to be of negligible value and ignores its effect on the reading.

The test voltage (*U*) is applied without disconnecting ground rod and/or the direct electrical connection by means of a clamp-on current transformer and the current detected by a second current transformer (some companies offer meters where the two transformers are combined in a single instrument).

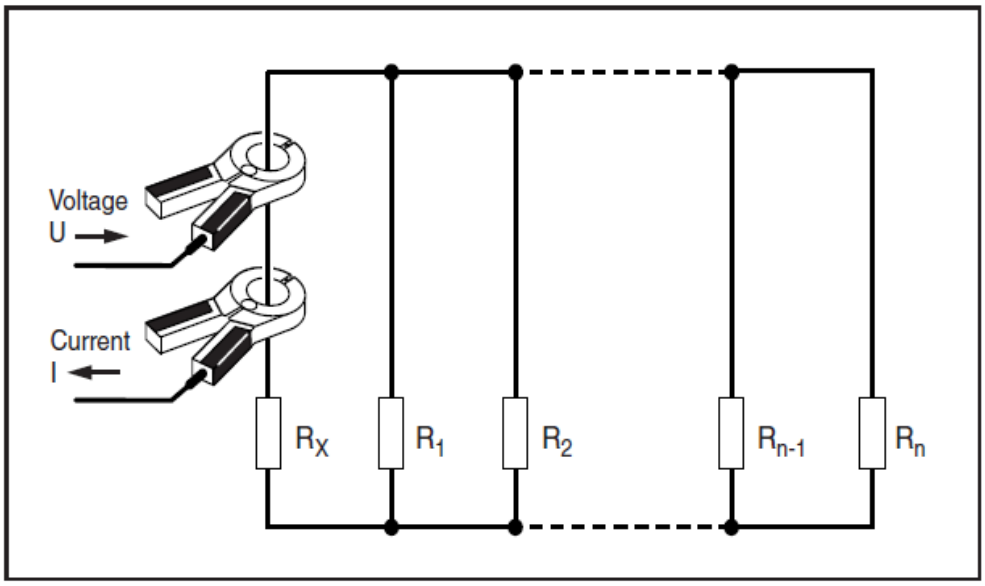

Figure 64: Clamp-on Ohmmeter Measurement of Earthing Resistance (R_X Earthing Resistance to be measured, $R_1 \ldots R_n$

It is recommended that the commercial power be turned off in order to eliminate any currents on the neutral wire that may affect the meter's ability to provide an accurate reading of R_X.

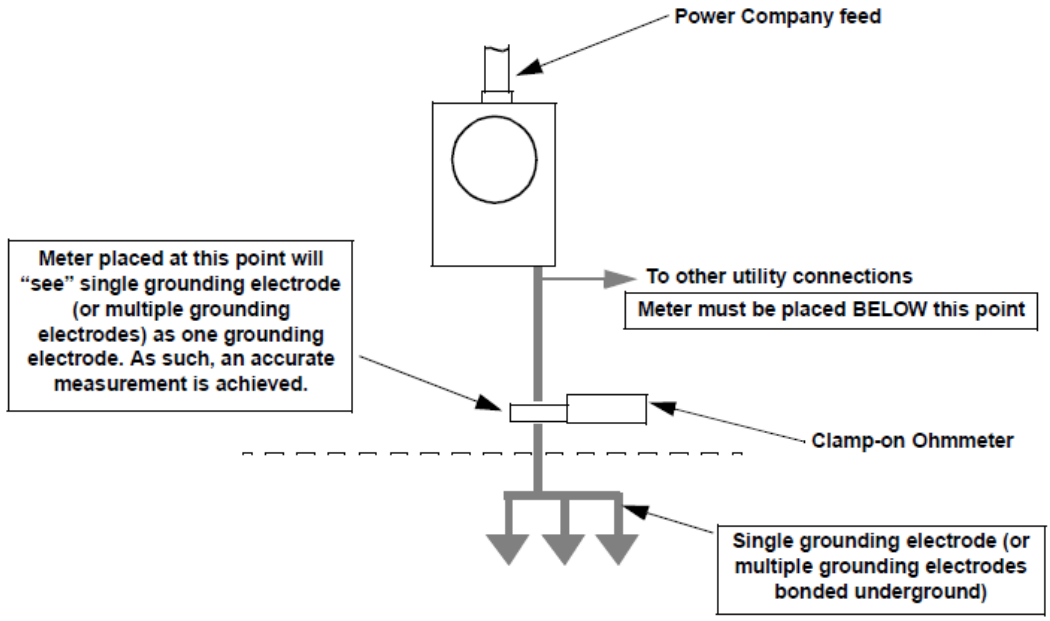

Figure 65: Clamp-on Ohmmeter placement

C.4 Prerequisites for Testing

The following conditions must be met in order to perform the earthing electrode system test:

(1) 3-pole/4-pole Measurement of Earthing Resistance is possible only when the following conditions can be met:

- Sufficient land area must be available to perform the 3-pole/4-pole Measurement of Earthing Resistance. The reference probe may likely need to be inserted into soil that is beyond the site fence or property line. Testing with a clamp-on ohmmeter may be an option in these cases.

- The earthing electrode system **must** be capable of being isolated from the utility grounded conductor (may be a neutral wire).

(2) Clamp-on Ohmmeter testing is possible only if the following conditions can be met:

- Site must be supplied with commercial power company-provided power. Sites powered only by a generator or other non-commercial power may not be suitable for clamp-on ohmmeter testing.

- Neutral wire must be present as part of the utility service.
- Neutral wire must be part of a comprehensive utility earthing system. In systems such as 3-phase delta service, the neutral wire may not be part of such a comprehensive utility earthing system.
- The earthing electrode system must be connected to the utility's grounded conductor (may be a neutral wire).
- For sites using a multi-bonded/multi-earthing electrode system (such as is commonly used at communications sites), a point on the neutral must be available for the meter to clamp onto prior to its first bond to the site.
- For a single earthing electrode system, the earthing electrode conductor must be accessible for the meter to clamp onto at a point between the earthing electrode and any other connection (such as the telephone company ground or a metal pipe).

(3) Combined Soil Resistivity/Clamp-on Ohmmeter testing is possible only if the following conditions can be met:

- System must be such that the collection of individual earthing electrode system component values with a clamp-on-ohmmeter is available for use by an engineering firm.
- A soil resistivity profile for the site has been performed and is available for use by an engineering firm.

If these conditions cannot be met, an added supplemental earthing electrode system can be installed. This supplemental earthing electrode system could be installed and tested prior to its connection to the existing system. This supplemental system should be installed in such a way as to provide an easy disconnect point for future testing.

C.5 Required Test Equipment and Supplies

- Ground Resistance Tester (with supplied test leads, test clips, and probes)
- Small sledgehammer
- Tape measure
- Safety glasses
- Gloves
- Earthing/Bonding System Test Worksheet (Table 17)

Table 17: Earthing/Bonding System Test Worksheet

Test completed by:		
Date:		
Client/Project:		
Site Location/ID:		
Ground Resistance Tester Model: S/N: Calibration date:		
Soil Description		
Ambient Conditions during test Temperature: Present conditions (dry, rain, snow): Date of last precipitation:		
Documentation available to the person performing the test: • Documentation of the earthing system • Test results of the previous test		
Type of Test: • Initial Test after completion • Scheduled test after …. Years • Unscheduled test after a lightning strike • ……..		
Material(s) used for earthing/earthing system (result of visual inspection)		
	o.k	not o.k
• Copper	•	•
• Stainless steel	•	•
• Galvanized steel	•	•
Results of measurement: Specific Ground Resistivity (ρ): …….(Ωm)		

Individual earthing rods:

#	1	2	3	4	5	6	
R_E (Ω)							

Comments:

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Annex D *Dissimilar Metals and Corrosion Control*

Components of an LPS shall withstand the electromagnetic effects of lightning current and foreseeable accidental stresses without damage. Components of an LPS shall be made of the materials listed in Table 18 or from other materials with equivalent mechanical, electrical and chemical (corrosion) performance.

Table 18: LPS materials and conditions of use (Table 5 in [7]*)*

Material	Use			Corrosion		
	In open air	In earth	In concrete	Resistance	Increased by	May be destroyed by galvanic coupling with
Copper	Solid Stranded	Solid Stranded As coating	Solid Stranded As coating	Good in many environments	Sulphur compounds Organic materials	
Hot dip galvanized steel [c,d,e]	Solid Stranded [b]	Solid	Solid Stranded [b]	Acceptable in air, in concrete and in benign soil	High chloride content run-off from copper [j]	Copper
Steel with electro-deposited copper [f]	Solid	Solid	Solid	Good in many environments	Sulphur compounds	
Stainless steel	Solid Stranded	Solid Stranded	Solid Stranded	Good in many environments	High chlorides content	–
Aluminum	Solid Stranded	Not allowed	Not allowed	Good in atmospheres containing low concentrations of Sulphur and chloride	Alkaline solutions High chloride content run-off from copper [j]	Copper
Lead [f, g]	Solid As coating	Solid As coating	Not allowed	Good in atmosphere with high concentration of sulphates	Acidic soils	Copper

[a] This table gives general guidance only. In special circumstances, more careful corrosion immunity considerations are required (see Annex D).

[b] Stranded conductors are more vulnerable to corrosion than solid conductors. Stranded conductors are also vulnerable where they enter or exit earth/concrete positions. This is the reason why stranded galvanized steel is not recommended in earth.

[c] Galvanized steel may be corroded in clay soil or moist soil.

[d] Galvanized steel in concrete should not extend into the soil due to possible corrosion of the steel just outside the concrete.

[e] Galvanized steel in contact with reinforcement steel in concrete should not be used in coastal areas where there may be salt in the ground water.

[f] Underground connections in soil which require removal of conductor coatings is not recommended without adequate post corrosion protection.

[g] Use of lead in the earth is often banned or restricted due to environmental concerns.

[h] To avoid corrosion, bare aluminum and aluminum alloy should not be used in direct contact with soil, gravel, limestone or lime mortar.

[i] Assessment of environmental conditions (i.e., expected wind load) must be considered during the dimensioning of air-termination rods.

[j] Possible transfer of water (rain, condensed water) from copper to galvanized steel or aluminum should be

avoided.

Earth electrodes made of a uniform material may be subject to corrosion from corrosive soils and the formation of concentration cells. The risk of corrosion depends on the material and the type and composition of the soil.

The pH (hydrogen ion concentration) of the soil in which an earthing electrode system is to be installed should be tested before the system is installed.

Test the soil pH using a commercially available soil pH meter or a swimming pool acid/ base tester. If using a swimming pool acid/base tester, mix and test a solution containing one part site soil and one part distilled water. In very acidic soils (pH of 5 or less), it is recommended that precautions be taken to extend the life of the earthing electrode system.

Some options may be as follows:

- Consult an engineering firm;
- Encase all earthing electrode system components in an earthing enhancing material [27];
- Use stainless steel or solid copper ground rods instead of copper-clad rods.

D.1 Choice of earth electrode materials

Table 8 in this document, taken from the IEC standards for lightning protection, is a compilation of commonly used earth electrode materials and their minimum dimensions.

D.1.1 Hot-dip galvanized steel

Hot-dip galvanized steel is also suitable for embedding in concrete. Foundation earth electrodes, earth electrodes and equipotential bonding conductors made of galvanized steel in concrete may be connected with reinforcement iron.

D.1.2 Bare steel

Bare steel should only be used when fully embedded in concrete. Where bare steel (not embedded in concrete) is used in existing installations, the effects of corrosion over the years should be carefully monitored.

D.1.3 Copper clad steel

In the case of copper clad steel, the comments for bare copper apply to the cladding material. However, damage to the copper cladding results in a high risk of corrosion to the steel core; therefore, a fully enclosed copper layer must always be present.

D.1.4 Bare copper

Bare copper is very resistant as it is a rather “noble” metal, i.e., exhibits low reactivity. In addition, when combined with grounding electrodes or other installations in the ground made of more reactive (“less noble”) metals (e.g., steel), copper receives some additional cathodic corrosion protection, albeit at the expense of the more reactive metal.

D.1.5 Stainless steels

Certain high-alloy stainless steels are inert and corrosion-resistant in the ground. The free corrosion potential of high-alloy stainless steels in normally aerated soils is usually close to that of copper.

Because the surface of stainless-steel earth electrode materials passivates within a few weeks, they are neutral to other more inert and base materials.

Extensive measurements have shown that only high-alloy stainless steels containing at least 16 % chromium and 2 % molybdenum with ca. 10% nickel are sufficiently corrosion resistant in the ground. Such standard steel grades are Material No. 1.4401, 1.4404, 1.4571 (equivalent to AISI 316, 316L, 316Ti).

D.2 Combination of earth electrodes made of different materials

No combination of materials shall be used which forms a galvanic couple such that corrosion is accelerated in the presence of moisture. In those cases where it is impractical to avoid a junction of dissimilar metals, the corrosion effect shall be reduced by the use of plating or special connectors, such as stainless-steel connectors used between aluminum and copper or copper alloys.

The cell current density resulting from the combination of two different metals installed in the earth to be electrically conductive, leads to the corrosion of the metal acting as the anode. This essentially depends on the ratio of the size of the cathodic area A_C to the size of the anodic area A_A. A higher degree of corrosion can only be expected if the ratio of the areas is

$$\frac{A_C}{A_A} > 100 \quad .$$

Table 19 shows possible combinations (+) of materials and materials that cannot be combined (-) when $A_C > 100 \times A_A$.

Table 19: Material combinations of earth-termination systems for different area ratios (avoid $A_C > 100 \times A_A$)

		A_A			
		Material with great area			
	Material with small area	Galvanized Steel	Steel	Steel in concrete	Copper
A_C	Galvanized Steel	+	+ Zinc removal	-	-
	Steel	+	+	-	-
	Steel in concrete	+	+	+	+
	Steel with Cu coating	+	+	+	+
	Copper/StSt	+	+	+	+
+ combinable - not combinable					

D.3 Methods to help reduce corrosion

D.3.1 Galvanized steel connecting cables from foundation earth electrodes to down conductors

Galvanized steel connecting cables from foundation earth electrodes to down conductors shall be buried in concrete or masonry up to above the surface of the earth. If the connecting cables are routed through the ground, the galvanized steel conductors must be covered with concrete or synthetic sheathing or, alternatively, terminal lugs with NYY cable, stainless steel or fixed earthing terminals must be used. Inside masonry, the earth conductors can also be routed to the top without corrosion protection.

D.3.2 Earth entries

Earth entries, e.g., made of galvanized steel, must be protected against corrosion for a distance of at least 0.3 m above and below the earth surface (Figure 66). Generally, bitumen coatings are not sufficient. Protection can be provided by a non-absorbent covering, such as butyl rubber strips or heat-shrinkable tubing.

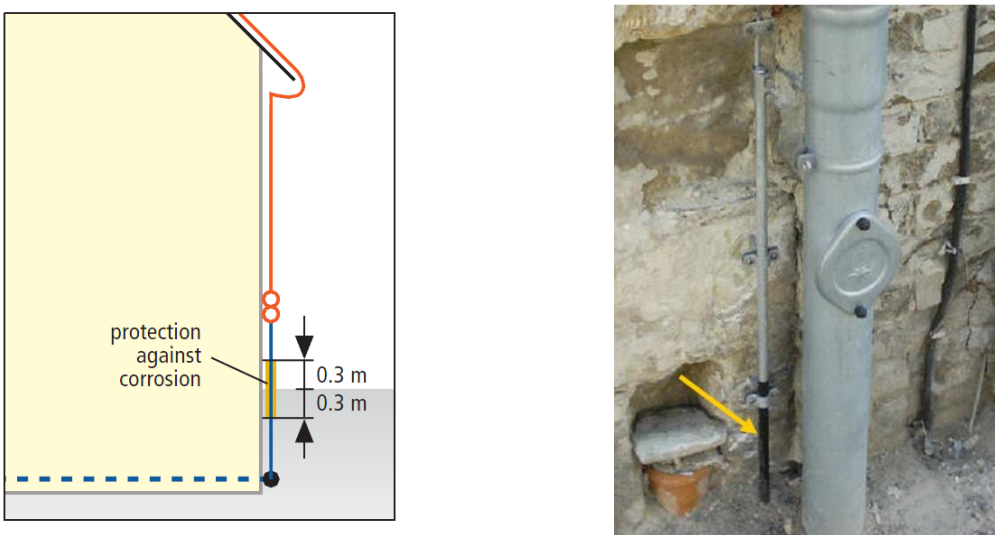

Figure 66: Points threatened by corrosion and practical solution

D.3.3 Underground terminals and connections

Cut surfaces and joints in the ground must be designed so that their corrosion resistance is as good as the corrosion resistance of the basic earth electrode material. Therefore, it may be necessary (e.g., when there is a cut of galvanized steel), to cover the connection points in the ground with a suitable coating, e.g., sheathed with an anticorrosive band.

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Annex E *Lightning Protection System Compliance Matrix*

	CTBTO guidelines minimum requirements	Reference	Station Design	Remarks
AIR TERMINATION SYSTEM				
Design Parameters	Rolling sphere radius: 30m Mesh size: 10 m x 10 m Protection angle: see Table 2 of IEC 62305-3 (2010)	IEC 62305-3 (2010), Table 2 [3]		
Air termination system material	Galvanized steel Stainless steel Copper Aluminum	IEC 62305-3 (2010), Table 6 [3]		
Diameter/cross-section of air termination conductors	Galvanized steel: solid round Ø8 mm or cross section 50 mm^2 Stainless steel: solid round Ø8 mm or cross section 50 mm^2 Copper: solid round Ø8 mm or cross section 50 mm^2 Aluminum: solid round Ø8 mm or cross section 50 mm^2	IEC 62305-3 (2010), Table 6 [3]		

	CTBTO guidelines minimum requirements	Reference	Station Design	Remarks
DOWN CONDUCTORS				
Design Parameters	Maximum distance between down-conductors 10 m	IEC 62305-3 (2010), Table 4 [3]		
Minimum number of down conductors	Two (2)	IEC 62305-3 (2010), 5.3 [3]		
Down conductor material	Copper Aluminum Galvanized steel Stainless steel	IEC 62305-3 (2010), Table 6 [3]		
Diameter/cross-section of down conductors	Galvanized steel: solid round Ø8 mm or cross section 50 mm^2 Stainless steel: solid round Ø8 mm or cross section 50 mm^2 Copper: solid round Ø8 mm or cross section 50 mm^2 Aluminum: solid round Ø8 mm or cross section 50 mm^2	IEC 62305-3 (2010), Table 6 [3]		

	CTBTO guidelines minimum requirements	Reference	Station Design	Remarks
EARTH TERMINATION SYSTEM				
Design Parameters	For the specific soil resistivity up to 800 Ωm: Horizontal electrodes: 5.0 m Vertical electrodes: 2.5 m	IEC 62305-3 (2010), Figure 2 [3]		
Earth termination system material	Copper Galvanized Steel Stainless steel	IEC 62305-3 (2010), Table 7 [3]		
Earth rod diameter	Copper solid round: Ø 15 mm Galv. steel solid round: Ø 16 mm Stainless steel solid round: Ø 15 mm	IEC 62305-3 (2010), Table 7 [3]		
Earth conductor cross-section	Copper: 50 mm^2 Galv. steel: 90 mm^2 Stainless steel: 100 mm^2	IEC 62305-3 (2010), Table 7 [3]		
Earthing resistance of the earth-termination system	Recommended < 10 Ω	IEC 62305-3 (2010), 5.4.1 [3]		

	LPL class II minimum requirements	Reference	Station Design	Remarks
EQUIPOTENTIAL BONDING				
Main bonding bar (MBB)	Placed close to the entry point of service lines			
Conductors connecting bonding bar to earth termination system	Copper 14 mm^2 Aluminum 22 mm^2 Steel 50 mm^2	IEC 62305-3 (2010), Table 8 [3]		
Conductors connecting internal metal installations to the bonding bar	Copper 5 mm^2 Aluminum 8 mm^2 Steel 16 mm^2	IEC 62305-3 (2010), Table 8 [3]		
Bonding of AC power line	by SPD (Typ1 or Type 2)	IEC 62305-3 (2010), 6.2.5 [3]		
Bonding of data and communication lines	by SPD	IEC 62305-3 (2010), 6.2.5 [3]		
Bonding of cable shields	directly to MBB	IEC 62305-3 (2010), 6.2.5 [3]		

	LPL class II minimum requirements	Reference	Station Design	Remarks
SURGE PROTECTION				
AC Medium Voltage Transformer	Transformer shall be protected by SPDs on MV and LV side in agreement with the local power utility	IEC 60099-4 [26] IEC 60099-5 [28]		
AC Power supply	Type 1+2 SPD[1]	IEC TR 62066 [29] IEC 61643-12 [25]		
Photovoltaic system	Type 1+2 SPD	IEC TR 63227 [13] IEC 61643-31 [23]		
GPS antenna	Place antenna within protected area of air termination rod (LPZ 0_B)	IEC 62305-1 [1]		
	SPD for RF coaxial cable, Type 2, with protective effect P1, for installation at the boundary LPZ 0_B/LPZ 1. Bandwidth must be suitable for GPS signal (carrier frequency of 1575 MHz). Operating DC voltage up to 8 V is necessary for active GPS antennas.	IEC 61643-21 [20] EN 61000-4-5 [22]		

[1] Installation requirements depend on local power network type (e.g., TT, TN system)

SURGE PROTECTION cont.				
RF antenna	Place antenna within protected area of air termination rod (LPZ 0_B)	IEC 62305-1 [1]		
	SPD for RF coaxial cable, Type 2, with protective effect P1, for installation at the boundary LPZ 0_B/LPZ 1. Bandwidth must correspond to RF equipment specifications.	IEC 61643-21 [20] EN 61000-4-5 [22]		
Meteorological data	Place sensors within protected area of air termination rod (LPZ 0_B).	IEC 62305-1 [1]		
	SPD for data lines, discharge capacity Type 2, with protective effect P1, for installation at the boundary LPZ 0_B/LPZ 1, corresponding to the signal parameters of the sensors.	IEC 61643-21 [20] EN 61000-4-5 [22]		
Signal cables	SPD for data lines, discharge capacity Type 2, with protective effect P1, for installation at the boundary LPZ 0_B/LPZ 1, corresponding to the type of the signal.	IEC 61643-21 [20] EN 61000-4-5 [22]		

Annex F *References*

[1] IEC 62305-1, *Protection against lightning - Part 1: General principles. ED 2.0*. 2013.

[2] IEC 62305-2, *Protection against lightning - Part 2: Risk management. ED 2.0*. 2012.

[3] IEC 62305-3, *Protection against lightning - Part 3: Physical damage to structures and life hazard. ED 2.0*. 2010.

[4] IEC 62305-4, *Protection against lightning - Part 4: Electrical and electronic systems within structures. ED 2.0*. 2010.

[5] IEC 81/695/CDV - 62305-1 ED3, *Protection against lightning - Part 1: General principles*. 2022.

[6] IEC 81/687/CDV - 62305-2 ED3, *Protection against lightning - Part 2: Risk management*. 2022.

[7] IEC 81/688/CDV - 62305-3 ED3, *Protection against lightning - Part 3: Physical damage to structures and life hazard*. 2022.

[8] IEC 81/693/CDV - 62305-4 ED3, *Protection against lightning - Part 4: Electrical and electronic systems within structures*. 2022.

[9] IEC 62858, *Lightning density based on lightning location systems (LLS) – General principles. Ed. 2.0*. 2019.

[10] IEC 62561-1, *Lightning protection system components (LPSC) – Part 1: Requirements for connection components*. 2022, p. Ed. 3.0 (CDV).

[11] IEC 62561-2, *Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes*, vol. ED 3 (CD). 2021.

[12] Dehn, *LIGHTNING PROTECTION GUIDE 3rd updated Edition Surge Protection Lightning Protection / Earthing Safety Equipment*. DEHN + SÖHNE, 2014. [Online]. Available: www.dehn-international.com

[13] IEC TR 63227, *Lightning and surge voltage protection for photovoltaic (PV) power supply systems*. 2020.

[14] IEC 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors. ED 3.0*. 2011.

[15] R. W. Drisko and A. E. Hanna, “Field Testing of Electrical Grounding Rods.” 1970. [Online]. Available: http://www.dtic.mil/dtic/tr/fulltext/u2/702040.pdf

[16] MOTOROLA, *Standards and Guidelines for Communication Sites*. 2005.

[17] IEC 60728-11, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety. ED 5.0*. 2023.

[18] IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests. ED 3.0*. 2020.

[19] IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods. ED 1.0*. 2011.

[20] IEC 61643-21, *Low voltage surge protective devices - Part 21: Surge protective devices connected to telecommunications and signalling networks - Performance requirements and testing methods. ED 1.2*. 2012.

[21] IEC 61643-22, *Low-voltage surge protective devices - Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles. ED 2.0*. 2015.

[22] IEC 61000-4-5, *Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test. ED 3.0*. 2014.

[23] IEC 61643-31, *Low-voltage surge protective devices – Part 31: Requirements and test methods for SPDs for photovoltaic installations. ED 1.0*. 2018.

[24] IEC 61643-32, *Low-voltage surge protective devices – Part 32: Surge protective devices connected to the d.c. side of photovoltaic installations – Selection and application principles*. 2017.

[25] IEC 61643-12 ED3, *Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*. 2020.

[26] IEC 60099-4, *Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems, Ed. 3.0*. 2014.

[27] IEC 62561-7/CDV, *Lightning protection system components (LPSC) - Part 7: Requirements for earthing enhancing compounds*. 2022.

[28] IEC 60099-5, *Surge arresters - Part 5: Selection and application recommendations. ED 3.0*. 2018.

[29] IEC TR 62066, *Surge overvoltages and surge protection in low-voltage a.c. power systems - General basic information Ed. 1*. 2002.

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

IMS Engineering & Development

IMS Standard Station Documentation Drawings Set, SHI stations Format 2022.01

Function	Name	Date
Submitted by	Pavel Martysevich IMS/ED/SA	2022-09-24
Reviewed by	Joseph Park IMS/ED	2022-09-27
Reviewed by	Pavel Martysevich IMS/ED/SA	2022-10-14
Endorsed by	Joseph Park IMS/ED	2022-10-17

1. SUMMARY

The document describes Format 2022.01 of the Standard Station Documentation Drawings Set, created and approved by IMS/ED in 2022.

The set consists of 5 drawings with variable number of sheets in each drawing, depending on particular station's situation:

- IMS-XXXX-DRW-001 Maps and Plans:
- IMS-XXXX-DRW-002 Station Block Diagram
- IMS-XXXX-DRW-003 Communications Diagram
- IMS-XXXX-DRW-004 Station Electrical Diagram
- IMS-XXXX-DRW-005 Photos

where XXXX represents the station treaty number.

The overall information presented in the set is equal or exceeds the information presented in the previous set format Rev 1 2018-05-22.

The format 2022.01 is the default drawing format used by IMS/ED/SA for seismic, infrasound and T-phase hydroacoustic stations starting from 01 October 2022.

2. GENERAL

Basic standard SSD Drawings Set consists of 5 types of drawings, namely:

- Maps and Plans:
- Station Block Diagram
- Communications Diagram
- Station Electrical Diagram
- Photos

The drawings are prepared in the MS Visio format and stored in MS Visio and Adobe PDF format. Each drawing consists of various number of pages representing as needed essential aspects of the station.

The Visio templates along with the symbols set are available in electronic form at *http://confluence.ctbto.org/display/SP/Drawings*

The general instructions for the drawings are listed below.

2.1 Paper page size

For IMS station EPD the standard paper page size is DIN A3. A documentation may consist of more than one page. In order to identify each page, for example for referencing purposes, a sheet number (lower right corner in the title block) must be provided in addition to the document identifier.

2.2 Text orientation

Any text within a document shall be oriented horizontally or vertically and intended to be read from the bottom edge or from the right-hand edge.

2.3 Text size

The standard height of letters shall be 2.5 mm equivalent to Arial 10 pt.

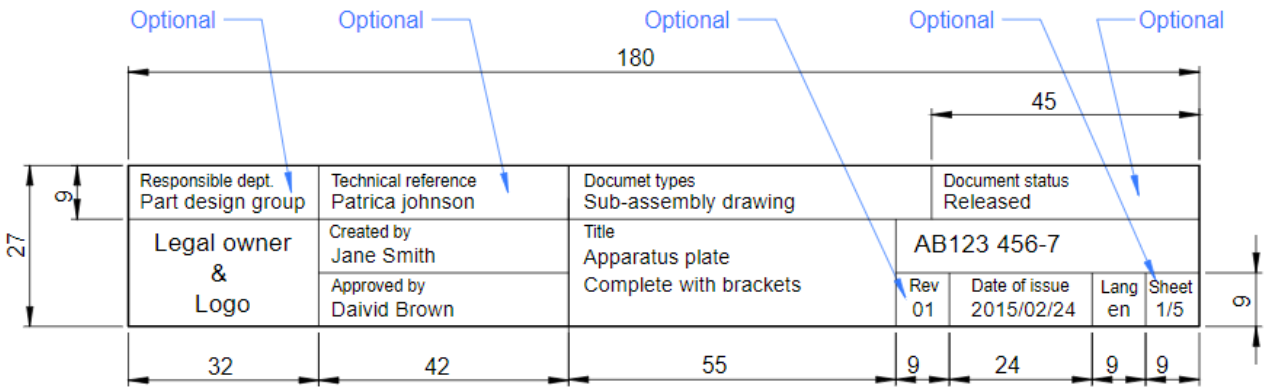
2.4 Lines

The standard line width shall be 0.25 mm equivalent to 0.75 pt or ¾ pt in Visio drawing. If different line widths are required, the ratio between any two-line widths shall be at least 2:1.

2.2 Title block arrangement

Each drawing shall have a title block (typically in the lower, right corner) detailing information about the drawing.

According to ISO 7200 [3] the title block template is shown in Figure 1.



A title block according to this standard is available as a MS Visio template for ladscape and portrait page layout.

REV	Description	Date	Approved

Responsible dept.	Technical reference	Document types	Document status
CTBTO PREPARATORY COMMISSION	Drafted	Title	
	Created		
	Approved		

Rev	Date of issue	Lang	Sheet

Figure 1: ISO 7200 type title block

2.3 Colours, shading and patterns

Colours should be used only as complementary information. Usage of different colours shall not be the only means for understanding presentations.

The meaning of the colors used shall be stated in the document or in supporting documentation. For documents on paper or equivalent media, the use of colours, shading and/or patterns should be usable for black and white printing.

2.2 Arrangement and orientation of connecting lines

Connecting lines shall be oriented horizontally or vertically except in those cases where oblique lines improve the legibility. Connecting lines should not interfere with other symbols. Bends and crossover of lines should be restricted to a minimum.

3. DRAWINGS

The content of 5 drawings is shown in the Figure 2Figure 1 below.

- Title and List of Content
- IMS-XXXX-DRW-001 Maps and Plans:
  - Sheet 1 - Location
  - Sheet 2 – Satellite View
  - Sheet 3 – Site plan(s)
  - Sheet 4 – Borehole / Pedestal / WNRS
  - …
- IMS-XXXX-DRW-002 Station Block Diagram
- IMS-XXXX-DRW-003 Communications Diagram
  - Sheet 1 – Network Diagram
  - Sheet 2- Data Flow Diagram
- IMS-XXXX-DRW-004 Station Electrical Diagram
  - Sheet 1 - CRF
  - Sheet 2 – Remote Element(s)
  - Sheet 3 – Repeater
  - Sheet 4 –Earthing Plan(s)
  - …
  - Sheet XX – Table of Installed Components
- IMS-XXXX-DRW-005 Photos
  - Sheet 1- Rack CRF
  - Sheet 2 - Site Layout
  - …

Figure 2: Titles and content of the drawings

Samples of the drawings are shown in the Attachment B.

3.1 DRW01 Maps and Plans

The drawing consists of:

- Sheet 1: Station Location (mandatory)
- Sheet 2: Station Layout (if applicable)
- Sheet 3 and further: Station site plan(s) and important infrastructure info, like borehole details (if applicable) and WNRS layout.

The key additional information compared to Rev 1, 2018-05-22 is a borehole drawing showing details of casing pipe, wellhead termination, depths and lithology, if known, pedestal information, if applicable, for seismic installations and site plans with WNRS layout for infrasound stations. Vaults drawings with dimensions should also be included.

3.2 DRW02 Station Block Diagram

This drawing remains unchanged in terms of content and symbols used compared to Rev 1, 2018-05-22.

3.3 DRW03 Communications Diagram

The DRW03 combines former DRW04 and DRW05 of Rev 1, 2018-05-22, Communication Diagram and Network Diagram. The diagram must use Cisco Topology Icons as globally recognized and generally accepted as standard for network icon topologies as much as possible. The diagram must include IP plan station's table and length(s) and type(s) of communication lines.

3.4 DRW04 Station Electrical Diagram

The Station Electrical Diagram must follow as much as possible the technical specifications IEC TS 63064 and standard giving instruction for using designing graphical symbols for diagrams in IEC 60617. Detailed instructions are given in the Attachment C. Note that the DRW04 can be prepared on DIN A4 paper size.

The drawing consists of:

- CRF Electrical Diagram
- Remote Element(s) Electrical Diagram(s) if applicable
- Repeater Electrical Diagram if applicable
- Earthing Plan for CRF
- Earthing Plan(s) for Remote Element(s)
- Table of Installed Components

Detailed instructions are given in the Attachment C.

3.5 DRW05 Photos

The content of the DRW05 remains unchanged compare to Rev 1, 2018-05-22, and includes photos of:

- CRF Rack
- Site(s) layout
- Pipe arrays, vaults, borehole, any applicable equipment, infrastructure or site conditions
- Repeater (if applicable)

ATTACHMENTS:

Attachment A: Templates & Stencils

Attachment B: Samples of the drawings

Attachment C: Instructions for DRW04, Station Electrical Diagram

ATTACHMENT C to the TERMS OF REFERENCE

SPECIAL INSTRUCTIONS

for Contracts - IMS stations operated by the SMS of MoD RF

1. The Contractor shall apply to the SMS authorities for obtaining/confirming site access permit for their specific personnel to enter the facility to perform the work at least 2 weeks before the scheduled visit. Passport copies of personnel designated to perform the work shall be attached to the request for the site access permit. The passport shall meet the following requirements:

    - Passport page with the photo and information about the issuing authority;
    - Page with address information.

2. In addition to the set of documents required for site access permit to perform the work, a Contractor shall also submit:

    - An approved design of the work to be performed;
    - A certified copy of self-regulatory company certificate confirming the Contractor's specialization (in case of work associated with design of facilities and systems, construction/repair, survey and other activities affecting safety);
    - A certified copy of the professional license (as required, in accordance with Federal Laws of the Russian Federation).

3. Upon review of the submitted documents, the SMS will approve/reject access of the Contractor's personnel to the facility to perform the work.

4. In the course of work execution, the Contractor shall follow the rules and requirements of the "stay" on site and shall maintain all required safety standards. In the event of violation of the rules of "stay" at the facility, violation of labor safety or other misconduct, depending on the extent of violation or misconduct, SMS reserves the right to cancel the access for either an individual Contractor Personnel or the Contractor as a whole. In the event such incidents occur, the SMS will promptly notify the Commission and provide clarifications accordingly.

5. **Temporary Interruption of the Work:** In the event that special internal activities are conducted by the SMS, the SMS reserves the right to suspend access to the Contractor's personnel to SMS's facilities (if these activities are of reciprocal influence) but not for a period longer than 5 work-days in each case. The SMS will notify the Commission and the Contractor about such activities.

6. **Tax -** In accordance with the provisions of the **Facility Agreement (CTBT/LEG.AGR/33); Federal Law No. 95 FZ "About grants (technical assistance)…" dated 4 May 1999;** and **Order of the Ministry of Foreign Affairs of the Russian Federation and Ministry of Finance of the Russian Federation**; **March 24, 2014 No. 3913/19n,** Work under this Contract shall be exempt from tax and relevant duties levied in the Russian Federation.

7. **Tax Exemption Certificate:** In the event a Tax Exemption Certificate is required by the Contractor, the Contractor shall communicate in writing with the Commission and SMS to agree on the required procedures to be undertaken.