

GAF-RE Phase VI Webinar for PV Installers - 16.02.2024

Promotion of Renewable Energies - GAF-RE Program Phase VI
Technical Requirements for small-scale projects up to 500 kW

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Revision status

Rev.	Date	Content/Amendments	Prepared	Checked
0	15.02.2024	Final draft	AM	Störring
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Technical Requirements for Small-Scale Projects up to 500 kW

- 1 Introduction
- 2 The Minimum Technical Requirements
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Introduction

Technical assessment of small-scale projects up to 500 kW

KfW is disbursing a loan volume of 12M EUR dedicated to small-scale PV projects up to 500 kW capacity while promoting gender equality.



Source: GK Today

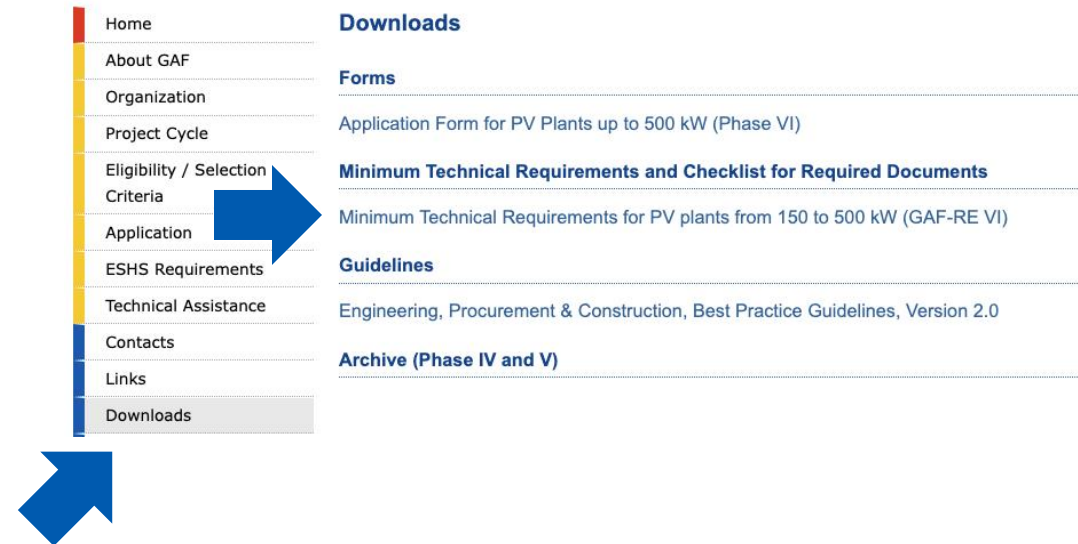
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The Minimum Technical Requirements (MTR)

- Provides technical requirements and recommendations for the implementation of ground-mounted and rooftop PV systems for own consumption over 150 kW up to 500 kW in Armenia.
- Specifies the standards and certifications that the PV systems and components must comply with, such as IEC, EN, ISO, and OHSAS.
- Outlines the procedures and criteria for the technical assessment, monitoring, and financing of the PV projects by the Renewable Resources and Energy Efficiency Fund of Armenia (R2E2) and the German-Armenian Fund (GAF), supported by Fichtner
- Includes a checklist of the required documents and information that the PV project developers must submit to the R2E2 Fund and GAF for approval



→ <http://re.gaf.am/>

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Minimum Project Requirements

- Applicants to ensure their project meets the current [minimum technical requirements](#) for up to 500 kW PV projects available on the GAF-RE and R2E2 website
- Projects to comply with all technical and HSE aspects, including:
 - ✓ General plant requirements
 - ✓ Criteria for Modules
 - ✓ Criteria for inverters
 - ✓ PV cable certificate
 - ✓ Mounting structures
 - ✓ Grid connection and electrical installation
 - ✓ Interim and final monitoring
 - ✓ Warranties
 - ✓ Environmental, health and safety requirements

Technical Requirements and recommendations for the implementation of ground-mounted and rooftop PV systems for own consumption over 150 kW up to 500 kW

The technical requirements and recommendations for the implementation of ground-mounted and rooftop PV-systems from 150 kW up to 500 kW will be checked based on the checklist provided below by the loan officer of the PFI and by the subcontractor of "Fichtner GmbH & Co KG" Renewable Resources and Energy Efficiency Fund of Armenia (R2E2). The results of the technical assessment will be summarized in the last column of the attached checklist as well as in a summary report, which should include:

- Short Project Description (location, installed capacity, financial volume, pictures of project area, name of ESCO company, and module producer)
- Analysis of checklist
- Summary of the site visit
- Conclusion and Recommendations

The completed checklist and report will be provided to "Fichtner GmbH & Co KG" in Armenian and English for approval. Based on the conclusion provided, a decision on the financing of the PV system will be made. A negative assessment/conclusion could lead to a rejection of the project. Such cases will be discussed between GAF PMU and "Fichtner GmbH & Co KG" before deciding on the financing of the project.

The technical assessment will be performed according to the requirements as follows.

Requirements

General

- The capacity of the solar PV plant should not exceed the consumption needs of the customer.
- Grid connection and evacuation of electricity are assured.
- Overbuilt (ratio of total module power to total inverter power in each sub-system) should not be higher than 1.2.
- According to local standards, justification of structural design for foundations and module mounting structures, especially considering wind loads and snow loads, shall be provided.
- Comprehensive and complete grounding.
- Adequate corrosion protection for all installed systems.
- All combiner boxes are adequately closed with all cable glands sealed
- Adequate labeling of module rows, combiner boxes, and cables
- Commissioning tests must be passed on system- and component level (factory acceptance tests, site acceptance tests)

Minimum Project Requirements – Submitted Documents

- Applicants to submit documents as required in the document checklist

- ✓ Land coordinates
- ✓ Land privatization certificate or rental agreement with permission to install the project by landowner
- ✓ 1. Energy yield forecast / PVsyst or equivalent report
2. Monthly load profile of own consumption
- ✓ Project description of the layout, civil structures, electrical and mechanical equipment
- ✓ Justification of structural design for foundations and module mounting structures for the wind and snow resistance in the corresponding area/roof.
- ✓ Electrical Single Line Diagram for DC
- ✓ Technical details of connection with the network, Single Line Diagram for AC

Checklist of received documents

Name of PV plant _____

N	Name of document	Received	Comments	Checked	Comments/remarks
1	Land coordinates	<input type="checkbox"/>		<input type="checkbox"/>	
2	Land privatization certificate for ground-based projects or rental agreement with permission to install the project of the landowner / Permission for rooftop installation	<input type="checkbox"/>		<input type="checkbox"/>	
3	1. Energy yield forecast / PVsyst or equivalent commercial simulation software. 2. Monthly load profile of own consumption based on existing data on demand (e.g., electricity bills) and / or plausible assumptions for new buildings / enterprises.	<input type="checkbox"/>		<input type="checkbox"/>	
4	Project description of the layout, civil structures, electrical and mechanical equipment	<input type="checkbox"/>		<input type="checkbox"/>	
5	Justification of structural design for foundations / rooftop installation and respective module mounting structures for the wind and snow resistance in the corresponding area/roof.	<input type="checkbox"/>		<input type="checkbox"/>	
6	Electrical single line diagram for DC single line, protections, switches, circuit breakers, cable specifications	<input type="checkbox"/>		<input type="checkbox"/>	
7	Technical details of the connection with the network, electrical single line diagram for AC single line, protections, switches, circuit breakers, cable specifications	<input type="checkbox"/>		<input type="checkbox"/>	

Minimum project requirements – submitted documents (cont.)

- ✓ Technical specifications for PV modules (including certificates)
- ✓ Technical specifications for Inverters (including certificates)
- ✓ PV DC cable certificates
- ✓ Official document from the distribution network operator or authority granting the connection to the network
- ✓ Cost Estimation
- ✓ Implementation Schedule
- ✓ Photos concerning the site and other structures
- ✓ O&M concept/budget
- ✓ Information on-site security (fence, security cameras, etc.)
- ✓ Information on Operation monitoring scheme
- ✓ Conclusion on the technical condition and durability of the roof

N	Name of document	Received	Comments	Checked	Comments/remarks
8	Technical specifications for PV modules (including PV module certificates)	<input type="checkbox"/>		<input type="checkbox"/>	
9	Technical specifications for Inverters (including Inverter certificates)	<input type="checkbox"/>		<input type="checkbox"/>	
10	PV DC cable certificates	<input type="checkbox"/>		<input type="checkbox"/>	
11	Official document from the distribution network operator or authority granting the connection to the network	<input type="checkbox"/>		<input type="checkbox"/>	
12	Cost Estimation	<input type="checkbox"/>		<input type="checkbox"/>	
13	Implementation Schedule	<input type="checkbox"/>		<input type="checkbox"/>	
14	Photos concerning the site and other structures	<input type="checkbox"/>		<input type="checkbox"/>	
15	O&M concept/budget	<input type="checkbox"/>		<input type="checkbox"/>	
16	Information on-site security (fence, security cameras, etc.)	<input type="checkbox"/>		<input type="checkbox"/>	
17	Information on Operation monitoring scheme	<input type="checkbox"/>		<input type="checkbox"/>	
18	Conclusion on the technical condition and durability of the roof	<input type="checkbox"/>		<input type="checkbox"/>	

Minimum Project Requirements

Equipment Requirements (Manufacturer's Responsibility)

Isolation and Protection

Earthing and Bonding

Temperature and Overload Protection

Ingress Protection

Installation Requirements (Installer's Responsibility)

Proper Mounting and Positioning

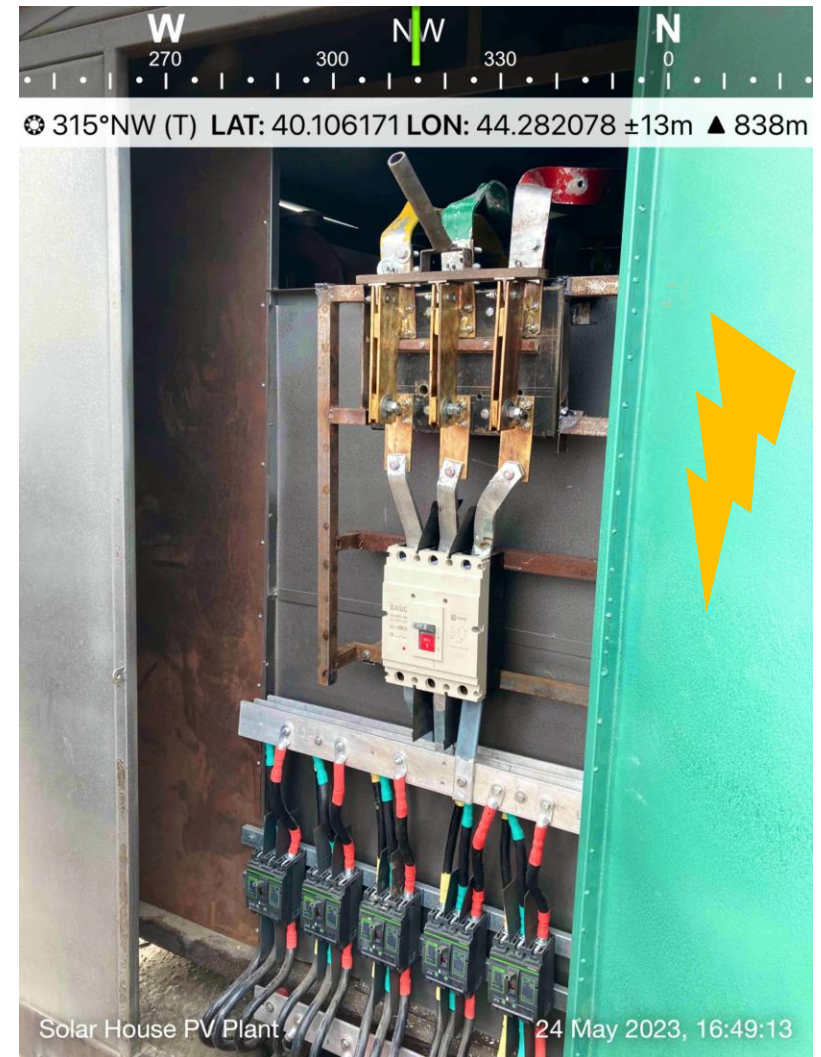
Electrical Connections

Earthing and Grounding

Insulation and Enclosure

Clear Markings and Labels

Testing and Commissioning



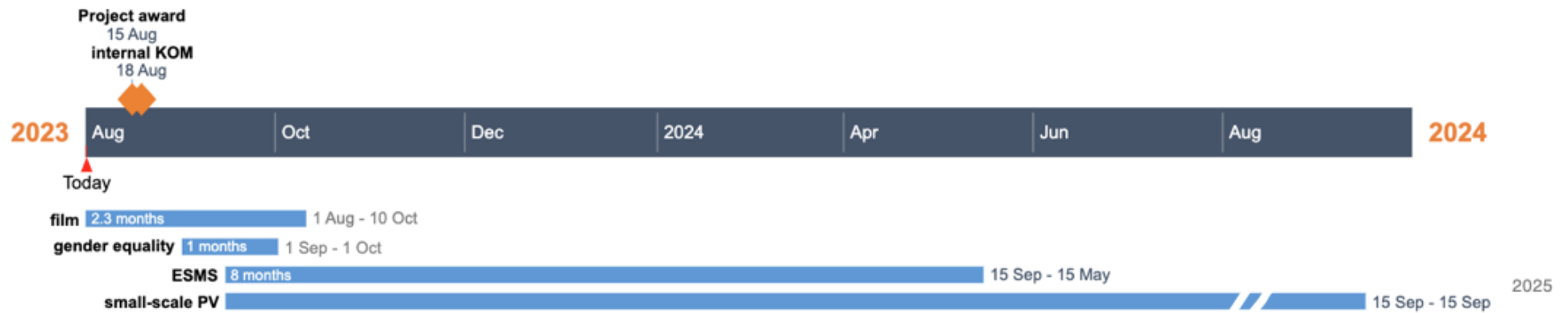
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Timeline of Services

The timeline of activities for GAF-RE Phase VI



- The planned duration of the small-scale PV project assessments is 24 months (2024 and 2025).

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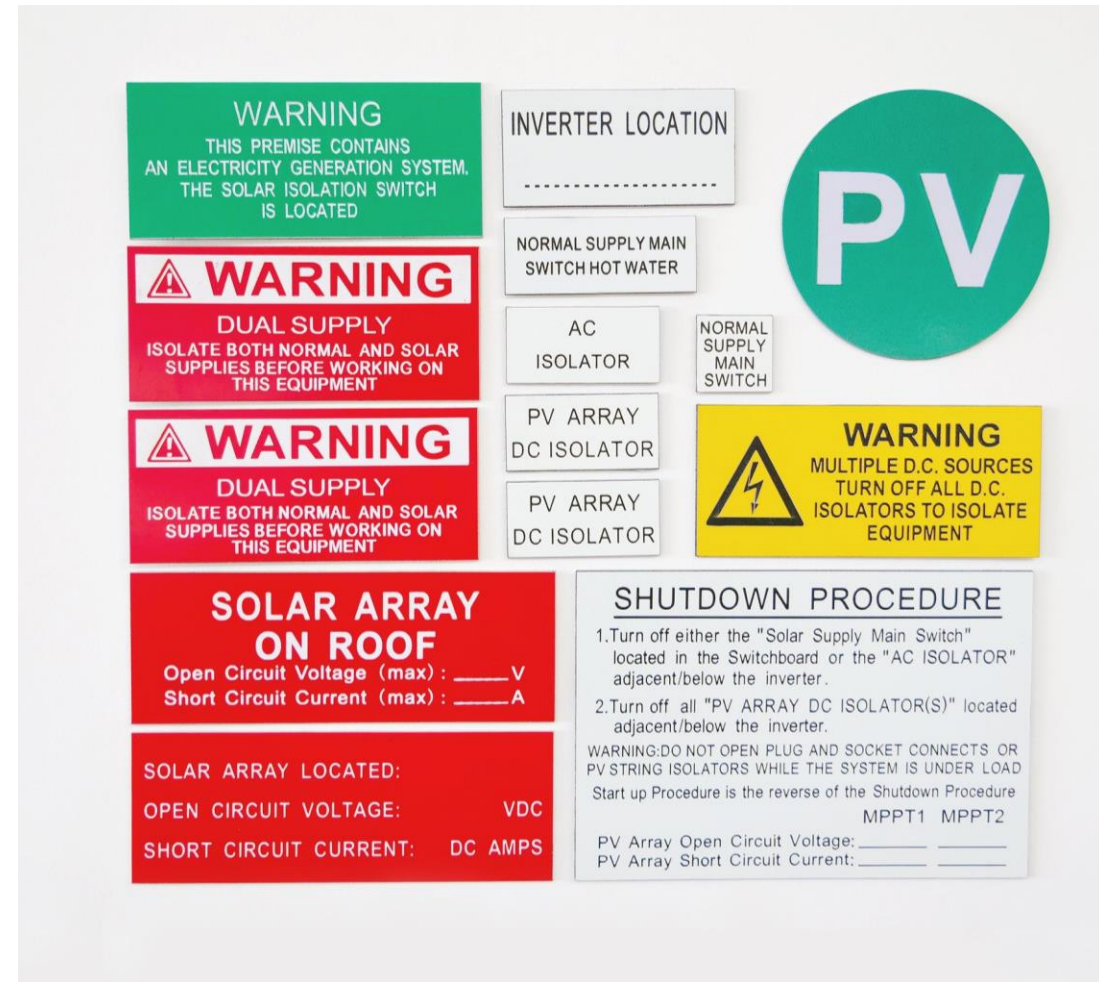
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General Requirements

Summarizes the general requirements for PV Systems up to 500 kWp

- Grid connection and evacuation of electricity are assured.
- Overbuilt ratio should not be higher than 1.2.
- Comprehensive and complete system grounding.
- Adequate labeling of components and cables.
- Commissioning tests must be passed.



Source: GridFree

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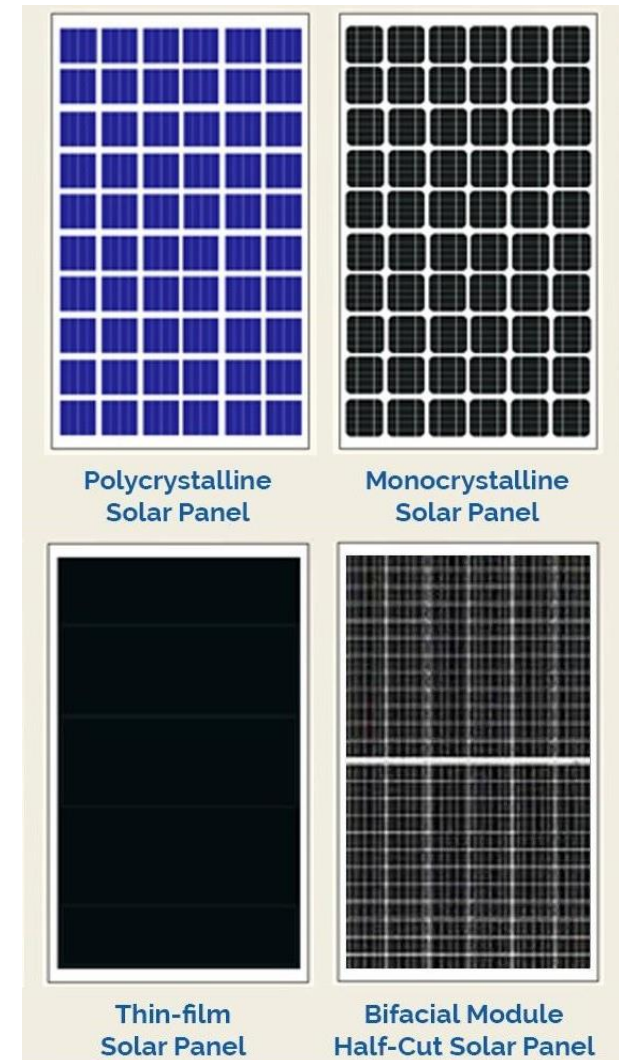
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Modules

Explains the technical specifications and certifications for PV modules

- Standard crystalline or thin film modules
- Linear performance guarantee of at least 25 years for modules
- Certified to bear snow load of 5400 Pa (pressure cycle)
- PID testing and electrical safety certification for modules
- Minimum efficiency of 21% (standard test conditions)
- Degradation warranty of less than 20% over the period of 25 years and less than 10% for first 10 years
- Compliance with relevant IEC standards and national regulations



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Inverters

Explains the technical specifications and certifications for Inverters

- Compliance with relevant IEC standards and national regulations.
- Product warranty of at least five years.
- All inverters must be of same type and from a single manufacturer.
- Inverters must have a minimum efficiency of 96%.



Source: ESTG

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Mounting Structures and Cables

Describes the design and installation aspects of mounting structures and cables

- Mounting structure shall be made of corrosion proof materials, suitable for a 25-year project lifetime, such as aluminum alloys (AlMgSi or AlMg), stainless steel, hot-dip galvanized steel
- Special anti-corrosion coating system such as Magnelis® can be approved on a project basis
- Black or painted steel is not acceptable
- Rooftop: module layout and clearance to roof edges for wind and snow loads
- Rooftop: Walkways for access and maintenance
- UV-resistant and sealed cables and conduit
- Proper cable fixing, bending radius, and strain relief



Source: Axe Struct

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PV System Testing Essentials

Smooth Energization and Grid Connection Depend on Thorough Testing

- **Testing Objectives**
 - Certify professional installation
 - Verify compliance with technical requirements
- **Critical Tests**
 - **AC Side:** check AC circuits, cables, transformers, and main MV switchgear; ensure continuity and insulation resistance
 - **DC Side:** ensure continuity, polarity, open circuit voltage, short circuit current, insulation resistance at combiner box or string inverter input
 - Optional but recommended: String **I-V curve** measurements for optimal system performance.
- **Pragmatic Approach**
 - Test all equipment per **manufacturer's guidelines and checklists** and industry best practices
 - Optimal Conditions for string tests and Thermography



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Energization and Commissioning

Smooth Energization Ensures Long-term System Reliability

- **Off-Grid Testing Completion**
 - Successfully perform all **off-grid tests**, e.g.: earthing
 - **Energize** at inverter and main switchgear levels
- **Verification before Energization**
 - Ensure equipment is installed according to:
 - Manufacturer specifications (Inverters, Transformers, MV Equipment)
 - EPC Contract specifications
 - Applicable Standards (IEC 61727, Local Grid Code)
- **Commissioning**
 - Commission the inverters, transformers and monitoring system as per **manufacturer procedures and checklists**
 - Verify completeness and correct installation of all substation components, if any
 - Include testing of **auxiliary** supply equipment and backup systems



Source: CLP Engineering

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Technical Requirements for Small-Scale Projects up to 500 kW





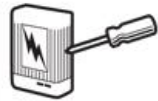









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Electrical Equipment Requirements

Responsibility of Equipment Manufacturer

- **Isolation and Protection**
 - Equipment must provide effective isolation between components carrying different electrical potentials.
- **Earthing and Bonding**
 - Equipment must include provisions for proper earthing, ensuring a low impedance path for fault currents.
- **Temperature and Overload Protection**
 - Components must incorporate thermal and overload protection mechanisms to prevent overheating and potential fire hazards.
- **Ingress Protection**
 - Equipment installed outdoors or in harsh environments must have appropriate IP (Ingress Protection) ratings to prevent the entry of moisture, dust, and other contaminants.

IP (Ingress Protection) Ratings Guide

SOLIDS		WATER	
1	 Protected against a solid object greater than 50 mm such as a hand.	1	 Protected against vertically falling drops of water. Limited ingress permitted.
2	 Protected against a solid object greater than 12.5 mm such as a finger.	2	 Protected against vertically falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.
3	 Protected against a solid object greater than 2.5 mm such as a screwdriver.	3	 Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted for three minutes.
4	 Protected against a solid object greater than 1 mm such as a wire.	4	 Protected against water splashed from all directions. Limited ingress permitted.
5	 Dust Protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment. Two to eight hours.	5	 Protected against jets of water. Limited ingress permitted.
6	 Dust tight. No Ingress of dust. Two to eight hours.	6	 Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.
Rating Example:		7	 Protection against the effects of immersion in water between 15 cm and 1 m for 30 minutes.
IP65		8	 Protection against the effects of immersion in water under pressure for long periods.
INGRESS PROTECTION			

Source: Blue Sea Systems

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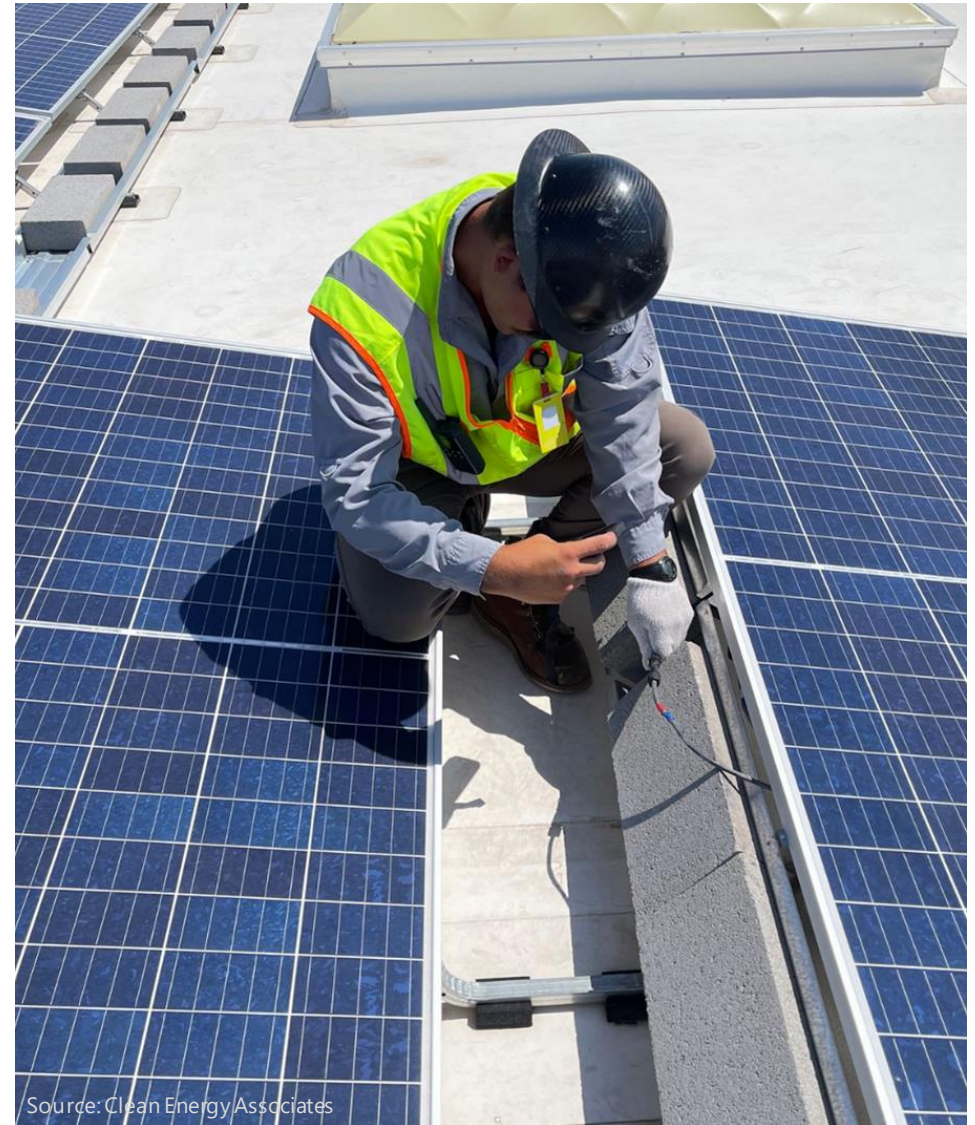
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Installation Requirements

Responsibility of Installer

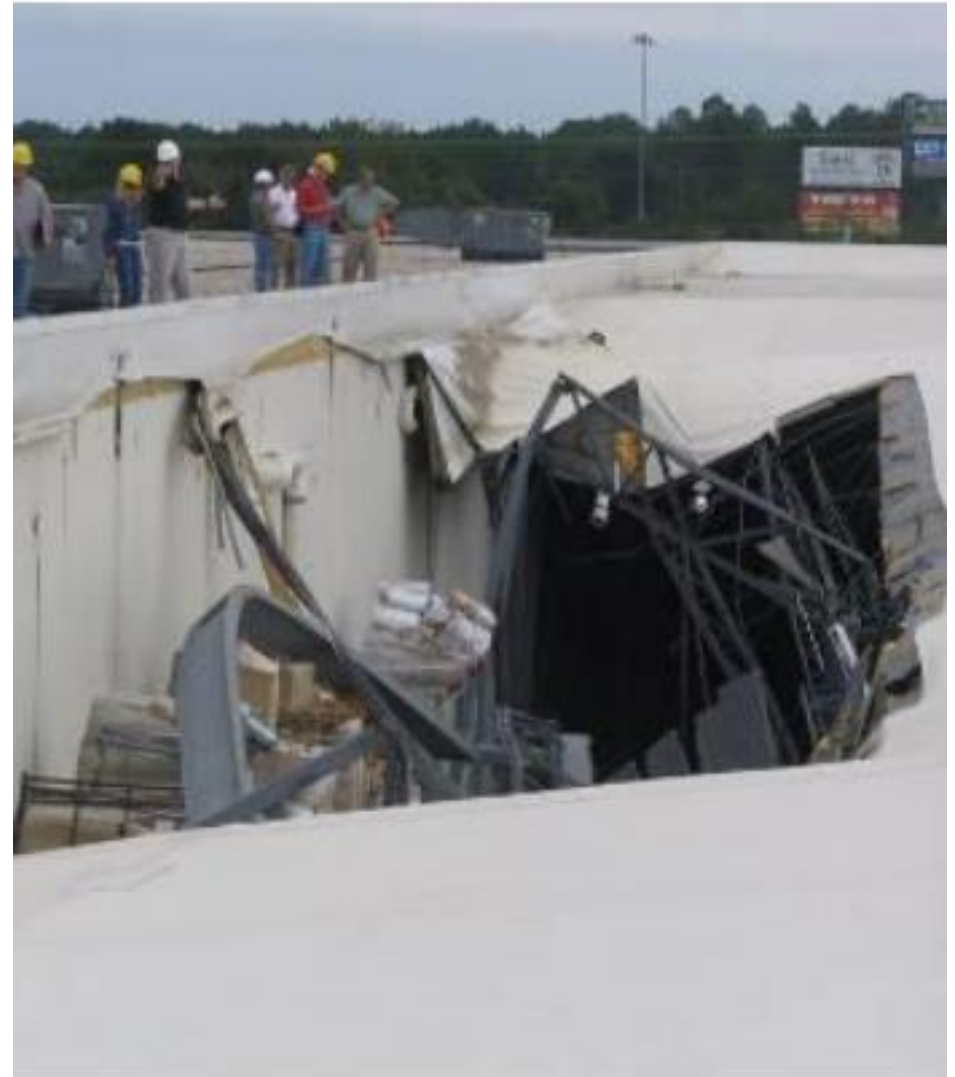
- Proper Mounting and Positioning
- Electrical Connections
- Earthing and Grounding
- Insulation and Enclosure
- Clear Markings and Labels
- Testing and Commissioning



Proper Mounting and Positioning

Responsibility of Installer

- Equipment should be securely mounted and positioned to prevent physical damage and ensure ease of maintenance
- Sufficient space must be provided around equipment for safe operation and access
- For rooftop installations keep following points in consideration:
 - Determine when roof inspection will take place and who will inspect (Roof survey)
 - Receive As-built structural drawings
 - Receive stamped structural information reflecting kg/m² roof loading capability
 - Determine where the best roof access point is for personnel



Electrical Connections

Responsibility of Installer

- All connections, including busbars, cables, terminals and lugs must be properly tightened to ensure low-resistance paths and prevent overheating
- Cable tray covers should be installed to prevent water from collecting in trays
- For rooftop, consider the following:
 - DC strings must be labeled minimum at both ends for ease of identification and troubleshooting
 - Inverters should be mounted vertically or tilted as per manufacturer recommendation
 - Rooftop temperatures can result in ground faults if cables are not properly padded and provided with strain relief
 - Install strain relief for main DC wire run down the facade (> 10m height)



Conductor insulation pierced by the bond bushing .

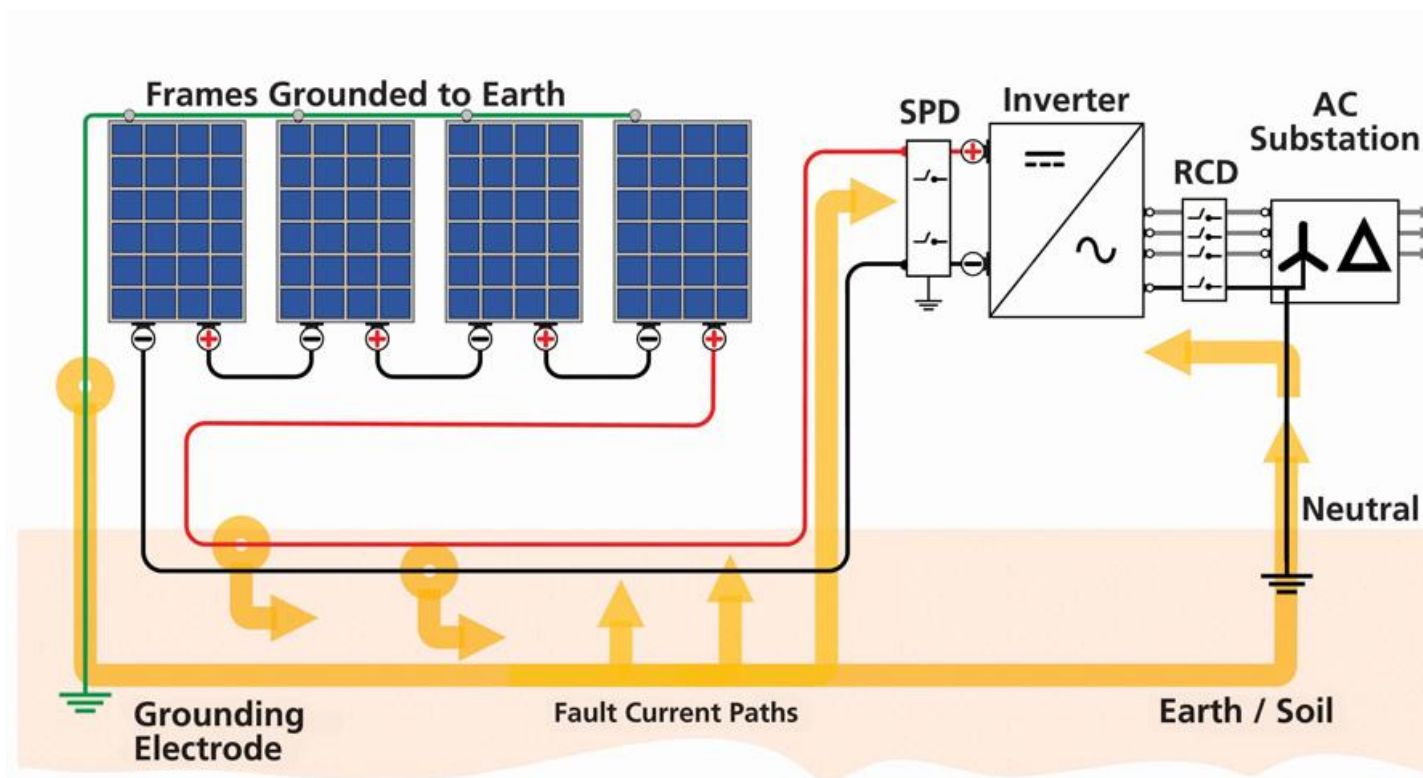
Bond bushing missing internal plastic bushing.



Earthing and Grounding

Responsibility of Installer

- Adequate grounding and earthing systems should be established, complying with local electrical codes and standards.
- Equipotential bonding must be established to avoid potential differences within the installation.
- Earth resistance should be measured and maintained within acceptable limits.

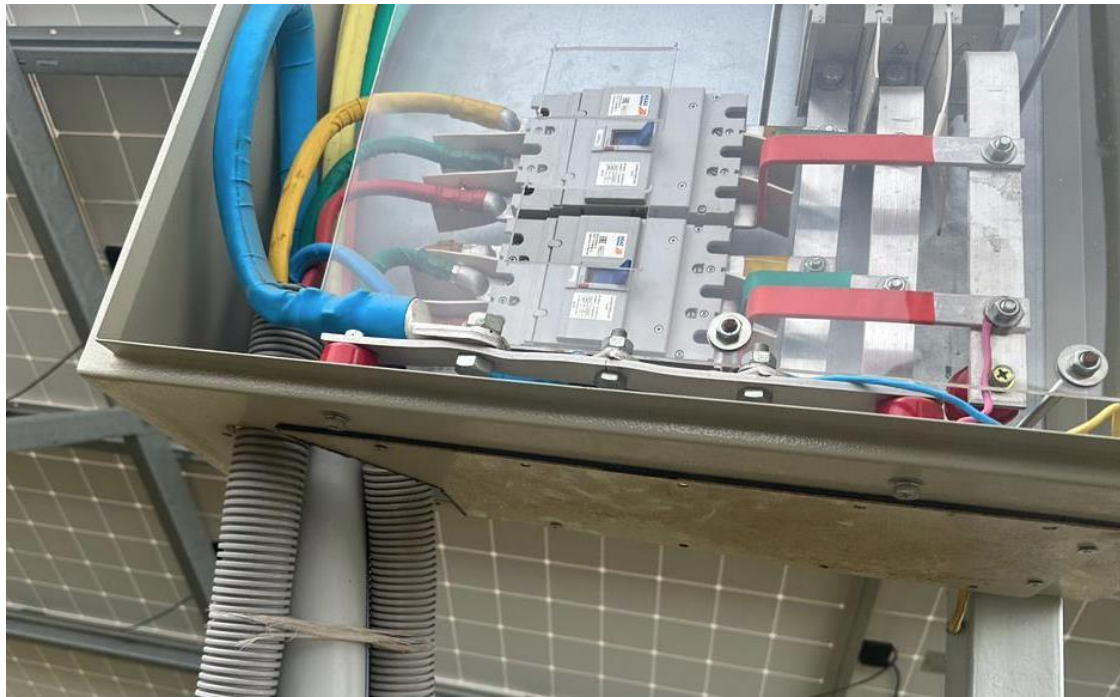


Source: NETA World Journal

Insulation and Enclosure

Responsibility of Installer

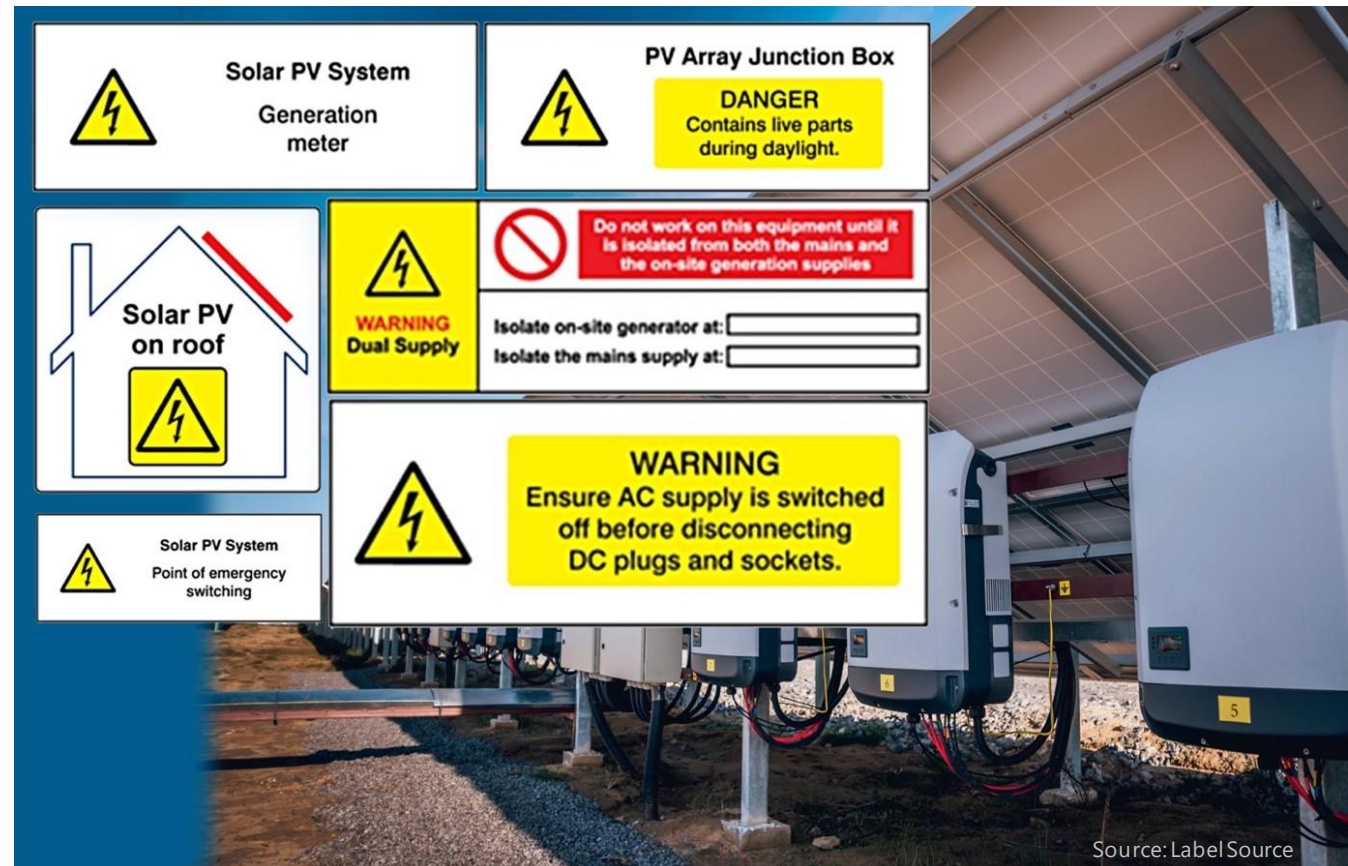
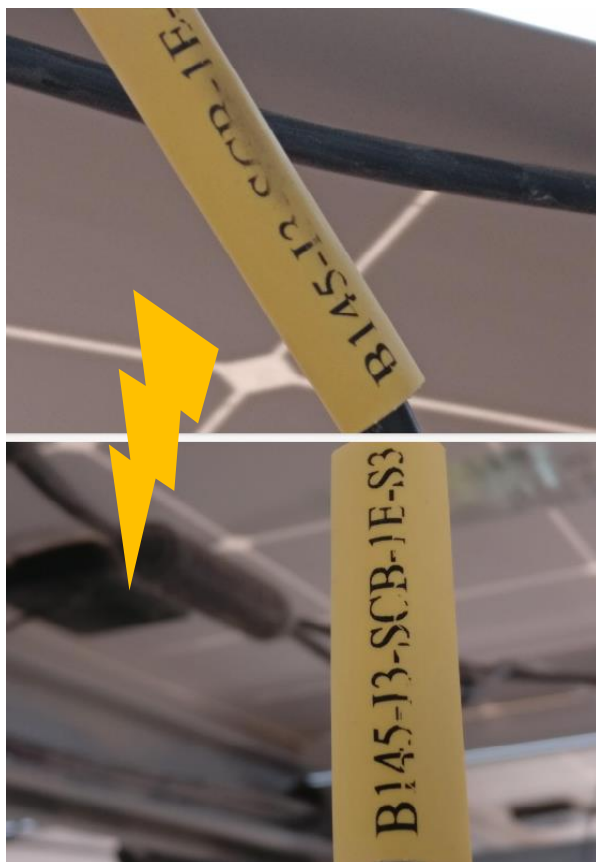
- All busbars, terminals, and conductive parts must be adequately insulated to prevent accidental contact
- Exposed live parts must be shielded or enclosed to prevent inadvertent access
- Outdoor installations must include weatherproof enclosures to protect against environmental elements



Clear Marking and Labels

Responsibility of Installer

- Equipment must have clear and durable markings indicating live parts, warning signs, and safety instructions
- Durable labels should be placed in easily visible locations for maintenance and operation personnel



Source: Label Source

Testing and Commissioning

Responsibility of Installer

- All equipment and connections must undergo thorough testing before commissioning to verify proper functionality and safety
- Insulation resistance, continuity, and earth resistance tests must be performed and documented
- Components must comply with Site Acceptance Test (SAT)



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Environmental and Social Aspects

Addresses the environmental and social impacts and mitigation measures for PV systems up to 500 kWp

- No use of protected areas
- No land with unique archaeological, historical, or cultural value
- Land ownership or land lease agreement with permit
- Stakeholder awareness and consent
- EHS during construction and operation
 - PPE
 - Housekeeping
 - Waste Management



Health and Safety

Personal Protective Equipment (PPE)

The minimum PPE set shall include:

- Safety helmet
- Gloves
- Hi-visibility vest
- Safety shoes (steel cap toe)

During operation:

- Hi-visibility vest
- Dielectric gloves
- Dielectric shoes

Other PPE depending on task:

- Harness – working at height
- Mask/Respirator – excavation, dusty conditions
- etc

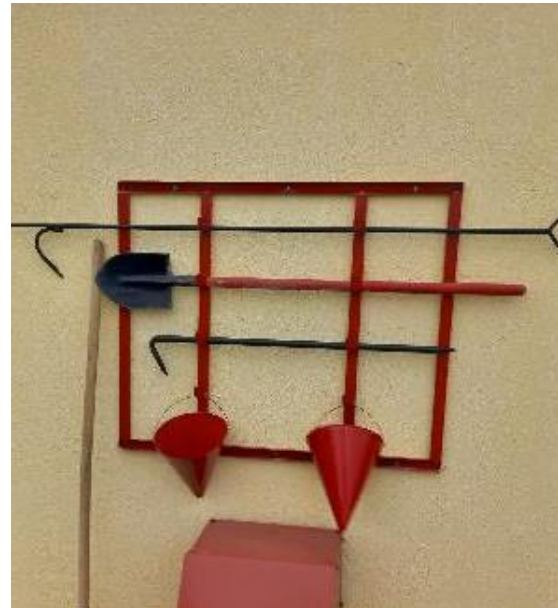


Health and Safety

Fire extinguisher

Fire extinguishers should be available near the transformer, hazardous waste storage, and flammable materials storage.

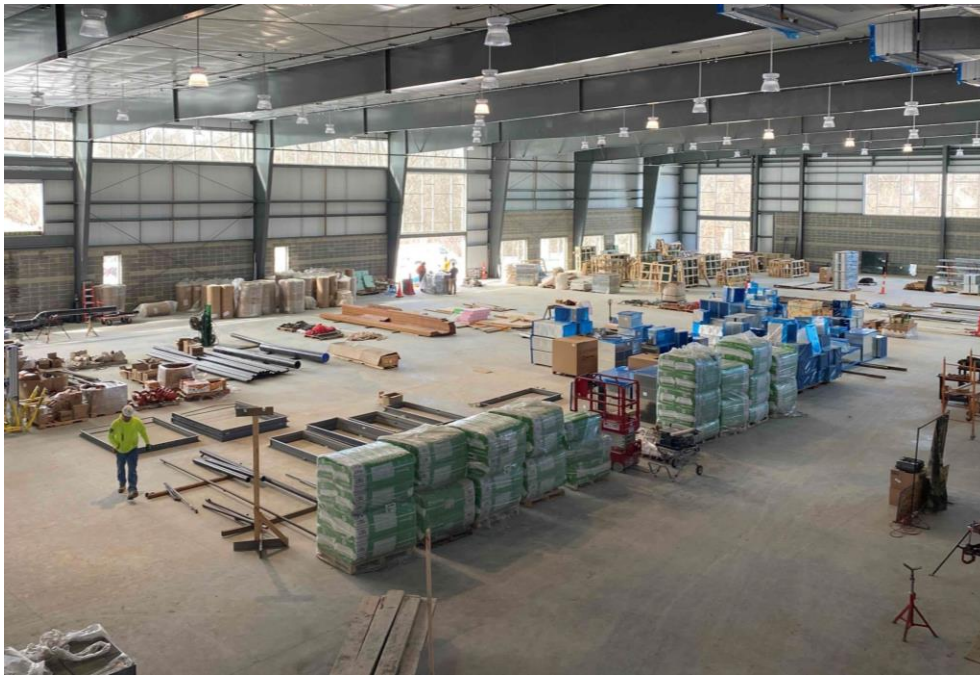
Portable extinguishers should also have valid expiry date.



Good

versus
Housekeeping

Bad



Good Housekeeping	Poor Housekeeping
Good storage = less wastages and saving money	Poor storage = excess purchases and wastage
Contained Oil drums	Oil spills, wastage resulting in costs and pollution
Waste sorted and stored appropriately	Fly waste all over property and surrounds
Reduce potential for accident and incidents	Increased potential for accident and incidents
Better moral	No care attitude

ESHS housekeeping

Best practices for proper housekeeping

Proper housekeeping must be provided on the construction site not only after completion of construction works, but continuously during construction.

Actions

- Periodical removal of trash and debris shall be organized
- all types of waste shall be collected and disposed of off site
- solid waste shall be kept in a covered container, construction waste shall be collected at a separately allocated area
- construction and packaging materials must be collected and stored properly and not be spread on site
- construction waste shall be transported from the area (usually it is Contractor's responsibility) and disposed of at the community landfill (landfill, dumpsite) upon written consent of the community head.

Objective

Best practices for proper housekeeping



Waste Management on and off site

Construction period – hazardous waste

- ❑ Hazardous waste is classified in accordance with the Decree of the Minister of Environment N 430 dated 25.12.2006.
- ❑ Barrels with transformer oil or diesel should be stored on a waterproof surface and under cover to avoid direct sunlight.
- ❑ Secondary containment with a volume of 110% of the volume of drums or oil container shall be provided. The oil barrels/containers shall be properly labelled. The fire extinguisher shall be placed not far from the storage location.



Thank you for your attention





Contact

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