RENEWABLE ENERGY TECHNOLOGIES

INSTALLİNG THE CONTROL SYSTEM MODULE

2022-2-TR01-KA210-VET-000098216

IN RENEWABLE ENERGY TECHNOLOGIES NEW APPLICATIONS ACCORDING TO 4.0 STANDARDS

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DESCRIPTIONS

AREA	**Renewable Energy Technologies**
BRANCH/ PROFESSION	**Solar Energy Systems**
NAME OF THE MODULE	**Control System Installation**
DESCRIPTIONS OF THE MODULE	This module is a learning material that provides information about setting up a solar panel control system. .
COMPETENCE	Installing the control system of solar panels .
PURPOSE OF THE MODULE	**General purpose** You will be able to assemble the control panel, cable connection and install the battery system. **Purposes** 1. You will be able to mount the control panel at the designated location on the solar stand. 2. You will be able to connect the control panel cable using appropriate equipment. 3. You will be able to install the battery system.

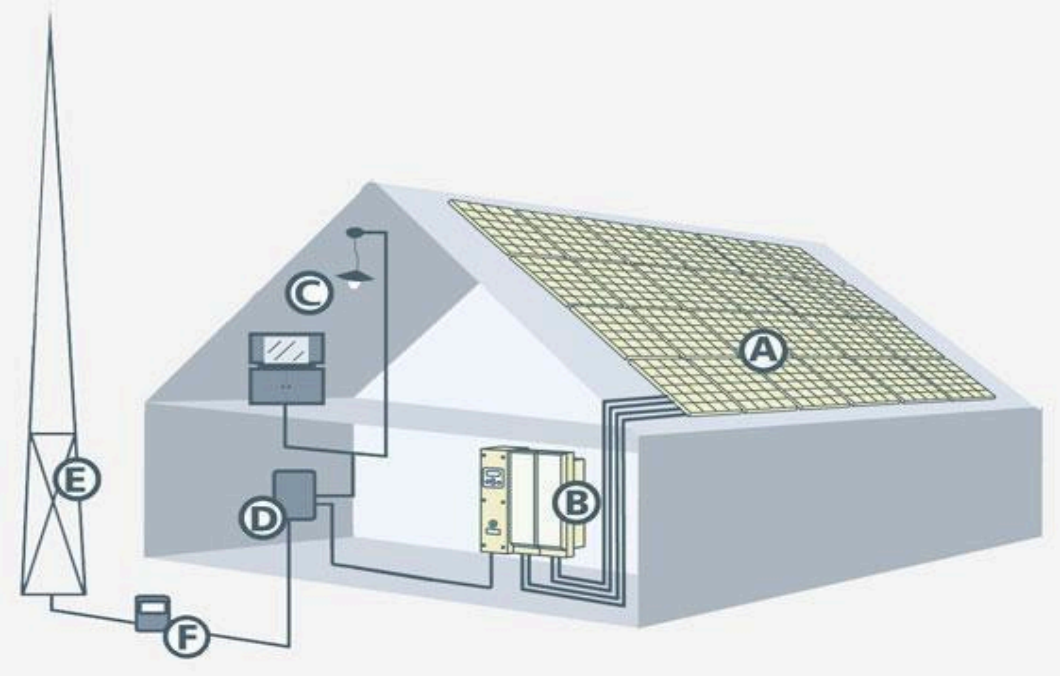
1.SOLAR PANEL CONTROL PANEL

1.1. Panel Elements

It is necessary to use solar panels equivalent to the power needed to obtain energy from the sun, batteries to store the energy obtained from solar panels, charge controllers to control the charging of the batteries, and inverters that bring the energy output from the batteries to a level that can be used in our home appliances. The basic elements that must be included in the panel of the solar panel system are the charge controller and inverter (Picture 1.1, Picture 1.2).

The direct current received from the solar panels will prevent the batteries from overcharging thanks to the charge controller, thus preventing the batteries from being damaged and, as a result, reducing the performance and lifespan of the batteries. On a sunny day, solar panels will produce more voltage. This excessive increase in voltage can damage the batteries. The charge controller controls the charge level in the batteries and prevents damage to the batteries by regulating the charge in case of any excess.

The inverter is one of the most important parts of the solar energy system. It converts the 12 volt DC voltage obtained from solar panels into 220 volt AC voltage (Picture 1.2).



A. Panel **B**. Charge Controller and Inverter Board **C**. Electric Pickups **D**. Home Fuse Panel **E**. Network **F**. Electric Meter

Picture 1.1: Charge controller and inverter panel in the solar panel system (B)

Picture 1.2: Charge controller and inverter

The panel elements that must be included in the panel of the solar panel system are basically the charge controller and inverter. In addition to these, fasteners, cable channels, carrier rails and terminal blocks are also the elements used in the panel.

1.2 Panel Fasteners

Panel fasteners; It consists of screws, bolts, sheet metal screws, nuts, washers, clamps, circlips and couplings.

Screws: Cylindrical or conical parts with right or left threads cut on them are called screws. In other words, it is a twisted nail with threads on it. It is an indispensable element of the industry. Just as it is made in metal, plastic types are also used today. Screws are manufactured in more than one way, depending on the type of threads cut into their threads (Figure 1.3).

Picture 1.3: Screw types

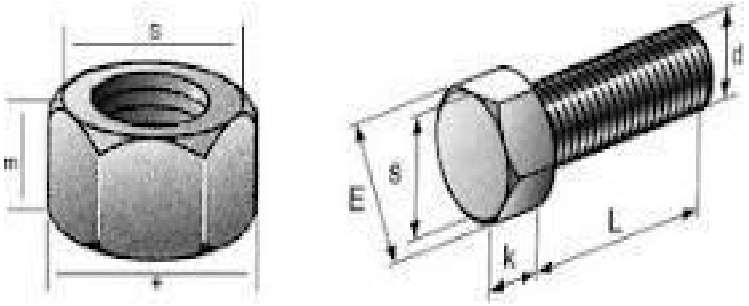
Bolts: It is a fixing and attachment part that allows connection by placing the hole prepared on the wooden or metal parts that are desired to be connected together and tightening the nut. In other words, the machine element formed when the head is added to the screw is called a bolt (Figure 1.4).

Picture 1.4: Bolts

Sheet metal screws: The threaded part of the bolt is called a screw, but screws themselves have different names depending on where they are used in our daily life (in practice). For this reason, the types used in sheet metal work are called sheet metal screws, while the type used in woodwork is called wood screw (Figure 1.5). The type of screw most suitable for joining two previously drilled sheet metal parts is called sheet metal screw. To use these screws, it is necessary to pre-drill holes with a drill. For this reason, today it is replaced by self-drilling screws. There is no need to drill the sheet metal when using self-drilling screws. Since the tip of the screw is made in the shape of a drill, it first drills the sheet metal and then screws it(Figure1.5).

Picture 1.5: Sheet metal and self-drilling screws

Nuts: They are attached to the end of the bolt, have threads (grooves) cut into them in accordance with the threads of the bolt, and their outer circumference is hexagonal, quadrangular, round, etc. Machine elements in different shapes are called nuts (Picture 1.6).



Picture 1.6: Nut and bolt

Washers: Between the nut or bolt head and the machine part. The parts used, made of sheet metal with a hole in the middle and often ring-shaped, are called washers or washers. It is placed under the bolt head and nut to increase the surface pressure and prevent the bolts from being to bend (Picture 1.7)

Picture 1.7: Washers

Clamps: Used to collect cables and fix them to the panel. It is manufactured in different shapes depending on where it is used **Picture 1.8: Clamps.**

Circlip: It is used in shaft-shaped bolts that need to be loosened when desired. They are machine elements with holes drilled at both ends, resembling washers. It is removed and installed with special pliers called circlip pliers (Picture 1.9).

Picture 1.9: Circlip

Detent Pin: It is made by doubling the wire made of hard steel. They are machine elements that prevent the nut from coming out as a result of bending the end of the bolts, which we call tipped, by passing them through the hole in the unthreaded part (Figure 1.10).

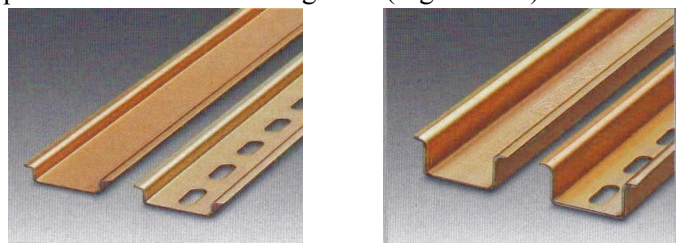
Picture 1.10: Detent Pins

1.3 Panel Mounting Elements

Panel mounting elements; It consists of cable channels, carrier rails and terminal blocks.Cable channels: Ensures that the cables used in the panel are stored properly and can be tracked within the panel. The edges of the channel are manufactured by leaving intermittent slits. The reason for this is to prevent possible overheating by ventilating the cables and to ensure easy cable passages. It is manufactured in two types: sheet metal and PVC cable trays. We will use PVC channels regarding our topic (Picture 1.11).

Picture 1.11: Panel type PVC cable duct

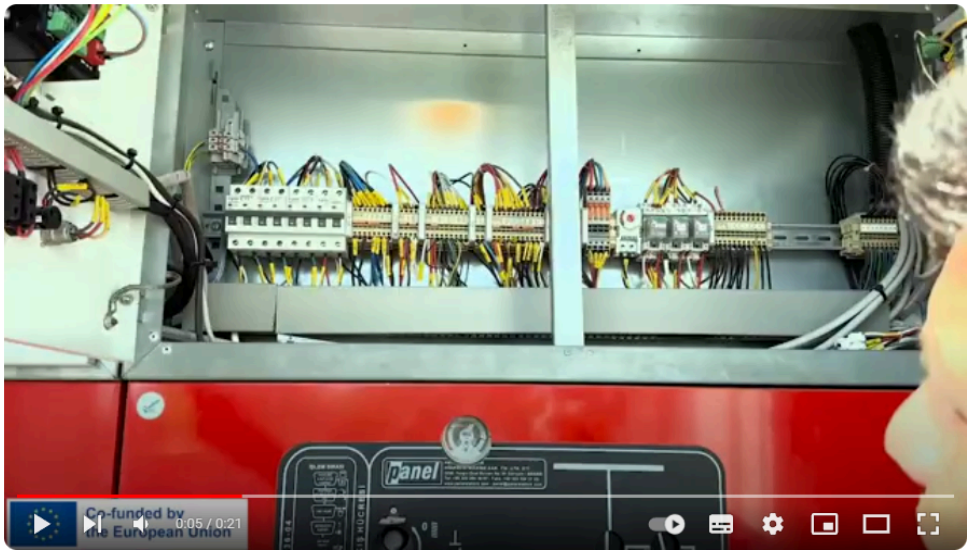
Carrier rails: Terminals, contactors, automatic fuses, etc. are placed on them. The elements on which we place electrical materials, such as rails, are called rails. In old panels, electrical materials were mounted to the trays with screws. This would take a lot of time and make it difficult to intervene in the event of a malfunction. The biggest reason why rails have become widespread today is that they provide the opportunity to mount electrical materials to the panel in a very simple way. In addition, we can easily replace the faulty element with a new one in the rail system. Carrier rails; It is divided into two: perforated/non-perforated rail and low/high rail (Figure 1.12).



Picture 1.12: Carrier rail (low, high, solid, perforated rails)

Terminals: The elements that enable the connection of electrical elements such as contactors, fuses, charge regulators and inverters used in the panel between themselves and with units outside the panel are called terminal blocks. Generally, electricity enters the panel through the terminals and exits through the terminals. For this reason, terminal blocks are the most important element of the panel. It must be of good quality and resistant to oxidation. We should not forget that the majority of building fires are caused by electrical contact**.**

Figure 1.13: Rail-mounted terminal blocks



To play the video, click on the image or click the link below and open it with your browser.

https://www.youtube.com/watch?v=W3MOnW5bzqA

2. PANEL SUPPLY WIRINGS

2.1Supply Cables

Due to the superior properties explained above, it is inevitable to use solar (photovoltaic) cables specially prepared with superior quality raw materials for these systems in photovoltaic systems.

Picture 2.1: Solar type supply cable

To play the video, click on the image or click the link below and open it with your browser.
https://www.youtube.com/watch?v=zQmmatmBuBc

Photovoltaic cables contain tinned copper conductor wire conforming to VDE 0295 / IEC60228 class 5. The inner part of the cable consists of a special copolymer combined electronically with rays and a second polyolefin copolymer layer surrounding it. The nominal cable cross-section of solar cables must be approved by TÜV. It should have a dense cable diameter and not take up much space. It must definitely be long-lasting and durable.

In general, the features that photovoltaic cables should have can be listed as follows:

- It has special electron beam textured insulation and sheath.
- ¬ It is resistant to extreme heat and cold.

- ¬ It is oil resistant.
- ¬ Resistant to friction.
- ¬ It is resistant to ozone.
- ¬ Resistant to ultraviolet rays.
- ¬ It is resistant to bad weather conditions.
- ¬ It has better protection against fire, does not produce much smoke and does not burn.
- ¬ It does not contain halogen.
- ¬ It is very flexible.
- ¬ Insulation is easy to open.
- ¬ It takes up little space.
- ¬ It has high mechanical strength.
- ¬ Leakage losses are minimal. It is long lasting**.**
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2.2 Supply Cable Apparatus

We will refer to the supply cable apparatus as solar cable connectors from now on. Calculating the system and selecting the required products in photovoltaic system installation is not easy, but the importance of connection products, which are generally neglected and should not be neglected, is extremely high. When you examine the cost of a system, the value of fittings is limited to ~5% on average. When you make the wrong choice in connection products, you may face fire danger., you may incur high losses and more importantly, human life may be at stake.

To produce electricity at large powers, solar panels are connected together to form solar PV arrays. Multiple solar panels are connected to each other in parallel or series to increase power output. When connecting solar panels to each other, solar cables that comply with the solar panel supply cable selection criteria in the previous topic should be preferred.

Solar cables and connectors should be used when connecting solar panels. (Picture 2.2).

TYCO ELECTRONICS		
Ürün	**Solar kablo**	**Konnektör**
Kesit	2.5; 4; 6 mm2	2.5; 4; 6 mm2
Minimum sıcaklık	-400C	-400C
Maksimum sıcaklık	1250C	1100C
Mevcut renkler	Siyah, mavi, kırmızı	Standard
Bağlantı şekilleri	-	Dişi, Erkek, T branch
Akım taşıma kapasitesi	2.5 mm2 - 41 A 4 mm2 - 55 A 6 mm2 - 70 A	25 Ampere kadar
Onay	IEC 60228 Class5 TÜV ve UL	TÜV ve UL

Picture 2.2: Solar cable and connector features

When connecting solar panels to each other, female or male connectors are connected to the junction boxes on the panels (Picture 2.3, Figure 2.1). Parallel connection connectors are used when solar panels are connected in parallel with each other.

(Picture 2.4).

Picture 2.3: Female and male solar cable connector

Picture 2.4: Connector for parallel connection to panels

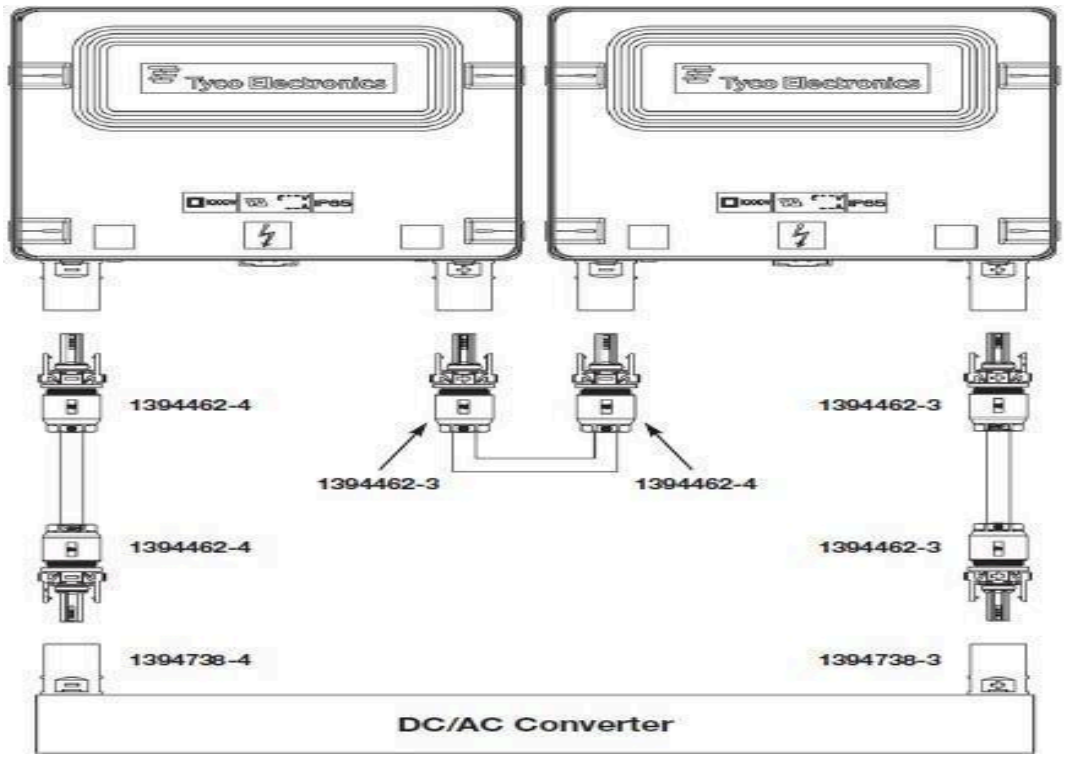

Figure 2.1: Junction box and connection apparatus (connectors) on the panels

3.STRUCTURE OF BATTERIES AND INSTALLATION OF THE SYSTEM

3.1. Structure and Types of Batteries

Batteries are complex electrochemical devices that convert and store chemical energy into electrical energy. The term battery represents one unit. However, there may be one or more cells in this unit. Cells are the building blocks of the battery. Batteries usually consist of more than one cell combined. Every battery consists of three basic elements: anode (positive pole), cathode (negative pole).

and the electrolyte that enables the chemical reaction. In other words, the electrolyte is the part that stores and returns electrical energy. Accumulators are an indispensable material for us. From the smallest individual use to the largest professional application, we need to store or back up the energy we provide from the sun. For example, we can illuminate at night with the electrical energy we store in daylight. We can also provide power to very serious and critical communication stations within the same principles. Also, in case of long-term mains power outage or disaster, etc. In such cases, it is certain that the energy we store in batteries will have a vital function.

Battery is an electrochemical static element that converts direct current electrical energy into chemical energy and stores it, and when receivers are connected to its circuits, it converts this energy back into electrical energy and operates the receivers. (Figure 3.1).

Briefly, the working principle of a lead acid battery is simply obtained by immersing a battery element and two lead plates in a container containing diluted sulfuric acid. If the ends of these two plates are connected to a direct current source and direct current is passed for a while, the surface of the plate connected to the (+) end is covered with a layer of lead peroxide (PbO2). Then, if the ends of the plates are connected to a receiver, they are seen to give current.

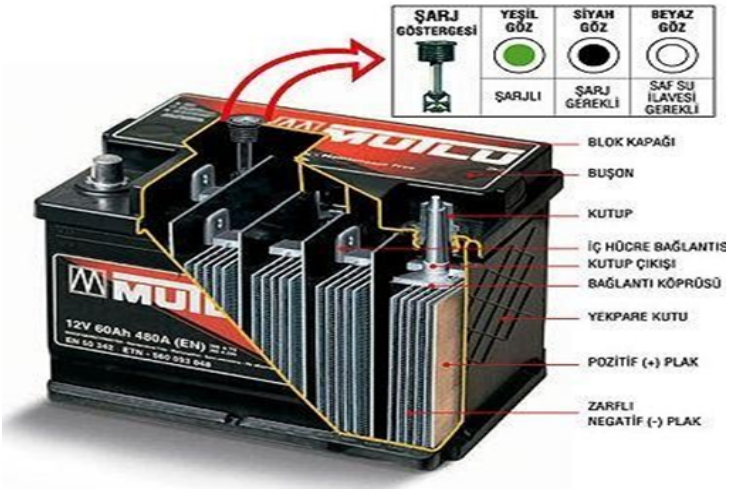

Figure 3.1: Internal structure of the battery

A battery cell consists of the following main elements:

Battery container: It is mostly made of ebonite or plastic material. Transparent battery containers allow inspection of the elements inside the battery. Battery containers are made in various sizes depending on the location where they will be used.

Battery cover: It is the part made of battery case material and covers the cell. It closes the top of the battery container by pressing or gluing it in an airtight manner.

Cell cover (plug): It is a small cover made of plastic material that is attached to the threaded hole on the battery cover.

It has three main functions:
--- Measuring the density of the electrolyte by removing it or adding pure water
--- To ensure that the gases formed in the battery come out through the small hole in the cover when the plug is closed.
--- In special type plugs, to ensure that the gas formed inside the cell condenses in the plug and returns to the electrolyte, thus reducing the loss of pure water in the battery.

Electrolyte: It is a liquid that is a mixture of sulfuric acid and pure water. Depending on the type of battery and the preference of the manufacturer or user, various batteries are manufactured with different sulfuric acid and water ratios.

Separator: These are the parts that prevent the plates inside the cell from touching each other and causing a short circuit. It is made of acid-resistant insulating material and comes in various profiles depending on the manufacturer's preference. However, the following points are taken into consideration when selecting the separator type and installing it:
--- Not increasing the battery internal resistance
--- Not to reduce the electrolyte contact between the plates by making the separators microporous
--- Compressing the plates to prevent them from bending and breaking, especially during transportation

Plates: There are two separate plate groups in a battery cell: positive and negative.

Battery cell: A battery cell is formed by placing the elements described above into the battery container in accordance with the technique. The number of negative plates in the battery cell is one more than the number of positive plates. In this way, both surfaces of the positive plate are kept active and its bending is prevented.

Batteries are also divided into wet or dry. In wet cell batteries, the electrolyte is liquid. Electrolyte in dry cell batteries; Available in paste, gel or other matrix form. The voltage value of the battery depends on the materials used in making the battery. For this reason, there are various batteries depending on the material used in the battery element.

The ideal battery should have the following features:

← It should have high energy density.

← It should be portable and resistant to environmental conditions.

← It should be long lasting.

← It should be safe.

← It should provide flexibility for the application site.

Battery groups are obtained by installing cells side by side and connecting the (+) and (-) poles to each other with external bridges. The connection of external bridges to the cell poles is a matter dependent on the manufacturer's technique. It is mostly bolted or welded.

Battery cells are grouped into groups for two reasons:

1-To increase the voltage

2-To increase capacity (current)

The rated voltage of a battery cell is 2 volts. For this reason, when it is desired to obtain a higher voltage proportional to the rated voltage, a battery group at the desired voltage can be obtained by connecting the (+) pole of a cell to the (-) pole of the next one, which is expressed as series connection.

NOTE: It is possible to increase both voltage and capacity by connecting battery cells in series and parallel (in other words, by connecting them mixed).

Battery connections are made in three types: serial connection, parallel connection and series-parallel connection.

Serial connection: It is a single serial branch formed by connecting battery blocks one after the other to form the battery group. The connection made by connecting the (+) pole of one cell to the (-) pole of the adjacent cell is called serial connection (Figure 3.1). Battery groupRechargeable batteries are produced in three types. The first is open type batteries. These batteries, which are open to the atmosphere, release hydrogen gas into the atmosphere during use and therefore require water as water decreases. Maintenance-free batteries only have more electrolyte, so they do not require maintenance throughout their service life. The second type of rechargeable batteries are semi-open or semi-closed batteries. The electrolytes used in this type of batteries also release gases into the atmosphere. However, the electrolytes of this type of batteries are gel type. The third type of batteries are completely sealed batteries. Closed type batteries normally do not release the released gas into the atmosphere.

Although there are many different types of batteries depending on where they are used and how they work, it is possible to categorize them into three main groups. These; automotive batteries, traction batteries and stationary batteries.

Its total voltage (V) is equal to the sum of each battery block voltage. Battery capacity (A/h) does not change in serial connection; The capacity of the battery group is equal to the capacity of each block in the group.

Automotive batteries: These batteries are the batteries used in motor vehicles. Their basic operating feature is that they deliver a large current in a short time during cranking. Apart from this, in order to enable them to deliver high current, their plates have been made thinner, allowing the active substance to come into contact with the electrolyte more easily. Since its plates are thin, it is relatively short-lived. In addition, the plates were brought closer together to reduce internal resistance and to ensure a small volume, and separators were placed in between to prevent them from touching each other. Since the two main substances of batteries used in motor vehicles are lead and sulfuric acid, they are called lead-acid based batteries. When it comes to batteries, the first application that comes to mind and is known to everyone is the series used for starting purposes in vehicles, that is, for automotive applications. It is expected to be as small in size, light and portable as possible. It is widely used in mobile applications. Known's main feature is that they are an open/aqueous system, that is, the acid inside is liquid/liquid based. There is a risk of releasing/secreting acid into the environment. These accumulators should be used in ventilated places.

Traction batteries: These batteries; It is used in vehicles powered by electric motors such as cranes, load carriers and especially submarines, and provides a medium-sized current continuously. Their structure is much stronger than automotive batteries and therefore they have a very long life. Their main known feature is that they are an open/aqueous system, that is, the acid inside is liquid/liquid based. There is a risk of releasing/secreting acid into the environment. In this field, there are well-known facilities in our country that produce serious and high-quality products, as well as imported brands.

Stationary batteries: These batteries are used in telephone switchboards. It charges and discharges with a small current. Their most important feature is their longevity. The general definition of the products used in industrial applications that particularly interest us in the

sector is stationary battery. As its name suggests, it is designed to be used in fixed/stationary places. Due to its working principle and plate structure, it has the ability to deliver constant current/power for a long time. There are quite extensive subheadings that fall into this category. These may also show physical, chemical and internal structure differences among themselves.

In principle, the main differences between lead-acid batteries and batteries that are suitable for buffer charging are their floating / buffer charging voltage and hibernation characteristics. It is constantly being improved technologically. Those with a long operating life and a higher number of cycles of charge/discharge are preferred. Closed system and maintenance-free dry ones can find widespread use. There are solution options for high power needs, as well as ones with very small physical size and capacity, with exactly the same operating principle. In-device, indoor environment, etc. It is very important for applications to be maintenance free/valve regulated. In this way, it is not expected to release gas/leak under normal conditions. In today's conditions, there are several different criteria when choosing an accumulator, such as application/need, field/environment conditions, anticipated budget and commercial conditions.

Stationary type lead-acid batteries used in solar systems are basically divided into four: OPzS, VRLA Gel, VRLA AGM, VRLA AGM GEL. Which of these battery types to use should be determined according to the importance of factors such as maintainability, ambient temperature, load profile and cycle life..

VRLA (Valve Regulated Sealed Lead Acid)/AGM: VRLA Batteries are named after the valve system mounted on them, which allows the gases to recombine in the battery at a high rate during charging and discharging (Picture 3.2). These batteries allow gas output of 1% of the gas output of flooded type batteries (to which water can be added). In this way, the need for ventilation is minimized where the batteries are stored.

Picture 3.2: VRLA AGM battery

It is a completely and truly sealed, dry type, maintenance-free stationary battery. Provides high performance and reliability for long-term applications. They are real dry type, fully maintenance-free accumulators with a "gas recombination" system used in the Uninterruptible Power Supplies System. This type of accumulators, which are in flame retardant boxes and have low pressure automatic closing valve control, have a high rate of gas recycling feature. There is no need for maintenance in closed system batteries, internal devices, etc. It has important advantages such as being able to be used in closed places, including horizontal or vertical positions. Its performance is very high in systems with load profiles that require high current in a short time. It is preferred in photovoltaic applications due to its deep discharge and high cycle number.

VRLA / GEL: The structure of VRLA gel batteries contains gel-formed acid as electrolyte instead of liquid acid (Figure 3.3). This gel electrolyte is filled into the battery with a special production process. The placement of the plates inside the battery is done in a way that takes up minimum space, similar to VRLA AGM batteries. VRLA gel has all the

advantages of VRLA AGM over flooded batteries, but the charging method is different compared to flooded and AGM batteries. The gel structure may deteriorate during fast charging or high current charging, which causes very high gas emissions. To prevent this, the load profiles of the systems containing these batteries should be planned for longer charging and discharging. The biggest advantage of gel batteries over AGM batteries is that temperature has less negative impact on life. This makes it inevitable to use VRLA gel batteries, especially in systems located in hot regions and non-climatic environments. In addition, VRLA gel batteries have higher resistance than VRLA AGM batteries to plate sulfation caused by partial charge and discharge to which photovoltaic systems are inherently exposed. In this way, the cycle life is higher than VRLA AGM. Gel batteries can be used at any angle without leaking, thanks to their dense electrolyte. They do not have problems discharging on their own. However, it is expensive and can be damaged by chargers that provide fast chargingBoth battery types are completely maintenance-free and can be used in renewable energy applications with their deep discharge feature. VRLA gel and VRLA AGM batteries have advantages and disadvantages against each other depending on the way they are used in photovoltaic systems.

Picture 3.3: VRLA GEL (gel) battery

OPZS / TUBULAR (with tube): Low-maintenance, tube stationary installation (OPzS) batteries are standby batteries produced to be connected to systems as an uninterrupted energy source (Picture 3.4). It requires minimal maintenance for the user and has low energy costs. Its key feature, the low-antimony lead alloy, reduces self-discharge, greatly reducing the rate of water loss. Its retention of active substance and charge-discharge ability are at the same level. OPzS accumulators, which are used to prevent shutdowns and stops that may be caused by sudden power cuts in the system, are manufactured with transparent boxes. With its separator and alloy structure, it requires low maintenance and has a long life of 20 years or more. Positive plates are manufactured with tubes. Tubular positive plates have high capacity and long service life. The plates consist of cylindrical polyester tubes connected to each other. Inside each tube there are lead rods made of a special alloy. Since OPzS type batteries allow gas to be released during charging and discharging, they require constant monitoring and maintenance, such as adding pure water. In addition, the place where the batteries are located must have good ventilation, as hydrogen gas creates danger when it exceeds a certain density in the air. For these reasons, it is generally not preferred in photovoltaic systems.

Picture 3.4: OPZS / TUBULAR battery

VRLA / TUBULAR / GEL: VRLA / TUBULAR / GEL type products can be used for places with difficulties such as maintenance and transportation and for professional applications where closed system application is required (Picture 3.5). In principle, it is more resistant to difficult field conditions. In addition, there is no risk of releasing gas into the environment under nominal usage conditions. This type of batteries is not yet produced in our country. The acid in them is not in a liquid basis, it has a gel-jelly consistency as we know it. It can be used for many years without needing any maintenance under rated usage conditions. It has long operating life, high performance, maximum reliability and more charge / discharge .

HBL is one of the largest and most well-known manufacturers in this field. All kinds of technical support, including pre-sales technical calculations and design for sectoral applications, are provided meticulously. For example, all physical dimensioning details and schematic layout plans for the battery groups to be created are presented to the owner at the design stage. In material delivery, all assembly equipment is provided to the user completely and free of charge with the shelving system.

Picture.5: VRL / TUBULAR / GEL (gel) battery

The lifespan of batteries in a photovoltaic system is directly proportional to how well the system is designed. During design, the first parameters that should be considered are the location where the system will be used, the load profile, solar energy estimation, and the quality of the charging systems. By optimizing these parameters well, the longest life and performance will be obtained from VRLA type batteries.

Factors affecting the operating life of batteries are:

Storage: Lead acid batteries are never kept discharged or partially discharged. If the batteries will be stored for a long time, it is appropriate to charge them once every 6 months.

Low charge: Discharging the battery is called discharging and charging it is called charging. An open-circuit voltage lower than the rated value may indicate sulfation.

Overcharging: Overcharging voltages cause high charging currents to flow from the battery, the release of excessive heat due to this current, and the release of gas from the safety valve (This is why the term "valve regulated" is used). This will corrode the positive plate material in a short time and quickly shorten the battery life.

Temperature: High temperatures above the recommended ambient temperature will cause possible oxygen/hydrogen gas formation, shortening the battery's service life.

.**Overdischarge**: 1.67 volts/cell is the limit value for most batteries. Deep discharge adversely affects battery capacity and operating life. Deep discharge increases the internal resistance of the battery, causing sulfation of the plates.

To play the video, click on the image or click the link below and open it with your browser.

https://www.youtube.com/watch?v=rtw-KYYiL1I

3.2 Battery Calculation for Solar Panels

The amount of electricity the battery supplies by discharging over time is called capacity and is determined as ampere/hour (A/h). Capacity depends on the surface area of the plates, their number and the permeability of the separators used. The amount of current that a battery can deliver continuously for 1 hour at the specified voltage is called battery capacity. Battery capacity is stated on the battery in ampere hours (A/h).

Apart from its brand, there are statements such as 12V 60A/h 255 on the battery. These mean; 12 V: Battery voltage (voltage)

60 A/h: Battery capacity

255 A: It is the maximum amount of current that can be safely taken from the battery.

For example, we can read 12 V 100A/h on the label of a battery. Theoretically, this battery will produce 1 A current with 12 V voltage, without losing any voltage for 100 hours. When 10 A current is needed, our battery will be able to supply it for 10 hours. However, in practice this does not happen. Especially at high currents, the internal resistance of the battery increases and the current it can deliver decreases. The voltage measured between the two poles of a good battery is 12.8 volts. Current draw from the battery should be stopped when the

voltage drops to 11.6 volts. After this, it is possible that the battery will be permanently damaged.

To keep the battery life long, it should be charged when its capacity is below 50%. Their efficiency is around 90%. Even if there is no sun, sufficient battery capacity is required to meet the needs of consecutive sunless days. Since absence of sun for three or more days in a row is relatively rare in most of our regions, purchasing more than enough batteries to last the 3rd day is an expensive investment compared to its benefits. Instead, it would be appropriate to use a battery sufficient to store the needs for 2 days where there is mains electricity, and for 3 days where there is no electricity. This means the battery capacity to meet 10 kW for a house with a daily consumption of 5 kW. 12 V 1200 A/h battery group can store 12 volt*1200 Ampere-Hour = 14.400 Watt. Using all or even more than 70% of what is stored in the battery quickly destroys the structure of the battery. Therefore, a 12 V 1200 A/h battery group would be ideal for the designed system. A higher capacity battery group can be obtained by connecting battery cells of certain capacity to each other. It is possible to create a 12 V 1200 A/h battery group by connecting 6 pieces of 12 V 200 A/h batteries in parallel. In this process, which is expressed by the word parallel bonding, the (+) poles of the cells are connected to each other and the (-) poles are connected to each other. What is actually done is to connect the same type of cells externally to each other. Therefore, the total capacity of the resulting battery group will be the cell capacity multiplied by the number of cells. On the other hand, the voltage of the battery group is equal to the voltage of one cell.

Example: A solar panel system will be installed for a house with a daily electricity consumption of 10 kW. The house where the solar panel system will be installed is located where there is mains electricity. Calculate the number and capacity of batteries required for this system?

Solution: Even if there is no sun, sufficient battery capacity is required to meet the need for consecutive sunless days. It will be appropriate to use a battery sufficient to store the needs for 2 days where there is mains electricity, and for 3 days where there is no mains electricity. The power of the battery to store the need for 2 days is 2xP=2x10000W(10kw)=20000w(20kw)
P=IxV

20000=Ix12

I=20000/12=1666.66A

Using all or even more than 70% of what is stored in the battery quickly destroys the structure of the battery. Therefore, we will increase the calculated battery current of 1666.66 A by 30%.

I.30/100=1666.66x30/100=499.99A (The 30% part that will not be used so as not to deteriorate the structure of the battery)

Finally, the capacity of our battery should be = 1666.66A + 499.99A = 2166.65A = 2200A.

A single 12 V 2200 A/h battery will be sufficient for this solar panel system. 12V

Instead of a single 2200A/h battery, it is possible to create 8 12V 275A/h batteries by connecting them in parallel.

3.3 Grouping and Connection of Batteries

Battery groups are obtained by installing cells side by side and connecting the (+) and (-) poles to each other with external bridges. The connection of external bridges to the cell poles is a matter dependent on the manufacturer's technique. It is mostly bolted or welded.

Battery cells are grouped into groups for two reasons:

1-To increase the voltage

2-To increase capacity (current)

The rated voltage of a battery cell is 2 volts. For this reason, when it is desired to obtain a higher voltage proportional to the rated voltage, a battery group at the desired voltage can be obtained by connecting the (+) pole of a cell to the (-) pole of the next one, which is expressed as series connection.

NOTE: It is possible to increase both voltage and capacity by connecting battery cells in series and parallel (in other words, by connecting them mixed).

Battery connections are made in three types: serial connection, parallel connection and series-parallel connection.

Serial connection: It is a single serial branch formed by connecting battery blocks one after the other to form the battery group. The connection made by connecting the (+) pole of one cell to the (-) pole of the adjacent cell is called serial connection (Figure 3.1). The total voltage of the battery group (V) is equal to the sum of the voltage of each battery block. Battery capacity (A/h) does not change in serial connection; The capacity of the battery group is equal to the capacity of each block in the group.

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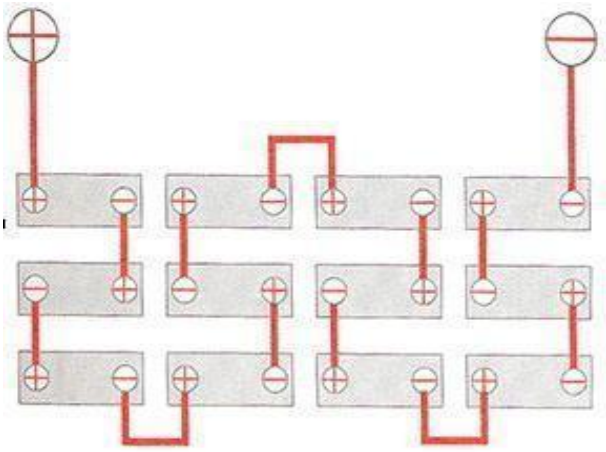

Figure 3.1: Serial connection of batteries

Parallel connection: The connection made by connecting the (+) poles of the batteries to each other and the (-) poles to each other is called parallel connection (Figure 3.2). The total capacity of the battery group (A/h) is equal to the sum of the capacity of each battery block connected in parallel. In parallel connection, battery voltage (V) does not change; The voltage of the battery group is equal to the voltage of each block in the group.

Batteries are connected in parallel for two reasons:

1- Increasing the capacity (Total capacity is equal to the sum of the capacity of each branch connected in parallel.)

2- Increasing reliability (A single faulty battery does not cause the backup energy supply of all batteries to be interrupted for uninterrupted power supply.)

It is not common practice to connect more than six battery packs in parallel. Regardless of which connection group is used, all cells in the serial branch must be identical to each other.

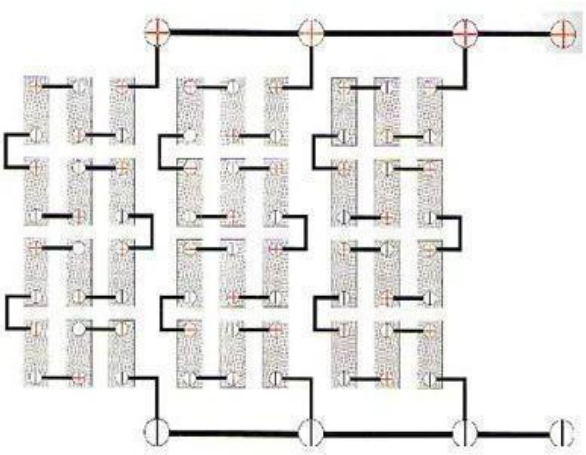

Figure 3.2: Parallel connection of batteries

Example-1: The daily electricity consumption required for lighting a house is 1 kW. A solar panel system will be installed for lighting of this house. The house where the solar panel system will be installed is located where there is mains electricity. Calculate the number and capacity of batteries required for this system?

Solution: Even if there is no sun, sufficient battery capacity is required to meet the needs of the house on consecutive days without sun. It will be appropriate to use a battery sufficient to store the needs for 2 days where there is mains electricity, and for 3 days where there is no mains electricity.

The power of the battery to store 2 days' needs
: 2xP=2x1000 W(1 kw)=2000 W (2 kw) P=IxV
2000=Ix12 I=2000/12=166,66A

Using all or even more than 70% of what is stored in the battery quickly destroys the structure of the battery. Therefore, we will increase the calculated battery current of 166.66 A by 30%.

I.30/100=166.66x30/100=49.99 A (It will not be used in order not to damage the structure of the battery.
30% part)

Finally, the capacity of our battery should be = 166.66A + 49.99A = 216.65A = 220 A.

A single 12 V 220 A/h battery will be sufficient for this solar panel system. Instead of a single 12 V 220 A/h battery, it is possible to create 4 12 V 55 A/h batteries by connecting them in parallel.

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