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IMPORTANT

This instruction manual should be kept in an accessible place, that is known by all the operators and maintenance staff. Before commissioning the machine, read the instructions thoroughly and observe the usage indications.
1. GENERAL DESCRIPTION AND TECHNICAL CHARACTERISTICS

1.1. INTRODUCTION

The dual-axis Solar Tracker is an electromechanical device that has the photovoltaic modules fixed to its upper frame and which achieves maximum insolation on top on them. The entire structure moves from East to West on an axis that can turn 240º (azimuth tracking) and a second axis with tilt movement from 60º to the horizontal plate position. Thanks to these devices, the panels are positioned so that they are always directed towards the sun, consequently improving their performance.

Looking to maximise photovoltaic energy production optimising the resources provided by the Sun, mecasolar has designed and manufactured the dual-axis, azimuth and height, solar tracker, MS-TRACKER in its two versions, MS-2 TRACKER 10 and 10+.

1.2. PRODUCTION: INCREMENTS FROM 35% TO 45%

The dual-axis tracking system is carried out using astronomic programming. The built-in PLC controls the drive of the gear motors making the MS-2 TRACKER follow the path of the sun from dawn to nightfall, and so achieves an optimum orientation and tilt to the sun during the entire day, making the most of all the solar radiation received by the panels during the day. In this way, increments in the performance of installations with MS-2 TRACKER are offered with respect to installations on fixed structures of over 35%, and this can reach 45% in some regions of Spain. This increased production enables the profitability of the investment to be maximised by obtaining higher production and
reducing the investment in solar panels, the most delicate and costly part of the installation, and which is in such short supply at the moment, achieving lower pay-backs and higher ROI.
1.3. STRUCTURE: STURDY, EFFICIENT AND FLEXIBLE

The solar tracker is made up by two hot dip galvanised steel metal substructures, which make the structure sturdy. The tracker’s central body is made up by a “V” shaped structure on which the frame is installed where the photovoltaic modules are placed.

This frame allows for anchoring and fixing different types of panels thanks to the omega profiles it includes, that make the photovoltaic grill’s configuration flexible. This is a major competitive and differential advantage over other trackers. The current shortage of modules in the photovoltaic sector has led many photovoltaic solar farm promoters to have to combine within the same solar field different powers in different trackers, and also different modules from different manufacturers in the same solar farm. The MS-2 TRACKER by mecasolar enables the clients not to be tied to a single module supplier, making it possible to install on a single surface photovoltaic modules of up to 90 m². The configurations that can be reached range from up to 12.8 kWp.

This “V” shaped support system offers greater stability and resistance than conventional systems based on single pole supports, in terms of the structure’s weight. This design provides a symmetrical distribution of the forces produced in the structure, distributing the loads to the sturdiest and strongest parts of the metal structure. The structure has been calculated under strict conditions, guaranteeing a robust design and manufacturing with highly resistant materials that make it highly durable and ensure optimum operation, even in adverse environmental conditions. It has been designed and subjected to the strictest endurance, power load and stress tests in different weather situations.

The mecasolar MS-2 TRACKER has been designed to withstand high wind speeds, tested at up to 140 km/h, and the PLC that controls movement for positioning itself horizontally in winds of over 60 km/h can be programmed, or another considered appropriate depending on the location of the solar farm.

![Figure 1.2 Finite Element Analysis](image)

This structure is based on a foundation or footing of reinforced concrete with corrugated rod wire mesh. It is fixed to the footing with nuts and counter nuts on steel anchor bolts. The foundation, with a round section, does not require excavation and only requires the base ground to be cleared, thereby reducing digging and civil engineering work, with the subsequent reduction in the construction costs of the farm. The dimensions of the foundation compared to the entire surface of panels to be installed, makes a minimal environmental impact on the area’s flora.

All the above benefit an easy installation in the solar farm. Only 10 minutes are required for unloading and installing it on the footing, from the lorry where the tracker is received, and only two people are needed to carry this job out.
There are two dampers assembled on each tracker on the tilted rotation plane, which prevent the oscillations produced by gusts of wind and are also a safety component in the event of mechanical actuator failure.

1.4. ANTICORROSION STRUCTURE

All of the tracker's metal structures, including anchors, are hot dip galvanised in accordance with UNE standards, and the coating has an average thickness of 105 microns.

A total quality and control process is followed during each of the hot dip galvanising stages, that guarantees a coating that is perfectly adhered to the structure.

As can be observed in the graph, the structure's galvanising thickness will ensure, for example, for an extreme environment, with a zinc coating of 4.13 mils (105 μm) a galvanising life in good conditions for much longer than 25 years.

Likewise, all the nuts and bolts used in the assembly of the tracker and its different elements are made out of steel with a strength of 8.8 and in accordance with DIN/ISO 898, with a “GEOMET” type antioxidant and anticorrosive coating, a non-electrolytic treatment with a zinc and aluminium lamination. The nuts and bolts used in the bearing have a resistance level of 10.9 in accordance with DIN/ISO 898.
1.5. FREEDOM OF MOVEMENT: 2 AXES

The MS2-TRACKER has two degrees of freedom allowing for the rotation of the zenith axis of the entire unit (optimising the tilt) and the rotation in the azimuth axis of the photovoltaic grill (optimising the azimuth position).

The azimuth movement is carried out by activating a planetary three phase gear motor on a cogged crown wheel situated in the base of the tracker.

The rotation range allowed by this azimuth activation is 240º, and ranges from 120º to -120º. Another important advantage compared to other solar tracker drives is the possibility for the pinion slipping on the cogged crown wheel in the event of fast wind, as a safety measure. We protect the transmission mechanisms in this way, preventing them from breaking due to extreme stress.

**Azimuth movement gear motor characteristics**

- Ratio 1/1500 rpm in 4 stages
- Output torque 2400 Nm
- Maximum torque 4600 Nm
- Efficiency 90%
- Electric motor power 0.25 kW, 4 poles 220/380V with IP55 protection for outdoors with stainless steel brake disc.
- 14 tooth, module 8 pinion
The second element to complete the movement of the azimuth axis is the cogged crown wheel. It is a bearing with crossed rollers, and these crowns are preloaded as standard, ideal for application that require an operating play of "0", when the rotation resistance is particularly even and when there are high crown accuracy and rigidity requirements.

Solar elevation tracking is carried out by means of a mechanically driven jack with a three phase electrical motor with a consumption of 0.75 kW. The action range of the vertical drive goes from 0° to 60°.
Depending on the location of the tracker and subsequent assessment by Mecasolar, a more resistant linear actuator may be included in the areas most exposed to strong winds.

**Standard Linear Actuator Technical Specifications**
- Gear box in nodular cast iron GJS-400
- Gear ratio 1/25
- Fixing with 2 Igus GSM-2023-25 Ø20 mm bushings.
- Nut in bronze 12% threaded at Ø40 mm with 7 mm pitch
- Ball and socket joint in stainless steel with Ø25 mm axis
- Screw Stainless Steel AISI 303
- Rear antirotation tube 60x60x3
- Motor 0.75 kW 220/380V IP55 1500 rpm
- Maximum axial load on the screw 50KN (extended up to 1300 between axes)
- Axial thrust force 25 KN

![Linear Actuator](image.png)

**Figure 1.7 Linear Actuator**

They both have a very low consumption of 0.75 and 0.25 kW, and therefore the tracker's annual consumption is very low, under 100 kWh/year, minimising the maintenance to be carried out and logically any potential faults. Such a low consumption ensures the motor a longer useful life.

Another component to be highlighted in the MS2-TRACKER is the hydraulic damper. This component makes the structure safer, preventing the frames and modules from moving suddenly in the event of the linear actuator breaking, which would break the structure and modules. It also makes the structure more stable against vibrations caused by the wind, as it absorbs these vibrations.
1.6. TRACKING PLC

In weather-tight cabinet for use outdoors, with IP66 protection that protects the inside from any penetration of liquids and impurities, such as dust or any other type of impurity we may find outdoors.

Each tracker includes its own solar tracker PLC with astronomic programming, which equips each one with totally independent movement. This PLC governs the operation of the motors, executing the accurate movements to obtain the correct position with regards to the Sun.

It allows for the independent automation of each tracker with a wide range of remote control operating and interconnection options. The PLC guarantees the correct positioning of the tracker - normal photovoltaic surface to the sunrays - even after resetting due to a fault or grid disconnection and allows for automating the night and defence positioning.

The PLC also controls the signal that comes from a wind gauge (shared by the whole farm) and during strong winds it positions the tracker in the horizontal defence position.

This PLC will be programmed by mecasolar staff observing the geographical coordinates, topographical characteristics and special climatology of the farm location.
The following table shows the technical specifications of the tracking PLC:
Reference no.: 6ES7 214–1AD23–0XB0
CPU model: CPU224

<table>
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<tr>
<th>General characteristics</th>
<th>Minimum</th>
<th>Nominal</th>
<th>Maximum</th>
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<td>24.0</td>
<td>28.8</td>
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<tr>
<td>Communications Ports</td>
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<td>Dimensions [mm]</td>
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</tr>
<tr>
<td>Dissipation [W]</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Real time clock</td>
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<tr>
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<tr>
<td>Analogue I/O</td>
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<td>Extension modules</td>
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<td></td>
</tr>
<tr>
<td>Communications</td>
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<td>RS485 Ports</td>
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<tr>
<td>Maximum stations per segment</td>
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<tr>
<td>MPI Links</td>
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</table>

Table 1.1 PLC technical specifications
1.7. ELECTRICAL SWITCHGEAR

The MS TRACKER has an electrical supply cabinet and connections where the necessary protections for the correct operation of the photovoltaic installation are located, minimising possible electrical risks during earth leakages, atmospheric surges and overcurrents. This board’s protection degree is IP66 ensuring perfect operation in adverse environments, with no penetration of water or other impurities from the outside. The MS-2 TRACKER 10+ includes magnetothermics, circuit breaker and protection against surges by the means varistors.

The electricity supply cabinet protections can be adapted to the destination market of the MS-2 TRACKER 10+ trackers.

1.8. COMMUNICATIONS

1.8.1 RS485 wiring

Communication between the area master and the slaves in its area is carried out in RS485 and it is a multipoint communication. The physical base on which the communication is carried out is a twisted and shielded pair, connected to the surge arrester situated on the bottom right-hand part of each tracker’s control cabinet. The control cabinet and surge arrester appear highlighted in the following images. The protocol used in communication is PPI from Siemens.

![Figure 1.11 Control cabinet and surge arrester](image)

Although this is not necessary, the area master can be defined before carrying out the RS485 wiring. After connecting the trackers, one of the trackers in the area is enabled as the master. From this moment on, this tracker will be called the area master and will be in charge of collecting the status information from the trackers in its area, and transmitting this information to a higher level if this exists and communicating the set points, alarms and configuration parameters to the slave trackers.
The connection point of each tracker's RS485 bus is situated on the bottom right-hand part of the control cabinet. It is a surge protection board that protects the PLC's communications port. The protection board can be replaced by another one if it is damaged in any way. The RS485 bus cable is connected as follows:

- Terminal 1 surge arrester: Terminal 1 should be connected to terminal 1 of the previous and/or subsequent unit in the communications bus if these exist.
- Terminal 2 surge arrester: Earthing.
- Terminal 3 surge arrester: Terminal 3 should be connected to terminal 3 of the previous and/or subsequent unit in the communications bus if these exist.
- The protected terminals of the surge board are connected to the PLC's port using a male DB9 connector. Both the board and the board's cable to the PLC port are supplied with the tracker. The correspondences in the wiring of the protected side of the board according to the supplied components are as follows:
  - Terminal 4 surge arrester $\rightarrow$ Pin 8 connector DB9 (Brown cable)
  - Terminal 5 surge arrester – Earthing
  - Terminal 6 surge arrester $\rightarrow$ Pin 3 connector DB9 (White cable)

The connection of the surge arrester can be seen in the following image. The protected side that is connected using the DB9 connector to the PLC port can be seen in the image on the left and the side that is connected to the RS485 can be seen on the right. This image shows two cables connected to terminal 4 and two cables connected to terminal 6. This is due to a cable coming from the previous unit connected to the bus and the other cable goes to the following unit connected to the bus. If this is a unit that is either the start or the end of the bus, there will be a cable connected to terminals 4 and 6.
In the following diagram, the start and end of the bus correspond to the trackers with addresses #14 and #16. This address inside the RS485 bus is configured in the tracker parameter menu.

The RS485 bus cable goes from tracker to tracker without intermediate connections. This cable enters through the electrical supply cabinet and passes directly to the control cabinet where it is connected to the surge arrester board. It is not necessary for a specific tracker to be at either the start or the end of the bus, and it does not have to be the area master or the lowest address. The choice of the bus start and end points and the connection order are determined by the location on the ground of the tracker supply conduits (channelling).

The following restrictions and recommendations can be highlighted on the configuration of the RS485 bus:

> Figure 1.13 Surge arrester board connection

> Figure 1.14 Example of RS485 bus wiring in an area
If the trackers have an energy meter, the maximum number of units that can be connected to the bus is 10.

If the trackers do not have an energy meter, the normal number of units that are connected to the same bus is also 10, however, up to 14 units have been connected in the past.

- A bus made up by 10 units is usually 400 to 600 metres long. Increasing the length of the bus connected to more units could cause problems in the communications, as the surge arrester boards introduce an attenuation of the communication signal.

- The starting address of the tracker area is always 11.

- The end address of the area is calculated as 10 plus the number of trackers that make up the area. It is not recommended to have more than 10 or 14 trackers per area according to the tracker configuration (with energy meter or without energy meter).

  - If we have an area with 5 trackers, the starting address will be 11 and the end address 15.

- Master PLC address: Variable address in the 11-20 range in areas with 10 trackers.

- Slave PLC address: Variable address in the 11-20 range in areas with 10 trackers.

- The lower addresses are reserved for additional devices such as a computer (address 0) or the TD200 maintenance screen (address 1).

In addition to the restrictions described here, the recommendations indicated in standard RS485/EIA485 should be observed.

### 1.8.2 Ethernet Wiring

The following image (Figure 1.15) shows an example of the structure of the upper levels of the farm made up by the weather station and the area masters. Other elements necessary for the communication between the two and plant monitoring can also be seen.

The farm's structure can be divided into 3 levels:

- The slave trackers would be on the lower level.
- In the intermediate level we have an area tracker that is enabled as the area master and that communicates with the slave trackers using the RS485 standard. The area master can take any address in the RS485 network, and it does not have to be configured with any specific address.
  - The communication of the area master with the upper level is via Ethernet.
  - The area master operates as an intermediary between the weather station and area slaves, collecting the slave status information for the weather station and sending the weather station set points to the slaves.
- On the highest level we would have the weather station that communicates with the lower level via Ethernet.
  - Information on tracker status is collected from the upper level and set points, parameters and alarms are communicated to the farm's trackers.
  - The farm's monitoring system accesses the information contained in the weather station to ascertain the tracker status.
Communication between the area masters and weather station is carried out via Ethernet. Ethernet communication can be on copper (cable), fibre optics or a combination of both. The use of Ethernet communication on WiFi is not recommended due to the problems that appear in the shielding of the trackers that act as Faraday cages.
For the area master to be able to communicate via Ethernet with the weather station, it should be connected to a CP243 module. The CP243 module is situated next to the PLC and connected to it by the I/O bus it is equipped with. The location of the CP243 module in the control cabinet of the area master can be seen in the following diagram.
For the correct installation of the CP243 module, the following cables have to be connected:

- Female connector of the I/O bus from Siemens: It is connected to the PLC which operates as the area master
- RJ45 eight pole connector for the Ethernet connection. The Ethernet cable is connected to this port and from here we will connect to a switch. The connection with the switch can be:
  - Direct: The cable is connected directly between the CP243 module and the area master and the switch
  - With a change in medium: In this case, the connection to the CP243 module is carried out with Ethernet cable, an Ethernet/Fibre Optic to make link of over 120 metres and the Fibre Optic/Ethernet is converted again before the switch. The connection with cable is made from the converter to the switch
  - Via fibre optic: In this case, the connection to the area master with cable, an Ethernet / Fibre Optic converter is used to change the medium and the fibre optic is connected directly to the switch.
- Terminals for power supply at 24V and earthing connection.

The connection on the weather station side is identical. There is a CPU and two CP243 modules. These two CP243 modules should be connected to the network using an Ethernet cable and then the network can be configured.
The weather station communicates with the area masters to collect the information on their status. Different devices can be connected to the weather stations such as a wind gauge or wind vane that allow for transmitting wind alarms to the trackers. In addition to the weather station, time synchronisation signals can be sent and certain configuration parameters transmitted (travel limits, work modes, defence positions, etc.).

The farm’s monitoring system is connected to the weather station to collect information on the trackers. The SCADA connection is carried out via Ethernet. In the same network, if a router is connected, Internet access is possible and therefore the solar farm can be monitored remotely.

1.9. INVERTERS

In its MS TRACKER 10+ version, it includes three single phase inverters for connection to SMA SB-3000 or SB-3300 grids according to the installed power, which is extremely efficient and reliable. The inverters used are the most advanced in photovoltaic modular system technology, and have an EC conformity declaration and non objection Certificate (network protector), as well as surveillance of insulation in the direct current network.

The SMA Sunny Boy inverters are outdoor units with IP65 protection degree and are installed on the structure of the tracker itself, therefore it is not necessary to assemble housing panels with the necessary cooling which would increase the price of the unit.

The possibility exists for installing any other inverter that the client decides to use in its project in the tracker.

2 possible tracker configurations are shown in the following images:

- Photovoltaic modules with SMC 11000 TL inverter
- Photovoltaic modules with 3 SB 3300 inverters
Figure 1.20 Tracker with photovoltaic panels and SMC 11000 TL inverter

Figure 1.21 Tracker with photovoltaic panels and 3 SB 3300 inverters
1.10. 10 YEAR WARRANTY

The MS-2 TRACKER 10 from meca solar has a ten year parts and workmanship warranty. It is the only tracker in Europe with this warranty.

The 10 year warranty allows meca solar’s clients to cover the 10 years of repayment of the photovoltaic installation, with absolute financial freedom and guarantees the investment with a view to financial entities interested in covering with solid and sturdy products the financing of their clients and with a view to financing schemes in which the guarantee is the project itself.

This warranty is subject to a yearly inspection by meca solar (or authorised company) during the warranty period.

This inspection will consist of a yearly visit to the solar farm carrying out a visual control of the trackers, checking the correct condition and optimum operation of the different elements in the solar tracker, and checking the correct compliance of the instructions included in the Maintenance Manual.
### 1.11. SPECIFICATION SUMMARY TABLES

#### 1.11.1 Mecasolar MS-2 TRACKER 10 and 10+ Solar Trackers

<table>
<thead>
<tr>
<th><strong>MS-2 TRACKER 10. TECHNICAL SPECIFICATIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
</tr>
<tr>
<td><strong>Maximum module surface</strong></td>
</tr>
<tr>
<td><strong>Maximum photovoltaic power</strong></td>
</tr>
<tr>
<td><strong>Tracking technology</strong></td>
</tr>
<tr>
<td><strong>Wind protection system</strong></td>
</tr>
<tr>
<td><strong>Tracker height</strong></td>
</tr>
<tr>
<td><strong>Weight without modules and without foundation</strong></td>
</tr>
<tr>
<td><strong>Foundation</strong></td>
</tr>
<tr>
<td><strong>Tracker axes</strong></td>
</tr>
</tbody>
</table>
| **Rotation angles** | Azimuth axis: -120° to 120°  
Elevation: 0° to 60° |
| **Azimuth rotation** | On cogged crown wheel and driven by planetary electrical gear motor |
| **Elevation** | By means of electromechanically driven linear actuator |
| **Motor service power supply** | 400 V Three phase |
| **Motor consumption** | 100 kWh/year |
| **Automation** | Totally independent programmable PLC in each tracker, with possibilities for remote control and interconnection |
| **Bearing and rotation adjustment** | Cogged crown wheel. Motorised bearing for azimuth tracking driven by an epicycoidal reducer and gaugeable motor brake (it allows slipping in very strong winds and protects the transmission mechanism) |
| **PLC and protection electrical cabinets** | Metal, weather-proof, fully wired. IP66. Includes motor protections. |
| **Maintenance** | Six-monthly inspection of mechanical and electrical parts |
| **Anti-theft system** | Module disconnection alarm (OPTIONAL) |
| **Monitoring** | On site, Ethernet, Internet (OPTIONAL) |
| **Warranty** | 10 years on Parts and Workmanship. |

**Subject to modifications on behalf of the manufacturer**

### MS-2 TRACKER 10+. TECHNICAL CHARACTERISTICS

As MS-2 TRACKER 10 and also (Any other configuration on order):

| **Inverters** | 3 SMA Sunny Boy 3300 inverters, with 3.3 kW rating, single-phase, IP65, installed and wired |
| **Protections** | Includes electrical protections (magnetothermics, circuit breaker and surge protection) |
| **Warranty** | Tracker warranty: 10 years on Parts and Workmanship.  
Inverter warranty: 5 years |

*Table 1.2. Tracker characteristics*
1.12. COMPETITIVE ADVANTAGES

meca solar's trackers include several competitive advantages thanks to the technology they have been designed and built with. The tracker's mechatronic power electronics, tracking and automation technologies allow for obtaining a series of clear DIFFERENTIAL advantages regarding the rest of the trackers on the market.

10-YEAR WARRANTY ON PARTS AND WORKMANSHIP

meca solar has designed a product that has been the subject of many years of research, that has been submitted to the strictest resistance and efficiency tests, obtaining as a result the UNIQUE solar tracker with the best GUARANTEES on the market.

MULTI-POWER and MULTIPLE MANUFACTURER FLEXIBILITY

The design of the omega panel support structure provides the meca solar tracker with incredible FLEXIBILITY when it comes to installing different panels made by various manufacturers. The system can handle a maximum power of over 12 kWp, depending on the number of panels and their power.

+35% INCREASE IN PRODUCTIVITY

The meca solar solar trackers are capable of increasing photovoltaic solar energy production by more than 35%, when compared to a fixed installation. This maximises profits by reducing on your investment.
OUTPUT / THREE PHASE CONNECTION

Each of the 3 series of photovoltaic modules is connected to one of the 3 inverters. The advantages of the meca solar THREE PHASE solar trackers are: reduction of losses in the wiring, easy installation and on the other hand the output power is more even. In the event of a fault in any of the 3 phases, 2/3 of the installation remains in operation.
In its MS-2 TRACKER 10+ version, it includes magnetothermics, circuit breaker and protection against surges by the means varistors.

The mecasolar trackers are connected to a weather station which works with a PLC controller. This solar tracking device uses this technology to guide the panels under a variety of climate conditions. PLC programming permits the tracker to operate in snow, electrical storms, fog, darkness and windy conditions.

INDEPENDENT CONTROL

Each mecasolar tracker comes equipped with its own independent PLC controller, with which the tracker carries out the astronomical solar monitoring, and handles the prevailing weather conditions and performs remote operations. The PLC controller launches the movement instructions to the motors at each given moment, which means that the motor is not constantly operating and this has a bearing on its longer useful life.

Likewise, and depending on the prevailing weather conditions (strong wind, fog or diffuse light, rain, storms and at night) the PLC controller is programmed so that the tracker is suitability positioned at each moment. This configuration requires an additional weather station or wind gauge.

The PLC controller is a standard reference on the market, so that it can be easily and immediately replaced and its parameters reprogrammed.

![Figure 1.24 Control cabinet](image)

STURDY, EASY TO INSTALL, REDUCED MAINTENANCE AND LOW POWER CONSUMPTION

mecasolar tracker motors consume less energy per year (100 kWh/year), resulting in reduced maintenance. Likewise, the sturdiness of their design and manufacturing guarantees the investment in the long-term. Furthermore, the easy installation reduces labour costs and time spent on the on building work.

DEFENCE POSITION

Against exposure to strong winds that may damage the tracker, our PLC controller has a function that allows for positioning the tracker in the defence position (horizontal position) to protect the structure from external stresses, of up to 140 km/h, in accordance with the Eurocode standard.
WIND VANE AND WIND GAUGE

The installation of these devices equips the trackers with a safe safety position system in the event of strong winds. These devices are installed in strategic places to get perfect wind measurement, in order to position the trackers in a defence position when necessary.

2. CALCULATION ACTIONS

2.1. OBJECTIVES

The objective of this project is to define and calculate the structure and foundation for the design of the MS-2 TRACKER 10 SOLAR TRACKER.

2.2. APPLIED STANDARDS

All the calculations in this project comply with the following standards that in some way affect the work that is planned.

For Europe:
EUROCODE:
- IN 1990: Structure bases of calculation
- EN 1991-1-1: Specific weights, dead weights, and overloads
- EN 1991-1-3: Snow loads
- EN 1991-1-4: Actions of the wind
- EN 1993-1-1: General rules and rules for buildings
- EN 1993-1-8: Joints
- EN 1993-1-12. Additional rules for the application of standard EN 1993 up to steels of grade S 700
- CONCRETE STRUCTURES EHE-98.

For North America:
- ASCE IEC 7/2005 (North America)
- ANSI AISC 360/2005 (North America)
2.3. BASES OF CALCULATION

For the calculation of the tracker structure, the loads that act on each of its components have been taken into account in the different hypotheses considered, taking the sizing of the most unfavourable load in each case.

The loads to be considered will be as follows:

Fixed loads: dead weight of the materials that make up the structure and weight of the materials that withstand them.

Wind pressures: pressures produced by the wind, determined by the topographical situation and orographic characteristics of the site.

Service load: insignificant.

Snow loads: is the load produced by the snow, determined by the topographical situation.

Calculation hypothesis:

Wind upwards + dead weight + snow
Wind downwards + dead weight + snow
Snow + Dead weight + wind upwards

2.3.1 GENERAL PROJECT CHARACTERISTICS

Starting data: MATERIALS

- Steel structure
  - Hot rolled steel in accordance with standard UNE EN 10025
  - Hot dip hollow steel profiles standard UNE EN 10210
  - Cold shaped hollow steel profiles standard UNE EN 10219

Steel designation S275JR
Elastic limit stress (fy) 275 N/mm²
Elasticity module 210,000 N/mm²
Rigidity module 81,000 N/mm²
Density 7,850 kg/mm³

- Concrete
  - Type of Concrete: HA-25 / P / 25 / IIa
  - Characteristic resistance (N/mm2): 25
  - Type of consistency: Plastic
  - Maximum aggregate diameter (mm): 25

- Environment
  - Type of Environment: IIa
  - Maximum cracking width (mm): 0.3 mm
  - Minimum nominal coating (mm): 50 mm

- Framework steel
  - Type of steel: B500S
  - Characteristic resistance (N/mm²): 500

Starting data: SAFETY COEFFICIENTS
Execution control level: Reduced
Project situation: Persistent or transitory
On the actions: 1.60
On the steel: 1.15
On the concrete: 1.50

- Specific for Footings
  Against slipping: 1.5
  Against overturning: 1.75

**Starting data: GROUND**

- Foundation ground

<table>
<thead>
<tr>
<th>Nature</th>
<th>Coherent ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
<td>Hard clays</td>
</tr>
<tr>
<td>Acceptable pressure (N/mm²):</td>
<td>0.06</td>
</tr>
<tr>
<td>Ballast coefficient (N/mm³):</td>
<td>0.08</td>
</tr>
<tr>
<td>Internal friction angle (º):</td>
<td>30.0</td>
</tr>
<tr>
<td>Cohesion (N/mm²):</td>
<td>0.01</td>
</tr>
<tr>
<td>Maximum acceptable subsidence (mm):</td>
<td>50</td>
</tr>
</tbody>
</table>

(according to NBE table 8.2)

A geotechnical ground study should be carried out in each case to obtain its characteristics, to check that they are not more unfavourable than the ones considered.

**CONSIDERED LOADS:**

- Constant actions:
  Dead weight: 3900 kg

- Variable actions:
  Wind: 80 kg/m² (140 km/h)
  Snow: 50 kg/m²

**2.3.2 FOOTING CALCULATION**

**Footing dimensions**

- Footing height: 0.6 m
- Footing diameter: 4 m

**Considered catchment surface**

- Total panel length: 11.8 m
- Panel height: 7.5 m
- Surface: 88.5 m²
- Maximum panel angle: 60 °
- Height rotation axis to Bearing: 2.9 m

**Resulting loads obtained:**

**Foundation stability calculation (overturn, slipping,...)**

- Axial N-Force: 4.64 KN
- V- Radial force: 62.10 KN
3. INSTALLATION

3.1. INTRODUCTION

The MS-2 TRACKER 10 is transported from the factory to the field in three main parts:

- On the one hand the main assembly of the hot dip galvanised “V” shaped structure that includes the azimuth bearing, all the motorisations, inverter supports and electrical boards, all fully wired.
- Upper grill, hot dip galvanised steel tubular structure.
- “C” shaped profiles on which the panel holder profiling will be installed

The foundation footing will be made in the field with the standby anchors, on top of which the described parts of the tracker will be assembled.

3.2. FOUNDATION EXECUTION

During the preparation of the ground and the execution of the footings, the stipulations of R.D. 1627/1997, of 24 October, which establish the minimum health and safety regulations for construction works, and the rest of the regulations derived from Act 31/1995, of 8 November, on Occupational Risk Prevention, will be complied with.

Before carrying out the foundation, a geotechnical ground study will be carried out to ascertain the acceptable ground resistance.

The characteristics of the foundation have been calculated for a ground resistance of 0.55 kg/cm².

The MS-2 TRACKER 10 trackers are installed on a reinforced concrete surface footing, according to plans.

This footing does not require any excavation, and it is only necessary to clean and clear the topsoil and level the ground. We will then pour a 10 cm layer of blinding concrete, leaving it as horizontal as possible.

3.2.1 FOOTING EXECUTION

For the execution or formwork of the footing, a mould designed for this purpose is used (refer to the attached plans) and the following steps followed:

Removal of the topsoil (15-20 cm).

Replacement of the 15-20 cm with a H-200/P/40 blinding concrete and levelling.

Once the blinding concrete has set, place the mould on it and level it with the help of the jacks.

Place a wire mesh or framework at the base of the footing, 16 mm diameter BS500S corrugated steel with a separation of 250 x 250 mm. This framework should be at a height of 8 cm from the ground.

Place the bridge-template on the mould with the threaded foundation anchors. Two factors are important at this point:

- Axial N-Force: 76.35 KN
- V- Radial force: 62.10 KN
- M-Momentum: 180.09 KN

Ground and formwork stress calculation.

- M-Momentum: 180.09 KN

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a.- After the nuts have been screwed onto the template, the anchors should be positioned with the heights in the attached drawing.

b.- The bridge-template should face the SOUTH, with the electrical supply pipe hole on the left.

Figure 3.1 Foundation anchor template

Concrete with HA-25/P/40/ concrete to the maximum mould height (60 cm in height) and vibrate.

Remove the formwork after 40 hours, loosening all the upper nuts on the anchors and keeping them to fasten the tracker. The lower nuts will remain on the anchor where they are.

Figure 3.2 Foundation footing
3.3. TRACKER POSITIONING AND ASSEMBLY

After transporting the main parts of the tracker to the field, and with the help of a small crane, we will start to assemble it. (According to the grill hoisting instructions).

Sufficiently strong and perfectly serviced hoisting accessories will be used (cables, chains, slings, rings...) for the hoisting, unloading and/or subsequent positioning of the tracker's main parts. The hoisting accessories will have EC markings in accordance with Directive 98/37/EC.

The boom will work at a maximum of 75% of its rated loading capacity. Loads will not be moved without having placed the telescopic supports (when the ground does not have the suitable resistance, the telescopic supports will be placed on platforms to distribute the loads). This equipment will fulfill the stipulations of R.D. 1215/1997, regarding work equipment safety, and will be up to date on all periodical inspections.

If there are electrical power lines near to the work area, the layouts established in R.D. 614/2001, on the protection of the health and safety of the workers against electrical hazards, will be taken into account. The established safety distances will be observed.

Guide ropes will be used during part hoisting and positioning. The use of hardhats, goggles, mechanical protective gloves, high-visibility vest and safety footwear will be mandatory.

Nobody will be allowed to stand underneath suspended loads in the working area of the boom during its positioning.

No operators will get onto the tracker to assemble the plates. Work at over 2 m in height will require the use of safe work platforms (railing and intermediate batten) or the use of a safety harness fastened to a fixed point.

3.3.1 Sequence to follow during the tracker assembly:

Positioning of the main tracker body on the anchors of the foundation footer. These anchors will have the nuts and standby washers installed. Very important: the tracker should be facing the SOUTH, i.e., the catchment surface tilted at 60º should be facing the south.

Level the bottom plate of the tracker, manually adjusting the standby nuts so that they touch this plate. Level adjusting these nuts. If necessary, they will be loosened or tightened so that they are level with the lower plate. It is very important not to leave gaps between the standby nuts and the plate to prevent the plate from bucking when the upper tightening is carried out.

When the lower plate has been levelled, place the upper washer and nut and tighten all the nuts following a sequence in the shape of a cross.

Place the main structure of the “grill” catchment surface on the ground on four supports.

Screw the “C” shaped profiles or straps onto the grill’s cleats using the nuts and bolts supplied (bolt DIN-933 8.8 DC M14x30 + nut DIN-985 8.8 DC M14 + 2 washers DIN-125 A DC M14). 3 bolts per cleat should be installed with a tightening torque of 140 Nm.

Distribute the “Puk” 40x22x2 profile type or similar galvanised rails to fasten the modules, according to their configuration, screwing it onto the straps with 6.5x30 mm self-threading galvanised bolts.

a.- two rail elongated modules
b.- three rail vertical modules

The modules will then be installed, screwing them onto the grails using the special rail nuts and bolts. Four free elevation points will be left on the module to hold the assembly from the grill.

From this point onwards, mecasolar’s instructions will be used to install the grill and actuator group. Mecasolar staff will travel to the farm to give advice on the sample assembly for this purpose and the rest of the farm will be assembled by the client in accordance with the indicated guidelines. The following guidelines will be followed to hoist the tracker:

3.3.2 Sequence to follow during the tracker hoisting:

1. Use slings with EC marking for 2000 kg or equivalent.
2. Position the slings as shown in the photo. This will balance the machine.
3. Place the crane’s hoisting tool just above the tracker so that its elevation does not move with unwanted movements.
4. Gently lift the tracker avoiding sudden movements, to control it at all times.
5. Carefully move the tracker from its position avoiding sudden movements.
6. Slowly lower the tracker until it is well rested on the surface.
7. 
### 3.3.3 Sequence to follow during the grill hoisting:

**PHASE. GRILL ASSEMBLY**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Position the grill with the cleats for the upper part. Check the condition of the cleats.</td>
</tr>
<tr>
<td>2</td>
<td>Assemble the straps on the corresponding sides of the cleats.</td>
</tr>
<tr>
<td>3</td>
<td>Assemble each cleat's three bolts on the outside.</td>
</tr>
<tr>
<td>4</td>
<td>Assemble the PUK profiles.</td>
</tr>
<tr>
<td>5</td>
<td>Assemble the solar plates according to the power configuration. Do not assemble the plates that coincide with the vertical crossbeams.</td>
</tr>
<tr>
<td>6</td>
<td>Tie up the grill with 4 fabric slings according to the photograph.</td>
</tr>
</tbody>
</table>
Lift the grill after tying it.

Make sure that the grill's lugs are free of dirt and mud. If they are dirty, clean them and remove this dirt. When the lugs have been cleaned, apply grease to all of their surfaces. Check for the existence of the PVC bushing.

Place the grill (007) with the jack bolt support on the jack side.

Lift until the grill is positioned on the bolt holes.
<table>
<thead>
<tr>
<th><strong>MS-2 TRACKER 10 and 10+ Solar Tracker</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Steps</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease the Ø35 mm bolts (011) and assemble them. Assemble the Ø36 mm washer and the Ø8 mm ring pin.</td>
</tr>
</tbody>
</table>
| Connect the jack with the rotation tool.  
  
U-black.  
V-brown.  
W-grey |
| Remove the spindle from the jack until the ball and socket joint is positioned with the pin hole. The course should never exceed the ends of travel. |
| Grease the grill's Ø20 mm hole (007).  
Grease the bolt (010) and assemble.  
Assemble a Ø20 mm washer and Ø4.5 mm ring pin.  
Refer to group drawing. 06/09-000 |
Place dampers on the supports of the grill damper. The bottle side is fastened and the M-4x80 screw greased.

Lift the grill until the dampers’ M-14x80 fixing screw can be inserted.

Tighten the dampers’ M-14x80 screws.

Rotate the grill (007) to the horizontal position.
Disconnect the rotation tool.

Mechanical jack box connection.
U-black.
V-brown.
W-grey.

Table 3.1 Grill instructions

Figure 3.4 Assembled solar tracker

During the assembly of the tracker, a hoisting machine is necessary to position the central body on the footing, and to fix the frame on the tracker body. Likewise, a three phase electrical generator is necessary to energise the mechanical actuator.
The generator's minimum requirements should be adapted to the motor characteristics.

**EUROPE:**
- Voltage 400 VAC
- Frequency 50Hz
- Power 3KW

**USA (the most normal):**
- Voltage 480 VAC
- Frequency 60Hz
- Power 3KW

The conditions of each of the rest of the countries will have to be checked.

The client will pay for this machinery for the assembly of the trackers.

The manufacturer should offer the option for the commissioning of the trackers after the installation. The commissioning protocol will be followed during this phase, including the corresponding tests and checks.
4. COMMISSIONING AND ELECTRICAL MAINTENANCE

4.1. TRACKER CONNECTION

In the tracker wiring we should distinguish between the power part (motors, inverters...), the control part (PLC and sensors) and the communications part. The tracker's electrical diagrams can be found in the document's attachments (Electrical diagrams).

4.1.1 POWER WIRING

The connection is in the cabinet fixed to the concrete footing (refer to photograph). The circuit breaker that protects the tracker, the main magnetothermic and surge arresters are housed in this cabinet.

![View of the assembly and electrical supply cabinet](image)

Figure 4.1 View of the assembly and electrical supply cabinet

Complete the outdoor SMA inverter power circuit. The group of 3 inverters is assembled on the tracker's structure. Each of the inverters is protected by fuses installed in the fuse cabinet. The inverter's output power passes through the fuse cabinet and is connected to the input connection.
4.1.2 CONTROL WIRING

The tracker is controlled by a PLC. The following image shows the different elements that are assembled inside the PLC’s cabinet.

The sensors that control the position of the tracker’s azimuth axis and zenith axis reach the PLC’s cabinet. We can see the location of these sensors in the following images.

4.1.2.1. Azimuth axis sensors

We have three sensors in the azimuth axis. The north and south sensors are used to reference the tracker and the movement detector determines the tracker’s orientation.

The north sensor is a safety measure that makes the tracker stop if due to abnormal tracker operation it reaches the north position. In certain sites, the north sensor can be used to reference the tracker azimuthally.
The south sensor is the azimuth axis' main reference. Every time the tracker passes this position it is referenced again. The value the tracker is referenced at can be changed from the TD200 screen.

4.1.2.2. Zenith axis detectors

We have three sensors in the zenith axis. The maximum tilt “lower limit” sensor is used as a travel limit. The horizontal catchment plane “upper limit” and the movement detector transmit some pulses to the PLC from which the tracker's tilt is determined.

The maximum tilt sensor makes the tracker stop when it reaches the maximum tilt.
4.1.3 COMMUNICATIONS

The communication cables are connected to the surge arrester situated in the control cabinet. The communications cable is connected to each of the trackers in the installation with the bus master using a RS485 bus.

Different levels can be distinguished in the configuration of the farm's communications:

- Slave tracker: The lowest level is made up by the Place in each tracker, which we will call slave trackers.
- Area master: The trackers are divided into control areas, and there are normally 10 trackers in these areas. There is an area master in each area, in charge of communicating with the slave trackers using a RS485 communication.
- Bus master or weather station: It is the level above the area masters. This bus master collects the information coming from the trackers and has the possibility of transmitting certain safety and configuration commands. The communication with the area masters is via Ethernet.

The bus master is in charge of collecting the most relevant data on each tracker. By connecting the TD200 Terminal to the bus master, which also works as a weather station, a status summary of all the trackers connected to the bus can be accessed.

In addition to the reading capacity, the bus master can also write on the trackers. Writing allows the bus master to give orders to all of the trackers connected to the bus. The bus master is not prepared for giving individual orders. Among the bus master's most relevant orders we underline:

- management of the safety warnings that send the trackers into the safety position due to wind or snow
- time synchronisation of the trackers connected to the master
- parameterisation instructions

4.2. COMMISSIONING

4.2.1 SAFETY DEVICE CHECK

The solar tracker's PLC calculates the position of the sun and controls the tracker's orientation at all times. The safety system consists of some travel limits that are connected to the tracking and
control system and lock the motor drive. In addition to the hardware system, the PLC has other parameters that allow for limiting the movement of the trackers (east and west travel limits, tilt limit).

Check that the travel limit sensors are correctly adjusted. To do so, move the tracker manually (manual mode on screen) in the direction of the sensor we want to check and check that the motor stops when it reaches the sensor. If the motor does not stop, correct the sensor position and check the safety device again. This procedure should be carried out in both axes with all the sensors.

Also confirm that the movement detectors work along the whole route. To do so, move the axis we are checking along its entire route and check that the movement detectors are flashing normally. The movement detectors are called IV (impulsos verticales - vertical pulses) and IH (impulsos horizontales - horizontal pulses). If the system stops during the travel indicating fault “HOR. DETEC/TRACCION” or “VER. DETEC/TRACCION”, it will be necessary to readjust the pulse sensors.

4.2.2 COMMISSIONING PARAMETERS

The following parameters (default value between brackets) have to be entered during tracker commissioning:

- Tracker CPU address (10)
- Degrees of the south orientation sensor (180º)
- Number of cogs in the horizontal crown (125 cogs)
- Mechanical jack pitch (7 mm)
- Farm area: limits the maximum tilt according to the entered parameter:
  - Area 0: Maximum tilt 60º
  - Area 1: Maximum tilt 59º
  - Area 2: Maximum tilt 58º
  - Area 3: Maximum tilt 57º
  - Area 4: Maximum tilt 56º
  - ... 
  - Area 20: Maximum tilt 40º
- Position of the flat plate sensor (0º)
- Tracker zenith defence position (0º)
- Current date and time: do not forget that the PLC's time follows the GMT time schedule. Taking as an example a farm installed in Spain, in the winter we should enter one hour less than the official time on that date and two hours less if we are in the summer. The same guideline should be followed in any other site outside Spain, entering the GMT time. Example of an installation in Spain:
  - 1 January, 17:10 h (winter time) → GMT time = PLC time 16:10
  - 1 July, 17:10 h (summer time) → GMT time = PLC time 15:10:00

4.2.3 AXIS REFERENCING

After entering the above parameters, the axes will be referenced.

From the TD200’s “MANUALES” (manual) screen, we shall move the tracker's zenith axis to the horizontal plate position (0º tilt). When we find the 0º sensor, we shall take the reference of the zenith axis. When the tracker has been referenced, and we exit the manual screen, it will go to its position determined by the sun. If the strip that indicates the south position is not properly adjusted, the parameter that determines its position in degrees may be modified.

The south sensor is used as a reference of the azimuth axis. After adjusting the sensors, we will take the reference from the manual screen. To do so, the tracker has to be moved towards the south cam. When the azimuth axis reaches the south position it will be referenced and will look for its position according to the real time clock on leaving the manual mode.

4.2.3.1. Daily axis referencing

After commissioning the tracker, the axes are automatically referenced every day.
- The zenith axis is automatically referenced every night when it reaches the 0º tilt position (horizontal surface).
- The azimuth axis is referenced twice a day when it passes the south position indicator. The first reference will occur coinciding with the solar midday and the second reference after sunset, when the tracker returns to the standby position where it will stay throughout the night.

### 4.2.3.2. Resolution of each axis

The resolution of each of the axes depends on the parameters entered during the commissioning, regarding the tracker's mechanical components.

The resolution of the azimuth axis depends on the number of cogs on the crown. A typical resolution value is 1.44º corresponding to a 125 cog crown. The following equation determines the resolution of the azimuth axis with an error of less than 1º:

\[
\text{res} = \frac{360º}{2 \cdot \text{Nº Dientes}_{\text{Corona Horizontal}}}
\]

The resolution of the zenith axis depends on the pitch of the worm screw. An integrated function in the PLC relates the length of the worm screw with the tilt of the photovoltaic surface. In the travel of the zenith axis, the resolution of the movement is 0.4 degrees and the maximum error made is under 0.8 degrees.

The control of the movement of both axes is determined by a function with programmable hysteresis. Typical values of the hysteresis in each axis would be 3º for the azimuth axis (6º of progress in each movement) and 1º for the zenith axis (2º progress in each movement).

### 4.2.4 FAULT INDICATION

If any faults have occurred in the PLC, this will be indicated with the Q1.0 and Q1.1 outputs of the PLC activated intermittently. The TD200 maintenance screen has to be connected to know the cause of the error.

The Q1.1 output indicates that the stoppage has occurred due to a fault in the azimuth axis. The Q1.0 output indicates that the stoppage has occurred due to a fault in the zenith axis. A fault in the zenith axis automatically blocks the movement of the azimuth axis and activates the PLC's Q1.1 output at the same time.

The Q0.7 output is related to the faults in produced in the zenith axis by the maximum tilt detector.

### 4.2.5 EDITING OF PARAMETERS AND ERROR DELETION

All of the tracker's parameters are protected with a password. When we want to change these parameters, the TD200 display asks for the editing password. We only have to use the arrows and ENTER key on the display to enter the password:

Editing password: 1234.

If a fault appears in the solar tracker, the procedure indicated below should be followed:

- Connect the TD200 screen and display the active alarm. There may be more than one active alarm at the same time.
- Solve the problem that has caused the alarm.
- Reset the PLC to delete the alarm. The reset can be carried out with the PLC’s RUN/STOP selector and RUN again.
  - **NOTE:** Resetting a PLC without having previously solved the fault that has caused the alarm does not solve the existing problem.
4.3. **TD200 – MAINTENANCE SCREEN**

These chapters on the maintenance screen reflect the standard characteristics of the Mecasolar tracker. This maintenance screen may be modified to adapt it to the client’s requirements. If a modification has been requested and it is not included in this manual, contact Mecasolar’s technical service.

By connecting the TD200 screen to the PLC we access the maintenance menu. The maintenance menu has the following sections:

- TRACKER DATA
- MANUALS
- AREA MASTER
- SAFETY
- WIND GAUGE / WIND VANE
- ADJUSTMENTS v10.8

### 4.3.1 ADJUSTMENT OF CPU ADDRESS IN TD200

When the TD200 Terminal is connected to the CPU, if we have the address of the CPU correctly configured the message “INICIALIZANDO” (STARTING) will appear on the screen.

If the CPU address is not correctly configured in the TD200 Terminal, the message “CPU NO RESPONDE” (CPU DOES NOT RESPOND) will appear on the screen. The procedure for changing the CPU address is as follows:

- Press ESC until the following text appears on the screen:
  - MENU OPERADOR (operator menu)
  - MENU DIAGNOSTICO (diagnosis menu)
- Select “MENU DIAGNOSTICO” and click on the menu on:
  - TD 200 SETUP
- The following text will be displayed
  - DIRECCION TD 200 (TD 200 address)
  - DIRECCION CPU (CPU address)
- Choose the “DIRECCION CPU” option and in the new screen enter the new value of the CPU address. The CPU addresses may be:
  - CPU address = 10 by default during commissioning
  - CPU address = 11 to 20 depending on the tracker number. The address of each CPU is determined as 10 + Tracker number in the area. For example, the address 10+7 = 17 will correspond to the G.027 tracker.

### 4.3.2 MAINTENANCE MENU. TRACKER DATA

#### 4.3.2.1. Tracker azimuth position

In this screen we have 3 different angles related to the azimuth position:

- Sun azimuth position: On the top right hand part we can see the azimuth position of the sun according to GMT and the farm coordinates. As a rule, this value is the tracker’s set point during the day.
- Tracker position: On the bottom left hand part we have the tracker’s current azimuth position in degrees.
- Tracker set point: On the bottom right hand part we have the tracker’s azimuth set point, i.e., the azimuth position where the tracker should be. As a rule, during the day
the tracker's azimuth set point will be the same value as the sun's azimuth position. At night the set point will be the position where the sun rises. In the event of a wind vane alarm, the set point will be the azimuth value sent from the upper levels.

This data cannot be changed from the maintenance screen.

Figure 4.6 Tracker data. Tracker azimuth position

4.3.2.2. Tracker zenith position

On this screen we have 3 angles related to the zenith position:

- Sun zenith position: On the top right hand part we can see the zenith position of the sun according to GMT and the farm coordinates. As a rule this value is the tracker's set point during the day, always bearing in mind the established zenith travel limits.
- Tracker position: On the bottom left hand part we have the tracker's current zenith position in degrees.
- Tracker set point: On the bottom right hand part we have the tracker's zenith set point, i.e., the zenith position where the tracker should be. As a rule, during the day the tracker's zenith set point will be the same value as the sun's zenith position. At night the set point will be the value established as the tracker's defence position. In the event of a wind or wind vane alarm the set point will be the value indicated by the defence position.

Figure 4.7 Tracker data. Tracker zenith position

4.3.2.3. Real time clock date and time (GMT)

The first line indicates the date of the current day. The second line shows the time according to the GMT time schedule. Taking as an example a solar farm located in Spain, in the winter we should subtract an hour from the official time and this will be the time displayed on screen. In the summer, the time difference between the official time and GMT is 2 hours.
4.3.3 MAINTENANCE MENU. MANUAL MOVEMENTS

On displaying the manual movement screens, the PLC blocks the automatic movement of the azimuth and zenith axes derived from the position correction. When we exit the manual screens, the PLC picks up the control of the tracker again and corrects its position if it has lost its orientation.

If the tracker has an emergency stop button, after exiting the manual movement screen the start button should be pressed to return to automatic mode.

4.3.3.1. Tracker azimuth movement

On displaying this screen, the tracker blocks the solar tracking both in azimuth and in zenith, disabling the automatic movement of the motors. Any movement of the tracker with this screen displayed will occur when the user directly orders it. Pressing F1 the tracker will move in azimuth in the east-west direction passing through the south. Pressing F2 the tracker will move in azimuth in the west-east direction passing through the south. In both cases, we can stop the movement by pressing F3. The motor will also stop if the azimuth axis reaches the south position or the travel limits.

4.3.3.2. Tracker zenith movement

On displaying this screen, the tracker blocks the azimuth and zenith position, disabling the automatic movement of the motors. Any movement of the tracker with this screen displayed will occur when the user directly orders it. By pressing F1 the tracker will move in zenith towards the horizontal surface position. By pressing F2 the tracker will move in zenith towards the tilt surface position with respect to the vertical position. In both cases, we can stop the movement by pressing F3. The motor will also stop if the zenith axis reaches the horizontal surface and 60º travel limits.
4.3.4 MAINTENANCE MENU. AREA MASTER

4.3.4.1. CPU enabling as area master

From this screen it is possible to enable the CPU as the area master, setting the Master field to 1 on the top left hand part of the screen. There can only be one master in each RS485 network, and this will be the area master that communicates with the Ethernet bus master (weather station) if it is available (the network master is optional). The other parameters of this screen are:

- **CP243 status**: On the top right hand part we have the status of the CP243 module. It is necessary to connect each RS485 area master to a CP243 module to access the Ethernet network. With the Ethernet network we can collect information on each of the trackers that comprise a farm. The CP243 Ethernet module is optional. If we have connected a CP243 module and the CPU is enabled as the area master, on this screen we can see the status of the CP243 module. The status of the CP243 module will be 0 if there are no problems. If any other value appears, contact Mecasolar’s technical service.

- **CPU start address**: On the bottom left hand section we enter the lowest address of those connected to the RS485 network. By marking the lowest and highest addresses we optimise the cycle time of the area master’s reading and writing processes.

- **Number of RS485 bus trackers**: If the tracker we are connecting to is configured as the area master, we should define the number of trackers that make up this area. By marking the lowest and highest addresses we optimise the cycle time of the area master’s reading and writing processes.

4.3.4.2. Configuration of the IP address of the area master

It is only necessary to configure the following screen if the CPU is enabled as the RS485 area master and we want to communicate with a higher level. The communication with the higher level is always via Ethernet and therefore the IP address of the area master has to be configured.
• IP address: The IP address of the area master should also be configured in the upper level to enable communication between the two levels.

![Figure 4.12 Area master. IP address configuration](image)

### 4.3.4.3. Subnetwork link and mask

To complete the IP configuration of the area master, it is necessary to define the TSAP and the subnetwork mask. The TSAP is the parameter obtained from the CP module of the weather station we are going to connect to, and the link number we are going to use.

- **CP**: The first digit is the CP module of the weather station we want to communicate with. The value will be 1 or 2 depending on whether we communicate with the first or the second CP243 module connected to the bus master.
- **LINK**: The second digit is the link number inside the CP module. The link number is a decimal value from 1 to 8.
- **Subnetwork mask**: We can configure the subnetwork mask of our area master at the bottom of the screen. The network mask can be modified to adapt it to the class of defined Ethernet network.

![Figure 4.13 Area master. Subnetwork link and mask configuration](image)

### 4.3.5 MAINTENANCE MENU. SAFETY

#### 4.3.5.1. Wind and wind vane alarm

This screen enables connecting and disconnecting the wind alarm from the screen as well as disconnecting the wind vane alarm.
4.3.5.2. Snow alarm

The snow alarm can only be connected manually from the master area or from the bus master. Alarm deactivation is also carried out manually.

4.3.6 MAINTENANCE MENU. WIND GAUGE AND WIND VANE

4.3.6.1. Wind gauge configuration

The tracker's control programme is designed to be able to connect a wind gauge to it. The wind gauge is the additional device of the trackers. The tracker with a wind gauge connected should be the area master, and it can transmit the alarms to the other slave trackers in its area if an alarm caused by air occurs. If the tracker with the wind gauge connected is not enabled as the area master the alarms will not be transmitted to the other trackers.

Two fields appear on the screen. The field on the left shows the current speed marked by the wind gauge, while the field on the right shows the speed at which the air alarm will activate. This parameter can be edited with the “1234” password as long as the value ranges from 30 km/h and 70 km/h.
4.3.6.2. Wind vane configuration - 1

The tracker’s control programme is designed to be able to connect a wind vane to it. The wind vane is the additional device of the trackers. The tracker with the wind vane connected to it should be the area master to be able to transmit the alarms to the other slave trackers in its area. If the tracker with the wind vane connected is not enabled as the area master the alarms will not be transmitted to the other trackers.

4.3.6.3. Wind vane configuration - 2

In this screen we continue to configure the wind vane. The parameters of this screen are:

- Current angle: In the top right hand area we can see the current position of the wind vane. This parameter cannot be modified.
- Alarm angle: In the top right hand area we can see the wind direction when the wind vane alarm activates. This parameter cannot be modified.
- Daily wind component: In the bottom left hand area we can see the prevailing wind direction throughout the current day. This parameter cannot be modified.
- Assembly offset: In the bottom right hand area we can enter an Offset to compensate for possible errors in the wind vane’s assembly.
4.3.7 MAINTENANCE MENU. ADJUSTMENTS

To be able to modify any parameter, it is necessary to enter the editing code, which is 1234. In the main menu, next to “AJUSTES” (adjustments), we can see the current version of the tracker programme indicated by an alphanumeric code. For example, if the text is “AJUSTES v10.6” the tracker’s programme version will be v10.6.

4.3.7.1. CPU address and south position

On this screen we can configure the parameters regarding the CPU address and the position of the south strip:

- CPU address: This parameter indicates the tracker address inside the RS485 bus it is connected to. There should not be 2 trackers with the same CPU address inside the same bus. To change the CPU address, this value has to be modified and the PLC reset.
  - The tracker’s CPU address will be its tracker number inside the area plus a set value that is normally 10. For example, for the 1.09 tracker (tracker 9 of area 1) and for the B.06 tracker (tracker 6 of area B) their CPU addresses are:
    - 1.09 - CPU Address = Tracker no. + 10 → 9 + 10 = 19
    - B.06 - CPU Address = Tracker no. + 10 → 6 + 10 = 16

- South position: The south strip is used to reference the tracker during its normal operation. This value has to be configured during the tracker commissioning.
4.3.7.2. Horizontal crown cogs and jack pitch

The number of cogs of the horizontal crown and the jack pitch can be configured in this screen (zenith elevation system).

- Horizontal crown cogs: We can enter the number of cogs of the horizontal crown on the top part. This parameter should be entered during the commissioning and has a default value of 125 cogs.
- Jack pitch (mm): We have the jack pitch of the tracker’s elevation system at the bottom. This parameter should be modified if necessary during the commissioning and has a default value of 7 mm.

4.3.7.3. Farm area and zenith reference

The parameters to be modified on this screen are the farm area, the 0º sensor position and the tracker defence position:

- Farm area: This parameter allows for restricting the tracker’s maximum tilt. The maximum tilt is obtained as 60º less the farm area number. In this way if the farm area is 4, the lower tilt limit will be 56º.
- Reference 0º: This parameter allows for modifying the value the tracker takes when it reaches the horizontal plate sensor. The range of values it can take go from -3º to 3º.

Defence position: Defence position is the zenith standby position during the night and the position to trackers go to in the event of a wind alarm. This value can range from 0º to 10º.
4.3.7.4. Additional parameterisation – Technical service use 1

From this screen a series of parameters can be displayed and modified that define the tracker's performance. Accessing these parameters and their description is restricted to Mecasolar's official technical service staff.

4.3.7.5. Additional parameterisation – Technical service use 2

From this screen a series of parameters can be displayed and modified that define the tracker's performance. Accessing these parameters and their description is restricted to Mecasolar's official technical service staff. It should be pointed out that entering 463 or 464 in the P6 parameter, the latitude (463) and length (464) of the farm can be seen.
4.3.7.6. Energy meters

The energy meters are optional. The maximum number of meters that can be connected to the PLC is 2. The reading of each of the meters can be seen in this screen. All this screen’s parameters can be modified if necessary to, for instance, give continuity to the energy readings in the event that the PLC requires replacement due to fault:

- D1: Daily accumulated production of energy meter number 1
- T1: Total accumulated production of energy meter number 1
- D2: Daily accumulated production of energy meter number 2
- T2: Total accumulated production of energy meter number 2

![Energy meters screenshot](image)

Figure 4.24 Settings. Energy meters

4.3.8 FAULT DISPLAY WITH THE TD200

The fault screen makes it easier to troubleshoot the tracker’s problem. When the display is connected, an exclamation mark will appear on the screen if there are any faults present. To see the fault, we should press the ESC key until the DISPLAY ALARMS text appears on the screen. When this message appears, we can access the alarms screen by pressing ENTER.

The programmed alarm messages are listed below.

4.3.8.1. Jack pitch

The jack pitch value is out of the authorised range. The value can be changed from the fault screen itself.

![Faults screenshot](image)

Figure 4.25 Faults. Jack pitch
4.3.8.2. **South sensor degrees**

The value in degrees on the south sensor is out of the authorised range. The value can be changed from the fault screen itself.

![Figure 4.26 Faults. South detector degrees](image1)

4.3.8.3. **Azimuth axis: movement detector – motor traction**

When the azimuth axis motor is started up, no movement has been detected. The fault may appear due to a traction fault in the motor of the azimuth axis or because the detector has “lost” one of the crown’s cogs.

![Figure 4.27 Faults. Detection / traction azimuth axis](image2)

4.3.8.4. **Azimuth axis: north sensor**

The tracker’s normal operation should never reach the north position. The azimuth movement of the tracker stops when the north position is reached and generates a fault. This fault may appear either due to a faulty axis referencing during the commissioning or due to a loss in the counting of the pulses by the movement detector.

![Figure 4.28 Faults. North sensor](image3)
4.3.8.5. **Zenith axis: movement detector – motor traction**

When the zenith axis motor is started up, no movement has been detected. The fault may appear due to a traction fault in the motor of the zenith axis or because the detector has “lost” one of the crown's cogs.

![Image](image.png)

Figure 4.29 Faults. Detection / traction zenith axis

4.3.8.6. **Zenith axis: 60º sensor**

The tracker's normal operation should never exceed a tilt of 60º. If it reaches this tilt for any reason, the zenith movement of the tracker stops and generates a fault. This fault may appear either due to a faulty axis referencing during the commissioning or due to a loss in the counting of the pulses by the movement detector.

![Image](image.png)

Figure 4.30 Faults. 60º sensor

4.3.8.7. **Zenith axis: 0º reference out of range**

If the zenith axis' pulse sensor loses a pulse, when the tracker reaches the 0º tilt position it thinks that it is not in this position. If when it reaches the 0º tilt the error exceeds a preset value, the fault occurs.

![Image](image.png)

Figure 4.31 Faults. Error horizontal surface referencing
4.3.8.8. Zenith Axis: 0º sensor disconnected

This alarm will only be activated if the tracker starts up without the 0º sensor. When the zenith movement motors are running for more than 5 seconds and the 0º sensor stays off, this alarm will be activated.

![Image of 0º sensor disconnected](image)

**Figure 4.32 Faults. 0º sensor disconnected**

4.3.9 FAULT DISPLAY IN THE PLC

4.3.9.1. PLC outputs related to the faults:

There are several PLC outputs related to the faults.

- Q0.7: Stoppage by the 60º sensor
- Q1.0: Stoppage of the zenith axis due to a fault in the zenith axis. It is important to point out that any fault in the zenith axis causes the automatic stoppage of the azimuth axis and the activation of the Q1.1 output.
- Q1.1: Stoppage of the azimuth axis due to a fault in the azimuth axis.

4.3.9.2. Possible causes of the stoppage:

- HOR. DETEC/TRACCION: The fault is caused because:
  - the sensor is incorrectly adjusted
  - the motor is not moving the tracker's azimuth axis (motor fault)
  - the azimuth axis' circuit breaker (FR1) has tripped
- HOR. DETECTOR NORTE: The north sensor has activated because:
  - the tracker has reached the north. This error may occur as there has been a fault in the referencing of the azimuth axis.
  - due to a fault in the sensor (sensor blink)
- VER. DETEC/TRACCION: The cause of the fault are:
  - the vertical pulse sensor is incorrectly adjusted
  - the motor is not moving the tracker's zenith axis
  - the FR2 zenith sensor circuit breaker has tripped
- VER. DETECTOR 60º: The most probable causes of faults are:
  - the 60º has activated due to the tracker reaching the 60º position. The real position of the tracker will have to be checked in the TD200 (POS.VER.REAL). If the real position is
any other than 60º the most probable cause of the fault is an incorrect adjustment of the pulse sensor in the vertical axis.

- VER. REFERENCIA 0º: This fault occurs:
  - when upon activating the 0º sensor the position registered in the PLC is any other than 0º
  - 0º is activated before the tracker reaches the 0º position due to a sensor fault or shavings in the jack's spindle.

### 4.4. ADDITIONAL DEVICES

#### 4.4.1 WIND GAUGE

The wind gauge is one of the additional devices that should be connected to the tracker. The connection of the wind gauge to the tracker is carried out via the I1.2 input. The wind gauge enables the safety device to be automatically activated by air.

Alarm activation by air can be carried out in different ways depending on the point from which the air alarm is activated or deactivated.

- **Weather station**: The wind alarm activation can be carried out from the TD200 screen or in automatic mode if the weather station has a wind gauge.
  - Wind gauge: The wind gauge activates the bus' air alarm and stays activated for at least 1 hour. Deactivation occurs when 1 hour elapses with winds under the activation speed.
  - TD200 screen: The air safety device (SEG_AIRE) of the weather station activated from the TD200 screen is reset after the minutes indicated on the screen have passed. If the time value is 0, the alarm will stay active until it is manually deactivated.

- **Area master**: The air safety device can be activated using the bus, from the I1.1 input or in automatic mode if the area master has a wind gauge or wind vane.
  - Bus alarm: The activation or deactivation of the bus alarm is carried out from the weather station. In the event of a loss of communication, this alarm can be reset turning the RUN/STOP selector to the TERM position for more than 10 seconds.
  - Wind gauge: In automatic mode, the signal activates when the alarm speed is exceeded. Deactivation occurs automatically when 1 hour passes with wind speeds under the activation speed. The alarm can be deactivated at any time turning the RUN/STOP to the TERM position for more than 10 seconds.
  - I1.1 selector input: The alarm is activated by pressing it for more than 2.5 seconds. The wind alarm can be deactivated with a negative edge in the I1.1 1 minute after its activation. If a selector is used, the wind signal will stay active while we have 24V in the input. If we do not have a selector and we have clicked to activate the alarm, the alarm is automatically deactivated after 2 hours. At any other time, the alarm can be deactivated at any time by turning the RUN/STOP to the TERM position for more than 10 seconds.
  - TD200 screen: The alarm can be activated via the TD200 screen. This alarm can be deactivated from the screen or with the RUN/STOP selector by turning it to TERM for more than 10 seconds.

- **Slave**: The alarm can be activated via the bus by an order from the weather station or the area master. It can be locally activated from the I1.1 input or from the TD200 screen.
  - Bus alarm: The alarm bus may come from the weather station or from the area master. It is activated when either of the two is active. Deactivation occurs when both signals, weather station and area master, are deactivated. In the event of a loss of communication, the alarm can be reset turning the RUN/STOP selector to the TERM position for more than 10 seconds.
  - The operation of the alarm generated from the I1.1 input or from the screen is identical to the operation of the area master.
4.4.2 WIND VANE

The wind vane is one of the additional devices that may be connected to the tracker. The connection of the wind vane to the tracker varies depending on the devices connected to the tracker. The wind vane enables positioning the tracker according to the wind direction when the alarm activation speed is exceeded. The wind vane may be installed in the area master, in the weather station or in both PLC’s at the same time, and running together.

If both the weather station and the area master have a wind vane, they can both communicate the wind vane alarm. The slave trackers will obey the weather station if they do not have a set point from the area master and will obey the area master set point if it is activated (regardless of if the weather station has the wind vane alarm activated).

4.4.2.1. Wind vane wiring

The wind vane can be installed in the area master or in the weather station. In both cases, 3 or 4 inputs can be used in the PLC. This parameter should be indicated in NBIT. The wind vane connected to the tracker should have a digital output with Gray code. The wiring for each case can be seen in the following table:

<table>
<thead>
<tr>
<th>Wind Vane Cable</th>
<th>Area Master 3 wires</th>
<th>Area Master 4 wires</th>
<th>Weather station 3 wires</th>
<th>Weather station 4 wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Thies</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>1 – White</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>2 – Brown</td>
<td>11.5</td>
<td>10.6</td>
<td>11.3</td>
<td>11.2</td>
</tr>
<tr>
<td>3 – Green</td>
<td>11.4</td>
<td>11.5</td>
<td>11.4</td>
<td>11.3</td>
</tr>
<tr>
<td>4 – Yellow</td>
<td>11.3</td>
<td>11.4</td>
<td>11.5</td>
<td>11.4</td>
</tr>
<tr>
<td>5 – Grey</td>
<td>NC</td>
<td>11.3</td>
<td>NC</td>
<td>11.5</td>
</tr>
<tr>
<td>6 – Pink</td>
<td>24V</td>
<td>24V</td>
<td>24V</td>
<td>24V</td>
</tr>
<tr>
<td>7 – Blue</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>8 – Red</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>GND – Earth</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
<td>GND</td>
</tr>
</tbody>
</table>

The wind vane has 2 cables (7/0V and 8/+24V) that supply a heating resistor, enabling the wind vane to operate correctly in extremely low temperature conditions.

4.4.2.2. Configuration of the wind vane in the area master

The parameters that have to be configured in the area master are:

- OFF1: Error in the wind vane positioning, requiring the use of a compass and looking for the point where the wind vane output is 0°. Check that the sign has been entered correctly.
- V_INT: Speed of start of integration. By default the start of integration is 60 km/h
- NBIT: Wind vane resolution or number of wires connected to the PLC. Configure this parameter at 3 or 4 according to how the wind vane has been wired.
- ACTIVATED: Set this bit to 1 to enable the wind vane
- In the tracker, the wind vane’s north mark should point towards where the tracker is pointing

4.4.2.3. Configuration of the wind vane in the weather station

In the case of the weather station, the wind vane can be configured in two different ways depending on whether it is installed on a tracker or on a fixed structure (a post for example). The recommended option is installation on a post.
4.4.2.4. Weather station – Installation on a post

In this case the parameters to be configured are:

- **NBIT**: Wind vane number resolution or number of wires connected to the PLC. Configure this parameter at 3 or 4 according to how the wind vane has been wired.
- **V_INTEG**: Speed that indicates the speed at which integration is started. It determines other Reference variables
- **OFF_1**: Orientation offset to determine wind direction. It is added to the angle of the wind vane. (If we assemble the wind vane in the trackers, the offset will be the azimuth position of the tracker). If communication is lost with the tracker on which the wind vane is installed, the wind vane function will be disabled.
- **OFF_2**: Offset 2 is a compensation due to an assembly error, which should be used in both wind vanes assembled on trackers and wind vanes in the weather station.
- **ZON**: If the wind vane is assembled on a post, this parameter should be set at 0
- **SEG**: If the wind vane is assembled on a post, this parameter should be set at 0
- The wind vane's north mark should point towards the north when we install it on the post.

4.4.2.5. Weather station – Installation on a tracker

When we install the wind vane on a tracker, it should always be the area master that facilitates the communication of parameters between the tracker and the weather station. We should configure the wind vane in the following way:

- **NBIT**: Wind vane number resolution or number of wires connected to the PLC. Configure this parameter at 3 or 4 according to how the wind vane has been wired.
- **V_INTEG**: Speed that indicates the speed at which integration is started. It determines other Reference variables
- **OFF_1**: Orientation offset to determine wind direction. It is added to the angle of the wind vane. (If we assemble the wind vane in the trackers, the offset will be the azimuth position of the tracker). If communication is lost with the tracker on which the wind vane is installed, the wind vane function will be disabled.
- **OFF_2**: Offset 2 is a compensation due to an assembly error, which should be used in both wind vanes assembled on trackers and wind vanes in the weather station.
- **ZON**: Area number of the tracker on which the wind vane is assembled
- **SEG**: Tracker number where the wind vane is assembled.
- The wind vane's north mark should point towards the south when the tracker is in the south position.

4.4.2.6. Checking the correct installation of the wind vane

The output data are the same regardless of where the wind vane is installed:

- **AHORA**: Current angle of the wind vane
- **ALAR**: Prevailing wind component when the alarm is activated. The values with which this component is calculated begin to be collected when the wind speed exceeds **V_INTEG**
- **DIA**: Prevailing wind component. The collection of data for calculating this parameter starts when the wind speed exceeds 5 km/h

To check that the wind vane is correctly installed, manually turn it and check that the AHORA angle goes from 0º to a value of around 360º (315º or 337º) turning the wind vane and checking that the AHORA angle always increases in value.

4.4.2.7. Wind vane operation

- The trackers go to the safety position (wind alarm) with winds over **V_INTEG** Km/h
• Above V_INTEG Km/h we start to register the wind direction
• When the wind exceeds V_INTEG * 1.33 km/h the wind vane activates and sends the ANG_AL set point to the trackers.
• Above (V_INTEG x 1.5) km/h the deactivation of the wind alarm is reset.
• Under (V_INTEG x 1) km/h the timer starts for the deactivation. The deactivation time is 2 hours and can only be changed by the programme.
## 4.5. LIST OF INPUTS AND OUTPUTS

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>ADDRESS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DET_H_NORTH</td>
<td>I0.0</td>
<td>AZIMUTH - NORTH SENSOR</td>
</tr>
<tr>
<td>DET_H_PULSE</td>
<td>I0.1</td>
<td>AZIMUTH - PULSES SENSOR</td>
</tr>
<tr>
<td>DET_H_SOUTH</td>
<td>I0.2</td>
<td>AZIMUTH - SOUTH SENSOR</td>
</tr>
<tr>
<td>DET_V_60GRD</td>
<td>I0.3</td>
<td>ZENITH - 60º SENSOR</td>
</tr>
<tr>
<td>DET_V_ENCOD</td>
<td>I0.4</td>
<td>ZENITH - PULSES SENSOR</td>
</tr>
<tr>
<td>DET_V_0GRD</td>
<td>I0.5</td>
<td>ZENITH - 0º SENSOR</td>
</tr>
<tr>
<td>ENERGY_METER</td>
<td>I0.6</td>
<td>ENERGY COUNTER / WIND VANE</td>
</tr>
<tr>
<td>SB_AUTO</td>
<td>I0.7</td>
<td>AUTOMATIC MODE PUSH BUTTON</td>
</tr>
<tr>
<td>FA_24V</td>
<td>I1.0</td>
<td>EMERGENCY PUSH BUTTON</td>
</tr>
<tr>
<td>WIND_SELECTOR</td>
<td>I1.1</td>
<td>WIND ALARM - HARDWARE INPUT</td>
</tr>
<tr>
<td>ANEMOMETER</td>
<td>I1.2</td>
<td>ANEMOMETER INPUT (OPTIONAL)</td>
</tr>
<tr>
<td>VEL1</td>
<td>I1.3</td>
<td>WIND VANE INPUT (OPTIONAL)</td>
</tr>
<tr>
<td>VEL2</td>
<td>I1.4</td>
<td>WIND VANE INPUT (OPTIONAL)</td>
</tr>
<tr>
<td>VEL3</td>
<td>I1.5</td>
<td>WIND VANE INPUT (OPTIONAL)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>ADDRESS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>KM1A</td>
<td>Q0.0</td>
<td>AZIMUTH MOTOR - EAST TO WEST</td>
</tr>
<tr>
<td>KM1B</td>
<td>Q0.1</td>
<td>AZIMUTH MOTOR - WEST TO EAST</td>
</tr>
<tr>
<td>KM2A</td>
<td>Q0.2</td>
<td>ZENITAL MOTOR - DOWN</td>
</tr>
<tr>
<td>KM2B</td>
<td>Q0.3</td>
<td>ZENITHAL MOTOR - UP</td>
</tr>
<tr>
<td>HL4</td>
<td>Q0.4</td>
<td>AUTOMATIC MODE SIGNAL</td>
</tr>
<tr>
<td>KA6</td>
<td>Q0.5</td>
<td>WIND ALARM SIGNAL</td>
</tr>
<tr>
<td>HL_SYNC</td>
<td>Q0.6</td>
<td>SYNCHRONIZATION SIGNAL</td>
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<tr>
<td>HL3</td>
<td>Q0.7</td>
<td>60º ALARM</td>
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<tr>
<td>HL2</td>
<td>Q1.0</td>
<td>ZENITHAL WARNING</td>
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<tr>
<td>HL1</td>
<td>Q1.1</td>
<td>AZIMUTHAL WARNING</td>
</tr>
</tbody>
</table>

Table 4.1. Inputs and outputs
### 4.6. LIST OF ELECTRICAL MATERIALS

**BOM - MS-2 TRACKER - CONTROL**

**PROJECT:** MS-2 TRACKER 10 +

**REVISED:** J.M. MARANINI  DATE: 05/11/2008

<table>
<thead>
<tr>
<th>QTY</th>
<th>UNITS</th>
<th>REFERENCE</th>
<th>DESCRIPTION</th>
<th>MANUFACTURER</th>
</tr>
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<tbody>
<tr>
<td>1 UD.</td>
<td></td>
<td>6EP1 331-15H02</td>
<td>POWER SUPPLY 12V/1.3A</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>1 UD.</td>
<td></td>
<td>6ES7214-1AD23-0XB0</td>
<td>PLC: CPU224 14 DIGITAL INPUTS / 10 DIGITAL OUTPUTS</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>4 UD.</td>
<td></td>
<td>6RT1015-1BB41</td>
<td>CONTACTOR 500.3KW</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>1 UD.</td>
<td></td>
<td>6VR1011-0KA10</td>
<td>CIRCUIT BREAKER (AZIMUTH MOTOR) - 0.9-1.25A</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>1 UD.</td>
<td></td>
<td>6VR1011-1CA10</td>
<td>CIRCUIT BREAKER (ZENTRAL MOTOR) - 1.8-2.5A</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>1 UD.</td>
<td></td>
<td>3SE6204-7</td>
<td>CIRCUIT BREAKER (PLC) 2P 4A C 0.8A</td>
<td>SIEMENS</td>
</tr>
<tr>
<td>2 UD.</td>
<td></td>
<td>0819113-2A</td>
<td>INVERTER KIT FOR CONTACTOR</td>
<td>SCHNEIDER</td>
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<tr>
<td>1 UD.</td>
<td></td>
<td>KBPC4.0884 4P 100A</td>
<td>DISTRIBUTION BLOCK 4P 100A</td>
<td>WEIDMÜLLER</td>
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<tr>
<td>1 UD.</td>
<td></td>
<td>VAK943493</td>
<td>SURGE PROTECTION IPU 485</td>
<td>WEIDMÜLLER</td>
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<tr>
<td>0.9 MTS</td>
<td></td>
<td>WEI 8007971001</td>
<td>BASE PROTECTOR IPU M40S</td>
<td>WEIDMÜLLER</td>
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<tr>
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<td>WEI 943493</td>
<td>SURGE PROTECTION IPU 485</td>
<td>WEIDMÜLLER</td>
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<tr>
<td>0.9 MTS</td>
<td></td>
<td>WEI 88010</td>
<td>SS3 OMEGA PROFILE</td>
<td>WEIDMÜLLER</td>
</tr>
<tr>
<td>8 UD.</td>
<td></td>
<td>WEI 9021130000</td>
<td>WIRE END FERRULE 6 mm GREEN</td>
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<tr>
<td>34 UD.</td>
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<td>WEI 9019430000</td>
<td>WIRE END FERRULE 1.5 mm BLACK</td>
<td>WEIDMÜLLER</td>
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<tr>
<td>2 UD.</td>
<td></td>
<td>WEI 9044200000</td>
<td>TWIN WIRE END FERRULE H-1.5/16 BLACK</td>
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<tr>
<td>22 UD.</td>
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<tr>
<td>7 UD.</td>
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<td>WEI 9047800000</td>
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<tr>
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<td>WEI 7501001778</td>
<td>CUSTOMIZED TERMINAL BLOCK</td>
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<tr>
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<td>TERMINAL BLOCK WDU 6 BLUE</td>
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<tr>
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<td>WEI 101050</td>
<td>TERMINAL BLOCK WPE 4 GROUND</td>
<td>WEIDMÜLLER</td>
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<tr>
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<td>TERMINAL BLOCK WDU 4</td>
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<td>TERMINAL BLOCK WDU 2.5</td>
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<tr>
<td>3 UD.</td>
<td></td>
<td>WEI 105000</td>
<td>WCAP COVER 2.5-10</td>
<td>WEIDMÜLLER</td>
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<tr>
<td>2 UD.</td>
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<td>WEI 8412GM5D-03-V1</td>
<td>DETECTOR M12 PNP NC. CONNECTOR</td>
<td>PEPPERL FUCHS</td>
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<tr>
<td>3 UD.</td>
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<td>WEI 8885-1BGM60-A2</td>
<td>DETECTOR M18 PNP 3 MTS. CABLE</td>
<td>PEPPERL FUCHS</td>
</tr>
<tr>
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<td>WEI 8813-4GM40-E2-V1</td>
<td>DETECTOR M8 PNP NO. CONNECTOR</td>
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<td>3 UD.</td>
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<td>V1-W-2M-PVC</td>
<td>CABLE FOR DETECTOR - M12 5M</td>
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<tr>
<td>2 UD.</td>
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<td>BODY / RING COILAR FOR ELECTRICAL BLOCK</td>
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<tr>
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<td>884-B344</td>
<td>MUSHROOM HEAD PUSHBUTTON</td>
<td>TELEMECANIQUE</td>
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<td>884-89333</td>
<td>ILLUMINATED PUSHBUTTON WITH FLUSH PUSH - GREEN</td>
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<tr>
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<tr>
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<td>2.5 MTS</td>
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<td>MAS0504030R3</td>
<td>ENCLOSURE 600x400x300 DRAWING 5149 / BOARD RMP06040 INCLUDED</td>
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<td>HD7Y-V 1x8 GREY</td>
<td>CABLE HD7V-K (6MM) GREY</td>
<td>GENERAL</td>
</tr>
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<td>1.84 MTS</td>
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<td>5 MTS</td>
<td></td>
<td>L11-36A,30</td>
<td>CONDUIT (30 MTS COL) - NOMINAL WIDTH 36.3mm</td>
<td>PMA</td>
</tr>
<tr>
<td>5 MTS</td>
<td></td>
<td>L11-17A,30</td>
<td>CONDUIT (30 MTS COL) - NOMINAL WIDTH 18.4mm</td>
<td>PMA</td>
</tr>
<tr>
<td>5 MTS</td>
<td></td>
<td>L11-07A,50</td>
<td>CONDUIT (30 MTS COL) - NOMINAL WIDTH 6.2mm</td>
<td>PMA</td>
</tr>
</tbody>
</table>

Other Enclosure references:

| 1 UD. | | ERT-64/300 PM | ENCLOSURE 600x400x300, DRAWING 5149, 4 HOLES / BOARD MM-64 | IMAB |
5. MECHANICAL MAINTENANCE

5.1. GENERAL COMMENTS

This Manual describes the planned preventive maintenance operations that should be carried out periodically on the equipment and components of the MS-2 TRACKER Solar Trackers.

It is aimed at foreseeing possible stoppages or faults, maintaining the tracking systems, equipment and production installations at full operation at the optimum levels and efficiency.

5.1.1 WARRANTY

Failure to observe the procedures in the Preventive Maintenance Plan, modifications in the equipment or the use of non-original spares may lead to losing the tracker warranty provided by the manufacturer.

Staff that carry out any type of preventive or corrective maintenance on the Solar Tracker, should be fully trained and have experience in these jobs.

5.1.2 HEALTH AND SAFETY

For any maintenance operation the suitable safety measures should be taken as well as those that are obligatory in accordance with the corresponding laws in force regarding Occupational Health and Safety Prevention matters.

During maintenance operations it will be compulsory to use a hardhat against knocks in accordance with EN 812 (a hardhat against falling objects in accordance with EN 397 may also be used), mechanical protective gloves in accordance with EN 388, safety goggles with protection against UV radiation in accordance with EN 166 and safety boots in accordance with EN 344 with a reinforced toe cap and sole.

5.2. TRACKER INTERLOCKING

As a safety measure, it will be necessary to electrically interlock the tracker before the maintenance procedures that involve handling the machine's moving elements.

From the PLC board the catchment surface will be taken to the horizontal position with the minimum resistance to the wind, to then disconnect the electrical supply from the tracker's motor.

When the maintenance operations have been finished, turn the machine's electrical supply on again, leave the control in automatic to activate the solar tracking function. The tracker will position as appropriate to the solar coordinates at that time.

5.3. MAINTENANCE PLANNING

5.3.1 MECASOLAR SOLAR TRACKER COMPONENTS

The Solar Tracker is made up of the following main components:

- Footing
- Lower anchor plate
- Azimuth positioning bearing
- Upper anchor plate
- Gear motor
- Support arms
- Articulated frame or grill.
- Straps
- Panel holder profiling
- Mechanical jack
- Control system and safety devices

5.3.2 MAINTENANCE PLANNING
### Table 5.1. Maintenance planning

<table>
<thead>
<tr>
<th>Maintenance</th>
<th>First 2 Months</th>
<th>Six Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retightening nuts joint to footing</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Tightening torque nuts main bearing</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Greasing main bearing</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Crown-pinion inspection</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mechanical jack greasing</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Visual inspection of welding</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Visual inspection rest of tracker</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
# Preventive Maintenance

<table>
<thead>
<tr>
<th>Solar Park:</th>
<th>Serial #:</th>
<th>Created by:</th>
<th>Date:</th>
</tr>
</thead>
</table>

## Metal Structure

<table>
<thead>
<tr>
<th>Anchor to the Footing</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check 4 bolts following in crossing sequence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leg Screws</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check 1 M18 screw of each leg. 290Nm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bridge Screws</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check 1 M16 screw on each side. 215Nm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Side Reinforcement Screws</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check PAR screws M18 - 290Nm, Check M14 - 140Nm screws</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Jack Support Screws</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check the condition of the galvanized surfaces (paint if needed)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Observations:**

## Structure and Grid

<table>
<thead>
<tr>
<th>Check PAR M16 - 215Nm jack support</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Check position of pins</th>
</tr>
</thead>
</table>

## Motorised Parts

<table>
<thead>
<tr>
<th>Main Bearing</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease the 2 greasers of the bearing area until the grease comes out through the retainer. GREASE-TCR MOLIDEBNO.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DAMPENERS</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check the condition of the dampeners, that they do not make noise and don't lose oil.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grease pins</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Gear Pinion</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check lubrication covering all the teeth evenly. GREASE-MOLIKOTE SPRAY</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Check cover</th>
</tr>
</thead>
</table>

| Condition of fastening screws of reducer. |

| Check level and possible oil leaks. |

| Fill oil (if needed). |

| Painting equipment (if needed). |

| Commercial Brand: |

## Reducer

| Check condition of bellow. |

| Painting equipment (if needed). |

| Lubricate box, only Niasa jacks. ULTRAPLEX LT2 GREASE |

| Grease spindle. ULTRAPLEX LT2 GREASE |

| Grease pin and stud. |

| Commercial Brand: |

## Mechanical Jack

| OK | No OK |
|-------------------------------------|
| Lubricate box, only Niasa jacks. ULTRAPLEX LT2 GREASE |

| Commercial Brand: |

## Electrical Installation

<table>
<thead>
<tr>
<th>Frames</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check cabinet ventilation. (if any)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| General checks on cabinet condition. (Paint if needed) |

<table>
<thead>
<tr>
<th>Wiring</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check fastening staples for cables.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Check condition of cable conduits. |

| Check condition of fastening flanges. |

**Observations:**
5.4. RETIGHTENING THE ANCHORS TO THE FOOTING

Procedure:

- Tracker interlocking
  Before regreasing the bolts of the footing, it is necessary to electrically interlock the tracker.
- Bolt retightening
  Necessary: Torque spanner

Adjust the torque spanner to the specified tightening torque. Retighten the 20 anchor bolts of the lower flange of the bearing following a cross sequence.

5.5. MAIN BEARING GREASING

Grease gradually loses its lubrication properties due to mechanical work, temperature, aging and accumulation of dirt. Therefore, it is very important to replace or renew the grease regularly.

Lubrication frequency will basically depend on the operating conditions and environmental influences.

The Safety Data Sheet of the grease to be used will be available and will be used following the precautions indicated thereon.

5.5.1 COG LUBRICATION

Cog lubrication will be carried out every six months with a grease spray, and excess grease should not be allowed to accumulate. Before greasing, the cogs used in the tracker’s movement will be cleaned if the grease were to have deteriorated or rust appeared.

5.5.2 BEARING LUBRICATION

Given the special working conditions of the bearing in this machine, we will limit ourselves to the yearly lubrication of the internal bearing track.

Lubricants for the bearing track

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Temp Field</th>
<th>Manufacturer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arallub HLP 2</td>
<td>from -30 °C to +130 °C</td>
<td>ARAL</td>
<td></td>
</tr>
<tr>
<td>Energrease LS-EP 2</td>
<td>from -20 °C to +130 °C</td>
<td>BP</td>
<td></td>
</tr>
<tr>
<td>EPEX ELF 2</td>
<td>from -30 °C to +130 °C</td>
<td>ELF</td>
<td></td>
</tr>
<tr>
<td>BEACON EP2</td>
<td>from -25 °C to +130 °C</td>
<td>ESSO</td>
<td></td>
</tr>
<tr>
<td>Centoplex GLP 402</td>
<td>from -20 °C to +130 °C</td>
<td>KLUBER</td>
<td></td>
</tr>
<tr>
<td>Molilux Ep2</td>
<td>from -20 °C to +120 °C</td>
<td>MOBIL</td>
<td></td>
</tr>
<tr>
<td>Alvania EP2</td>
<td>from -20 °C to +120 °C</td>
<td>SHELL</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2. Lubricants for bearing
**Procedure:**

In addition to the lubrication of the tracks and the roller bearings, thanks to the lubrication process, foreign bodies are ejected, such as dirt, dust and water that may have penetrated the revolving crown.

There are four greasing points on the outer side surface of the bearing to inject the grease inside it.

Use the same or compatible lubricant for regreasing according to the attached table (Table 5.1).

- Tracker interlocking. Before greasing the main bearing it is necessary electrically interlock the tracker.
- Clean the lubricators.
- Insert the grease lubricators until a bead of new grease starts to appear through the joints, to ensure that the old grease has been replaced.
- Remove and clean any excess grease.

**5.6. TIGHTENING CONTROL OF THE MAIN BEARING**

The bearing screws are assembled with the recommended tightening torque and at the same time the thread is impregnated beforehand with fixer adhesive which ensures a safe and long-lasting joint.

**Procedure:**

- Tracker interlocking. Before regreasing the bolts of the main bearing it is necessary to electrically interlock the tracker.
- Check the tightening of the bearing bolts

  Torque spanner (if necessary)

  - Check each of the bearing’s six bolts, to see if there are any signs of loosening.
  - If any loose bolts are seen, retighten them in a cross sequence.

**5.7. INSPECTION OF THE TRANSMISSION CROWN-PINION**

**Procedure:**

- Tracker interlocking. Before regreasing the bolts of the main bearing it is necessary to electrically interlock the tracker.
- Visually inspect the condition of the contact surface, checking for possible wear and tear, play or other faults.

  If there is a lot of wear, readjust the orientation.

  • Manual locking of the azimuth axis

  When it is necessary to disassemble the gear motor in a maintenance operation, when this is carried out the rotation of the tracker in the azimuth axis will have no brake, and it may therefore turn freely moved by the wind.

  For these operations, for safety reasons, in addition to electrical interlocking it will also be necessary to install a mechanical block between the two azimuth rolling tracks, before disassembling the pinion or gear motor.

  The upper and lower plates of the bearing have some holes to be able to block them with a spindle pin.
For cog adjustment operation the system should be blocked with mechanical jacks to stop any movement. Consult the manufacturer for this type of action.

5.8. MECHANICAL JACK GREASING

The monitoring of the lifting of the solar catchment surface is carried out using a mechanical jack (40x7 mm spindle) driven by an 0.75 kW electrical motor, minimising the maintenance to be carried out.

The only maintenance to be carried out will be the weekly greasing of this spindle.

Procedure:

The same lubricant as used for the initial greasing will be used for regreasing.

- Clean the greasers in the spindle casing
- Position the receiving surface at 60º, connect the mechanical jack to take it to the horizontal position while we are inserting the grease, and in this way it will be distributed along the entire spindle.
- Insert grease through the greaser.
- Remove and clean any excess grease.
- Two types of jacks, as described in the preventive maintenance sheet.

5.9. FULL VISUAL INSPECTION OF THE TRACKER

The manufacturer will visually inspect the general condition of each tracker once a year (during the warranty period).

- Check the applied maintenance plan.
## Warranty Inspection

<table>
<thead>
<tr>
<th>Metal Structure</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchors to the Footing</td>
<td>Check 4 bolts following in crossing sequence</td>
<td></td>
</tr>
<tr>
<td>Leg Screws</td>
<td>Check 1 M18 screw of each leg, 290Nm</td>
<td></td>
</tr>
<tr>
<td>Bridge Screws</td>
<td>Check 1 M16 screw on each side, 215Nm</td>
<td></td>
</tr>
<tr>
<td>Side Reinforcement Screws</td>
<td>Check PAR screws M18 - 290Nm Check M14 - 140Nm screws</td>
<td></td>
</tr>
<tr>
<td>Jack Support Screws</td>
<td>Check PAR M16 - 215Nm jack support</td>
<td></td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>Check the status of the galvanized surfaces.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check welding joints.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check that studs and grid tabs are greased.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check position of pins.</td>
<td></td>
</tr>
</tbody>
</table>

**Observations:**

<table>
<thead>
<tr>
<th>Motorised Parts</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Bearing</td>
<td>Check 4 M12 screws following in crossing sequence 120Nm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grease the 2 greasers of the bearing area until the grease comes out through the retainer. GREASE-TCR MOLIDEBO.</td>
<td></td>
</tr>
<tr>
<td>Damper</td>
<td>Check the condition of the dampeners, that they do not make noise and don't lose oil.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check the greasing on the pins.</td>
<td></td>
</tr>
<tr>
<td>Gear Pinion</td>
<td>Check lubrication covering all the teeth evenly. GREASE-MOLIKOTE SPRAY.</td>
<td></td>
</tr>
<tr>
<td>Reducer</td>
<td>Check plug</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Condition of fastening screws of reducer.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check level and possible oil leaks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check the condition of the paint on the equipment (rust).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial Brand:</td>
<td></td>
</tr>
<tr>
<td>Mechanical Jack</td>
<td>Check condition of bellow.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check the condition of the paint on the equipment (rust).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lubricate box, only Niasa jacks. ULTRAPLEX LT2 GREASE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check greasing of spindle, pin and stud.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commercial Brand:</td>
<td></td>
</tr>
</tbody>
</table>

**Observations:**

<table>
<thead>
<tr>
<th>Electrical Installation</th>
<th>OK</th>
<th>No OK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frames</td>
<td>Check cabinet ventilation. (if any)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General checks on cabinet condition.</td>
<td></td>
</tr>
<tr>
<td>Wiring</td>
<td>Check fastening staples for cables.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check condition of cable conduits.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check condition of fastening flanges.</td>
<td></td>
</tr>
</tbody>
</table>

**Observations:**

---

MS-2 Tracker 10 and 10+ Solar Tracker

Visit www.mecasolar.com for more information.
5.10. GREASE SAFETY DATA SHEETS

The Safety Data Sheets of the greases used in the tracker lubrication operations are included below. These sheets should be available to the maintenance operators at all times for consultation.
# MOLYKOTE(R) G-RAPID PLUS SPRAY

## 1. PRODUCT AND COMPANY IDENTIFICATION

<table>
<thead>
<tr>
<th>Dow Corning Corporation</th>
<th>24 Hour Emergency Telephone: (989) 496-5900</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Saginaw Road</td>
<td>Customer Service: (989) 496-6000</td>
</tr>
<tr>
<td>Midland, Michigan 48686</td>
<td>Product Disposal Information: (989) 496-6315</td>
</tr>
<tr>
<td></td>
<td>CHEMTREC: (800) 424-9300</td>
</tr>
</tbody>
</table>

MSDS No.: 01685392

<table>
<thead>
<tr>
<th>Generic Description: Molybdenum disulfide aerosol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Form: Aerosol</td>
</tr>
<tr>
<td>Color: Black</td>
</tr>
<tr>
<td>Odor: Solvent odor</td>
</tr>
</tbody>
</table>

NFPA Profile: Health 2 Flammability 4 Instability/Reactivity 0

Note: NFPA = National Fire Protection Association

## 2. HAZARDS IDENTIFICATION

### POTENTIAL HEALTH EFFECTS

#### Acute Effects

**Eye:** Direct contact may cause mild irritation.

**Skin:** May cause mild irritation.

**Inhalation:** Vapor and/or mist may irritate nose and throat. Overexposure by inhalation may cause drowsiness, dizziness, confusion or loss of coordination.

**Oral:** Low ingestion hazard in normal use.

#### Prolonged/Repeated Exposure Effects

**Skin:** Repeated or prolonged contact may cause defatting and drying of skin which may result in skin irritation and dermatitis.

**Inhalation:** Exposures to high concentrations may cause cardiac sensitization. Overexposure by inhalation may injure the following organ(s): Nervous system.

**Oral:** No known applicable information.

### Signs and Symptoms of Overexposure

No known applicable information.

### Medical Conditions Aggravated by Exposure

No known applicable information.
No known applicable information.

The above listed potential effects of overexposure are based on actual data, results of studies performed upon similar compositions, component data and/or expert review of the product. Please refer to Section 11 for the detailed toxicology information.

### 3. COMPOSITION/INFORMATION ON INGREDIENTS

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Wt %</th>
<th>Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>106-97-8</td>
<td>30.0 - 60.0</td>
<td>Butane</td>
</tr>
<tr>
<td>64742-48-9</td>
<td>15.0 - 40.0</td>
<td>Hydrotreated heavy petroleum naphtha</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>5.0 - 10.0</td>
<td>Calcium hydroxide</td>
</tr>
<tr>
<td>74-98-6</td>
<td>5.0 - 10.0</td>
<td>Propane</td>
</tr>
</tbody>
</table>

The above components are hazardous as defined in 29 CFR 1910.1200.

### 4. FIRST AID MEASURES

**Eye:** Immediately flush with water for 15 minutes.

**Skin:** Remove from skin and wash thoroughly with soap and water or waterless cleanser. Get medical attention if irritation or other ill effects develop or persist.

**Inhalation:** Remove to fresh air. Get immediate medical attention.

**Oral:** No first aid should be needed.

**Notes to Physician:** Treat according to person's condition and specifics of exposure.

### 5. FIRE FIGHTING MEASURES

**Flash Point:** Not applicable.

**Autoignition Temperature:** Not determined.

**Flammability Limits in Air:** Not determined.

**Extinguishing Media:** On large fires use dry chemical, foam or water spray. On small fires use carbon dioxide (CO2), dry chemical or water spray. Water can be used to cool fire exposed containers.

**Fire Fighting Measures:** Self-contained breathing apparatus and protective clothing should be worn in fighting large fires involving chemicals. Use water spray to keep fire exposed containers cool. Determine the need to evacuate or isolate the area according to your local emergency plan.
MOLYKOTE(R) G-RAPID PLUS SPRAY

Unusual Fire Hazards: Vapors are heavier than air and may travel to a source of ignition and flash back. Static electricity will accumulate and may ignite vapors. Prevent a possible fire hazard by bonding and grounding or inert gas purge.

6. ACCIDENTAL RELEASE MEASURES

Containment/Clean up: Remove possible ignition sources. Determine whether to evacuate or isolate the area according to your local emergency plan. Observe all personal protection equipment recommendations described in Sections 5 and 8. Local, state and federal laws and regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which federal, state and local laws and regulations are applicable. Sections 13 and 15 of this MSDS provide information regarding certain federal and state requirements.

Note: See section 8 for Personal Protective Equipment for Spills. Call (989) 496-5900, if additional information is required.

7. HANDLING AND STORAGE

Use with adequate ventilation. Avoid eye contact. Avoid skin contact. Do not breathe mist. Keep container closed.

Contents under pressure. Do not store above 120F/49C or in direct sunlight. Static electricity will accumulate and may ignite vapors. Prevent a possible fire hazard by bonding and grounding or inert gas purge. Keep container closed and away from heat, sparks, and flame.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Component Exposure Limits

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Component Name</th>
<th>Exposure Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>106-97-8</td>
<td>Butane</td>
<td>OSHA PEL (final rule): TWA 800 ppm, 1900 mg/m3. ACGIH TLV: TWA 1000 ppm.</td>
</tr>
<tr>
<td>64742-48-9</td>
<td>Hydrotreated heavy petroleum naphtha</td>
<td>Observe petroleum distillates limits. OSHA PEL (final rule): TWA 400 ppm.</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>Calcium hydroxide</td>
<td>ACGIH TLV: TWA 5 mg/m3.</td>
</tr>
<tr>
<td>74-98-6</td>
<td>Propane</td>
<td>OSHA PEL (final rule): TWA 1000 ppm, 1800 mg/m3. ACGIH TLV: TWA 1000 ppm.</td>
</tr>
</tbody>
</table>

Engineering Controls

Local Ventilation: Recommended.
## MOLYKOTE(R) G-RAPID PLUS SPRAY

### General Ventilation
Recommended.

### Personal Protective Equipment for Routine Handling

<table>
<thead>
<tr>
<th>Component</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eyes:</strong></td>
<td>Use proper protection - safety glasses as a minimum.</td>
</tr>
<tr>
<td><strong>Skin:</strong></td>
<td>Wash at mealtime and end of shift. Contaminated clothing and shoes should be removed as soon as practical and thoroughly cleaned before reuse. Chemical protective gloves are recommended.</td>
</tr>
<tr>
<td><strong>Inhalation:</strong></td>
<td>Use respiratory protection unless adequate local exhaust ventilation is provided or exposure assessment demonstrates that exposures are within recommended exposure guidelines. IH personnel can assist in judging the adequacy of existing engineering controls.</td>
</tr>
<tr>
<td><strong>Suitable Respirator:</strong></td>
<td>General and local exhaust ventilation is recommended to maintain vapor exposures below recommended limits. Where concentrations are above recommended limits or are unknown, appropriate respiratory protection should be worn. Follow OSHA respirator regulations (29 CFR 1910.134) and use NIOSH/MSHA approved respirators.</td>
</tr>
</tbody>
</table>

### Personal Protective Equipment for Spills

<table>
<thead>
<tr>
<th>Component</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eyes:</strong></td>
<td>Use full face respirator.</td>
</tr>
<tr>
<td><strong>Skin:</strong></td>
<td>Wash at mealtime and end of shift. Contaminated clothing and shoes should be removed as soon as practical and thoroughly cleaned before reuse. Chemical protective gloves are recommended.</td>
</tr>
<tr>
<td><strong>Inhalation/Suitable Respirator:</strong></td>
<td>Respiratory protection recommended. Follow OSHA Respirator Regulations (29 CFR 1910.134) and use NIOSH/MSHA approved respirators. Protection provided by air purifying respirators against exposure to any hazardous chemical is limited. Use a positive pressure air supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstance where air purifying respirators may not provide adequate protection.</td>
</tr>
<tr>
<td><strong>Precautionary Measures:</strong></td>
<td>Avoid eye contact. Avoid skin contact. Do not breathe mist. Keep container closed. Use reasonable care.</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td>When heated to temperatures above 150 degrees C in the presence of air, product can form formaldehyde vapors. Formaldehyde is a potential cancer hazard, a known skin and respiratory sensitizer, and an irritant to the eyes, nose, throat, skin, and digestive system. Safe handling conditions may be maintained by keeping vapor concentrations within the OSHA Permissible Exposure Limit for formaldehyde.</td>
</tr>
</tbody>
</table>

Note: These precautions are for room temperature handling. Use at elevated temperature or aerosol/spray applications may require added precautions.
### 9. PHYSICAL AND CHEMICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Form</td>
<td>Aerosol</td>
</tr>
<tr>
<td>Color</td>
<td>Black</td>
</tr>
<tr>
<td>Odor</td>
<td>Solvent odor</td>
</tr>
<tr>
<td>Specific Gravity @ 25°C</td>
<td>0.74</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Not determined</td>
</tr>
<tr>
<td>Freezing/Melting Point</td>
<td>Not determined</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>Not determined</td>
</tr>
<tr>
<td>Vapor Pressure @ 25°C</td>
<td>Not determined</td>
</tr>
<tr>
<td>Vapor Density</td>
<td>Not determined</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>Not determined</td>
</tr>
<tr>
<td>pH</td>
<td>Not determined</td>
</tr>
<tr>
<td>Volatile Content</td>
<td>Not determined</td>
</tr>
<tr>
<td>Flash Point</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Autoignition Temperature</td>
<td>Not determined</td>
</tr>
<tr>
<td>Flammability Limits in Air</td>
<td>Not determined</td>
</tr>
</tbody>
</table>

Note: The above information is not intended for use in preparing product specifications. Contact Dow Corning before writing specifications.

### 10. STABILITY AND REACTIVITY

- **Chemical Stability**: Stable.
- **Hazardous Polymerization**: Hazardous polymerization will not occur.
- **Conditions to Avoid**: None.
- **Materials to Avoid**: Oxidizing material can cause a reaction.

**Hazardous Decomposition Products**

Thermal breakdown of this product during fire or very high heat conditions may evolve the following decomposition products: Carbon oxides and traces of incompletely burned carbon compounds. Metal oxides. Sulfur oxides. Formaldehyde.

### 11. TOXICOLOGICAL INFORMATION

**Special Hazard Information on Components**

No known applicable information.

### 12. ECOLOGICAL INFORMATION
**Environmental Fate and Distribution**

Complete information is not yet available.

**Environmental Effects**

Complete information is not yet available.

**Fate and Effects in Waste Water Treatment Plants**

Complete information is not yet available.

<table>
<thead>
<tr>
<th>Ecotoxicity Classification Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Parameters (LC50 or EC50)</td>
</tr>
<tr>
<td>Acute Aquatic Toxicity (mg/L)</td>
</tr>
<tr>
<td>Acute Terrestrial Toxicity</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

This table is adapted from "Environmental Toxicology and Risk Assessment", ASTM STP 1179, p.34, 1993.

This table can be used to classify the ecotoxicity of this product when ecotoxicity data is listed above. Please read the other information presented in the section concerning the overall ecological safety of this material.

**13. DISPOSAL CONSIDERATIONS**

**RCRA Hazard Class (40 CFR 261)**

When a decision is made to discard this material, as received, is it classified as a hazardous waste? Yes

Characteristic Waste:
- Ignitable: D001

State or local laws may impose additional regulatory requirements regarding disposal. Call (989) 496-6315, if additional information is required.

**14. TRANSPORT INFORMATION**

**DOT Road Shipment Information (49 CFR 172.101)**

- Proper Shipping Name: Consumer Commodity
- Hazard Class: ORM
- Hazard Label(s): ORM-D (Other Regulated Materials)

**Ocean Shipment (IMDG)**

- Proper Shipping Name: AEROSOLS
- Hazard Class: 2.1
MOLYKOTE(R) G-RAPID PLUS SPRAY

UN/NA Number: UN 1950

Air Shipment (IATA)
Proper Shipping Name: Aerosols, flammable
Hazard Class: 2.1
UN/NA Number: UN 1950
Hazard Label(s): Flammable Gas

Apply Gross Wt Supplemental Label to Outer Package if shipping Limited Quantity

Call Dow Corning Transportation, (989) 496-8577, if additional information is required.

15. REGULATORY INFORMATION


TSCA Status: All chemical substances in this material are included on or exempted from listing on the TSCA Inventory of Chemical Substances.

EPA SARA Title III Chemical Listings

Section 302 Extremely Hazardous Substances (40 CFR 355): None.

Section 304 CERCLA Hazardous Substances (40 CFR 302): None.

Section 311/312 Hazard Class (40 CFR 370):
- Acute: Yes
- Chronic: Yes
- Fire: Yes
- Pressure: Yes
- Reactive: No

Section 313 Toxic Chemicals (40 CFR 372):
- None present or none present in regulated quantities.

Note: Chemicals are listed under the 313 Toxic Chemicals section only if they meet or exceed a reporting threshold.

Supplemental State Compliance Information

California
**Warning:** This product contains the following chemical(s) listed by the State of California under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) as being known to cause cancer, birth defects or other reproductive harm.

None known.

### Massachusetts

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Wt %</th>
<th>Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>106-97-8</td>
<td>30.0 - 60.0</td>
<td>Butane</td>
</tr>
<tr>
<td>1317-33-5</td>
<td>7.0 - 13.0</td>
<td>Molybdenum disulfide</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>5.0 - 10.0</td>
<td>Calcium hydroxide</td>
</tr>
<tr>
<td>74-98-6</td>
<td>5.0 - 10.0</td>
<td>Propane</td>
</tr>
<tr>
<td>7782-42-5</td>
<td>3.0 - 7.0</td>
<td>Graphite</td>
</tr>
</tbody>
</table>

### New Jersey

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Wt %</th>
<th>Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>106-97-8</td>
<td>30.0 - 60.0</td>
<td>Butane</td>
</tr>
<tr>
<td>64742-48-9</td>
<td>15.0 - 40.0</td>
<td>Hydrotreated heavy petroleum naphtha</td>
</tr>
<tr>
<td>8042-47-5</td>
<td>10.0 - 30.0</td>
<td>Mineral oil</td>
</tr>
<tr>
<td>1317-33-5</td>
<td>7.0 - 13.0</td>
<td>Molybdenum disulfide</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>5.0 - 10.0</td>
<td>Calcium hydroxide</td>
</tr>
<tr>
<td>74-98-6</td>
<td>5.0 - 10.0</td>
<td>Propane</td>
</tr>
</tbody>
</table>

### Pennsylvania

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Wt %</th>
<th>Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>106-97-8</td>
<td>30.0 - 60.0</td>
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<td>10.0 - 30.0</td>
<td>Mineral oil</td>
</tr>
</tbody>
</table>
MOLYKOTE(R) G-RAPID PLUS SPRAY

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Range</th>
<th>Chemical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1317-33-5</td>
<td>7.0 - 13.0</td>
<td>Molybdenum disulfide</td>
</tr>
<tr>
<td>1305-62-0</td>
<td>5.0 - 10.0</td>
<td>Calcium hydroxide</td>
</tr>
<tr>
<td>74-98-6</td>
<td>5.0 - 10.0</td>
<td>Propane</td>
</tr>
<tr>
<td>7782-42-5</td>
<td>3.0 - 7.0</td>
<td>Graphite</td>
</tr>
</tbody>
</table>

16. OTHER INFORMATION

These data are offered in good faith as typical values and not as product specifications. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine whether they are appropriate.

(R) indicates Registered Trademark.
GRASA ESPECIAL EP-2/3

Description

A grease formulated with highly refined mineral oil, thickened with lithium soap (hydroxystearate). It has been incorporated with anti-rusting, anti-corrosive, extreme pressure and adherence additives.

Recommended uses

- General greasing of agricultural, public works and automation machinery.
- Greasing of sifter bearings, piston pins, ball sockets, bearings, etc.
- Field of application from –20 to 120°C.

Qualities

- Great adherence, which avoids the seepage of grease.
- Good extreme pressure characteristics, for which it has a good capacity to withstand charges and vibrations.
- Excellent mechanical stability.
- Good protection against oxidation, corrosion and rusting.
- Excellent performance against water.

Quality Level

- DIN 51825 KP-2K

Technical Characteristics

<table>
<thead>
<tr>
<th>UNIT</th>
<th>METHOD</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Visual</td>
<td>Light Brown</td>
</tr>
<tr>
<td>Consistency</td>
<td>NLGI</td>
<td>2/3</td>
</tr>
<tr>
<td>Soap type</td>
<td>Lithium</td>
<td></td>
</tr>
<tr>
<td>Base oil, viscosity grade ISO</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Penetration, 25°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- worked at 60 strokes</td>
<td>1/10 mm</td>
<td>ASTM D 217</td>
</tr>
<tr>
<td>- worked 100,000 strokes</td>
<td>1/10 mm</td>
<td>ASTM D 217</td>
</tr>
<tr>
<td>Dropping point</td>
<td>°C</td>
<td>ASTM D 566</td>
</tr>
<tr>
<td>Cooper corrosion, 24h 100°C</td>
<td></td>
<td>ASTM D 4048</td>
</tr>
<tr>
<td>4 ball machine, 80 Kg, 1 minute, scar diameter</td>
<td>mm</td>
<td>IP 239</td>
</tr>
<tr>
<td>Properties EP 4 ball machine</td>
<td>Kg</td>
<td>ASTM D 2596</td>
</tr>
<tr>
<td>Timken, O.K.</td>
<td>lb</td>
<td>ASTM D 2509</td>
</tr>
</tbody>
</table>

Available in

180 and 45 Kg. drums and 18,5 and 2 Kg. metallic cans.
Hazard Identification

This product is not classified as toxic or hazardous under current legislation.

Handling

Certain minimum precautions to avoid prolonged contact with the skin should be taken when handling. The use of gloves, visors or masks is recommended in order to avoid splashes.

Health and safety hazards

**Inhalation:** Minimum risk of inhalation as it is a non-volatile product.

**Ingestion:** Does not provoke vomiting. Drink water. Seek medical assistance.

**Contact with Skin:** Wash with abundant water and soap.

**Eyes:** Wash with abundant water.

**General measures:** Seek medical assistance.

Fire fighting measures

No special measures are required.

**Fire control:** Foams, dry chemicals, CO2, water spray. Do not apply water jet directly as this may cause the product to spread.

Environmental precautions

Danger of physical contamination in the case of spillage (water flows, coastal areas, the ground, etc.) due to its floating capacity and oily consistency which may cause damage to fauna and flora with which it comes into contact. Avoid its penetration into water containers or outlets.

**Decontamination and cleaning:** Treat as an accidental oil spillage. Avoid spreading by using mechanical barriers and eliminate using both physical and chemical means.

Emergency telephone number. Instituto Nacional de Toxicología 915620420

A safety data file exists.

Unless otherwise specified, the values cited in technical characteristics should be considered as typical.
6. WARRANTIES AND CERTIFICATES

6.1. GENERAL WARRANTY CONDITIONS

CONDITIONS OF THE 5 OR 10 YEAR COMMERCIAL GUARANTEE ON PARTS AND LABOUR OF mecasolar TRACKERS

<table>
<thead>
<tr>
<th>Solar Farm:</th>
<th>Tracker Model:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>Amount of Trackers:</td>
</tr>
<tr>
<td>Town/City:</td>
<td>Serial Numbers:</td>
</tr>
<tr>
<td>Country:</td>
<td>Duration of the Guarantee:</td>
</tr>
<tr>
<td></td>
<td>Activation Date:</td>
</tr>
</tbody>
</table>

1.- Mecanizados Solares, S.L., hereinafter mecasolar grants a FIVE or TEN year guarantee for the above-mentioned solar tracker models with the sale of this equipment, the serial number/s of which are included above (or in the appendix to this document).

In the MS-2 TRACKER 10+ and MS-1E TRACKER 10+ models that are supplied as standard with the inverters, these components will have a FIVE year guarantee.

2.- The activation date, and therefore the start of the guarantee, is the date on which each tracker leaves the mecasolar facilities, regardless of whether it is installed and commissioned in the solar farm at a later date, except for the stipulations in point 7 of this commercial guarantee certificate.

This activation date will coincide with the last day of the month that appears on the delivery note, together with the serial numbers of the trackers subject to this guarantee.

If successive deliveries agreed with the owner or installer were to take place, the guarantee of each of the serial numbers supplied in this delivery will be activated on the last day of the month in which it left the mecasolar facilities.

This guarantee will end FIVE or TEN years after this date (FIVE in the case of the MS-2 TRACKER 10+ and MS-1E TRACKER 10+ inverters).

3.- Replacing any of the tracker’s components during the guarantee period will not give rise to the activation of a new 5 or 10 year period, or to an extension of the initial term, and in any event the guarantee will be understood to cover the equipment as a whole, and not its individual components.

4.- This guarantee covers the labour, parts and travelling expense items, as long as mecasolar carries out the work and/or supplies, or a company that mecasolar expressly delegates and authorises.

5.- This guarantee covers all the components and parts that make up the equipment with the serial numbers listed in this document. Therefore, none of the peripheral or additional equipment that should be connected to the original equipment that mecasolar delivers for the production of energy (e.g. photovoltaic panels, inverters that mecasolar does not supply, etc) is covered by this guarantee.

This guarantee will be considered to have expired when, without mecasolar’s authorisation, changes are made to the original ex works equipment settings sold (e.g., removing, replacing or adding components or elements other than those which mecasolar supplies).

6.- To access this guarantee, it is essential to have accurately fulfilled the operating instructions given in the equipment's technical manual. The guarantee does not cover any cases of poor assembly on the shallow foundation, poor foundation work, incorrect installation of the panels, installation of other inverters by the owner or installer (in the specific case of model MS-2 Y MS-1E TRACKER 10+), faulty network connection (monitoring) or improper handling. mecasolar staff (or staff from the company that mecasolar expressly delegates and authorises) will determine these circumstances, and others that might arise, and they will decide whether to execute the guarantee or not.

7.- mecasolar, due to the causes listed below, will assume the direct material damages caused internally that the guaranteed equipment accidentally, unforeseeably and suddenly suffers during its normal use, when it is in operation and the installation has been registered, after finishing the assembly, and the operating tests and trials. In the same way, damages produced during maintenance or inspection work will be included:

---

www.mecasolar.com
a) Hidden flaws: understood to be the damage produced as a result of manufacturing and construction faults, errors in calculation, material faults, smelting, welding or adjustment errors and, in general, similar inherent causes in the machine's design and manufacturing process.

b) Tearing, understood as the machine's breakage due to centrifugal force.

c) Electrical phenomenon, understood as the direct action of electric energy resulting from a short circuit, spark-over, overvoltage, and other similar effects.

d) Self-combustion, understood as the damages caused by a fire caused internally due to causes inherent in its operation. This coverage is extended to damages produced by smoke, soot and corrosive gases.

e) Standard operation, understood to be the damage caused by greasing faults, loosening of parts and faults in the adjustment devices, except when they are caused by poor preventive maintenance.

8.- **mecasolar** does not guarantee its products in the following situations:

a) Damages or disappearances that are caused by Fires, Explosions, Lightening, Acts of Vandalism and Malicious Acts, Atmospheric Phenomenon, Robbery, Pillaging and Theft, except those indicated in headings c) and d) in the previous chapter.

b) Direct and indirect damage to other assets and/or property, such as work stoppages, failure to comply with contracts, fines, contractual penalties and, in general, any revenue loss, shortfall in earnings or civil responsibility that could occur to the mecasolar trackers, which have no type of compensation whatsoever.

c) Damage covered by the guarantee of mecasolar's suppliers, as well as those for which it is Legally or Contractually responsible. Nonetheless, in the cases where mecasolar deems necessary, it could choose to compensate the owner for these damages, transferring all the rights to mecasolar to carry out as many actions as necessary against its suppliers.

d) The wear and tear of the trackers during operation or gradual wear due to atmospheric conditions or mechanical, chemical or thermal influences.

e) Experiments, trials or tests, during which the tracker is intentionally subjected to higher than normal stresses.

f) Failure to comply with current regulations on safety, failure to comply with mecasolar's specifications included in its technical documentation, or failure to comply with basic inspection and checking work.

g) Losses or damage caused to foundations, fuses and, in general, any object that is quickly worn or removable.

h) The costs incurred in finding or eliminating damages or operating faults, unless they are caused by recoverable damages.

i) In no event, the losses occurred in tracker production during its repair process and until its definitive setting to the owner's satisfaction.

j) If to carry out a repair easily and with guarantees it is necessary to disassemble any of the parts that do not belong to the tracker (e.g., the installed photovoltaic panels) or any other operation, the owner shall meet the costs resulting from this work.

9.- In the event of incidents or damage, the equipment owner expressly undertakes not to carry out any operation on them, without prior express and written consent from mecasolar.

10.- In the event of damage, the parts that mecasolar supplies will be identical or with similar characteristics, according to their availability and delivery time from its suppliers.

11.- mecasolar is obliged to repair the trackers for their use in the same place and for the same purpose for which they were sold to the owner. In the event that it is impossible to repair them with the same or similar components, mecasolar will compensate the owner for the real price of the faulty parts, although deducting the depreciation for their use, age, obsolescence, antiquity and state of repair.

12.- For this guarantee to take effect, it is a sine qua non condition that the equipment owner has a Guarantee Inspection service contracted (which verifies that the owner correctly services the equipment), and pays the corresponding yearly quotas for this service. Otherwise, this guarantee will not take effect and will expire.

13.- The Guarantee Inspection work, and the work that this Commercial Guarantee covers, should be carried out by mecasolar staff or by specialised staff expressly authorised by mecasolar.

14.- The Guarantee Inspection contract will consist of a yearly visit to the solar farm where the trackers are located. mecasolar will visually inspect the trackers with the aforementioned serial numbers, notifying the owner of any elements that might suffer potential damage. This inspection work does not include the repair of damages, parts and labour, except when they are covered under this guarantee.

15.- The yearly cost of this Inspection service required for the guarantee to be in force will be **£50.00 + VAT per year/tracker**, updated once a year according to the CPI (or a similar index that mecasolar decides). This amount will be paid once a year, before carrying out the Guarantee Inspection.

16.- After carrying out the yearly guarantee Inspection, the owner will receive a sheet-report for each of the tracker serial numbers, specifying the main parts and checked elements, and comments and recommendations that mecasolar makes for their efficient operation. In the future, this sheet-report may be replaced by information provided via Internet to each owner.
17.- This Inspection work will be carried out once a year, and should be carried out for the first time twelve months after the activation date of this guarantee, according to chapter 2 of this document.

18.- For any of the elements or parts that is not damaged, but could result in a possible fault, the owner may foresee this and ask mecasolar to replace them. In this case, the owner will meet the cost of the part and labour, upon submission and acceptance of the estimate.

19.- In the event of a change in ownership (sale, inheritance, transfer…) of the trackers to a third party, the initial owner is obliged to notify and inform the purchasing party of the existence of this guarantee, and of all of its conditions and requirements, together with its activation date. In the same way, the previous owner is obliged to notify mecasolar of the details of the individual or corporation that has acquired the equipment, to be able to notify and plan the necessary Guarantee Inspections.

20.- The Owner and mecasolar agree that this guarantee document will be governed by stipulations in Spanish legislation and also expressly waive the jurisdiction that might apply to them to them and agree to refer any lawsuit arising from this guarantee to the courts of Tudela (Navarre).

Signed:

General Manager

Date:
6.2. CERTIFICATE

6.2.1 EC MARKING

CE Compliance Statement

According to Annex II-A of Guideline 98/37/CE

MECANIZADOS SOLARES, S.L
Polígono Las Labradas – Vial País Vasco nº 13
31500 TUDELA (Navarra) Spain
Tel: +34.948.821.903
Fax. +34.948.820.547
Mail:
Website: www.mecasolar.com

States under its sole liability that the machine

**Brand Name:** MECASOLAR
**Name:** MS-2E TRACKER 10+ Solar Tracker
**Manufacturing Date:** 2009

described in the attached documentation, see Instruction Manual, complies with:


The following harmonized standards have been used for the design of the machine:


**Tudela, November 20, 2009**

Signed: __________________________
6.2.2 QUALITY CERTIFICATES

Certificate nº ES07/3650

The management system of

MECANIZADOS SOLARES, S.L.

Pol. Ind. Santos Justo y Pastor, s/n
31510 Fustiñana (Navarra)

has been assessed and certified as meeting the requirements of

ISO 9001:2000

For the following activities

Designing and Manufacturing of direction support for solar panels (tracking systems).

This certificate is valid from 7 April 2009 until 9 April 2010.
Issue 2. Certified with SGS since April 2007.

Authorized by

J. Moya
Certification Manager

SGS Iberica, S.A., Systems & Services Certification
C/Traspaderos, 29, 28942 Madrid, Spain.
T. 34 91 313 8115 F 34 91 313 8112 www.sgs.com

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Further clarifications regarding the scope of the certificate and the applicability of ISO 9001:2000 requirements may be obtained by consulting the Organization.
Certificate nº ES096779

The management system of

MECANIZADOS SOLARES, S.L.

Pol. Ind. Santos Justo y Pastor, s/n
31510 Fustiñana (Navarra)

has been assessed and certified as meeting the requirements of

ISO 14001:2004

For the following activities:

Designing and Manufacturing of direction support for solar panels (tracking systems).

This certificate is valid from
Issue 1.

Authorized by

J. Moya
Certification Manager

SGS ICS Ibérica, S.A. - Systems & Services Certification
C/Tresguerras, 25, 28042 Madrid, España.
+34 91 310 0110 / +34 91 314 1102  www.sgs.com

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6.2.3 GALVANISING

GALVAEBRO, S.L.
Mecanizados sólidos a galvanización para el sector de la industria de energías renovables.

MATERIAL: 12 PHOTOVOLTAIC GRID SUPPORTS

ACCORDING TO REGULATIONS: UNE-EN 1179/96 / UNE-EN ISO 1461-99

DATE OF MEASUREMENT: 10 Nov. 2008

AVERAGE PICKLING TIME: 120 MINUTES

HYDROCHLORIC ACID CONCENTRATION: FROM 80 TO 100 g/LITRE

BATCH OF ZINC ADDED TO THE KETTLE: BATCH 2N 000243

GALVANIZING TEMPERATURE: 450°C (VALID FOR THERMOMETER CALIBRATION)

AVERAGE THICKNESS OF COAT: 115 µ • 82,1 g/m²

MEASUREMENT OF THICKNESS: (ACCORDING TO METOD UNE-EN ISO 1461/99) MAGNETIC METHOD –
(LUMINOMETER 45° – CALIBRATION OF CONTRAST PATTERNS – VALID TECHNICAL ENAC CALIBRATION)

ADHESION: GOOD (METOD UNE-EN ISO 1461/99)

APPEARANCE: SHINY GRAY

OBSERVATIONS: ALL MATERIALS ARE IN GOOD CONDITION.

PRE-TREATMENT OF MATERIALS:

PICKLING:

GALVANIZED:

Signed by: [Signature]

Miranda de Ebro, 10 de Noviembre de 2008

Quality Department

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7. DRAWINGS AND DIAGRAMS

7.1. GENERAL MATERIAL GROUP
7.1.1 GENERAL ASSEMBLY AND FOUNDATION
7.1.2 FOUNDATION PLANT
7.1.3 FOUNDATION VERTICAL SECTION
Anchor bolts: A-42B galvanized

MATERIALS, SECURITY COEFFICIENTS

<table>
<thead>
<tr>
<th>Material</th>
<th>Security Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>HA25/F/25/Lbs</td>
</tr>
<tr>
<td>Steel</td>
<td>8500 N/mm²</td>
</tr>
<tr>
<td>Nominal covering</td>
<td>35 mm</td>
</tr>
<tr>
<td>Concrete reduction safety factor</td>
<td>1.50</td>
</tr>
<tr>
<td>Steel reduction safety factor</td>
<td>1.15</td>
</tr>
<tr>
<td>Partial safety factors for loads</td>
<td>1.50</td>
</tr>
<tr>
<td>Execution control level</td>
<td>Normal</td>
</tr>
</tbody>
</table>

20 units

E: 1/10
7.1.4 MOULD GROUP
7.1.5 MOULD – BRIDGE
7.1.6 MOULD
7.2. INTER-DISTANCES
EJEMPLO / EXAMPLE
SEGUIDOR CON INVERSOR MONOFÁSICO SMC11000TL Y 56 MODULOS TRINA 220
TRACKER WITH SINGLE PHASE INVERTER SMC11000TL AND 56 TRINA 220 MODULES

Cuadro Protecciones Corriente Continua (C.C.)
Fuse box, DC Protections

SMA INVERTER
SMC 11000 TL

Proyecto/Project:
TRACKER MECASOLAR 06/09
MÓDULOS E INVERSORES / MODULES & INVERTERS

Fecha/Date: 07/10/2009
Nombre/Name: J. MARIANNI

Fecha/Date: 07/10/2009
Nombre/Name: J. MARIANNI

Fecha/Date: 13/10/2009
Nombre/Name: F. ENRIGUE

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EJEMPLO / EXAMPLE:
SEGUIDOR CON 3 INVERSORES MONOFASICO SB3000 Y 48 MODULOS REC 220
TRACKER WITH 3 SINGLE PHASE INVERTERS SB3000 AND 48 REC 220 MODULES

Cuadro Protecciones Corriente Continua (C.C.)
Fuse box, DC Protections

SMA INVERTER
SB 3300

SMA INVERTER
SB 3300

SMA INVERTER
SB 3300

Módulos e Inversores / Modules & Inverters

Plano N°: Dwg No: 06/06