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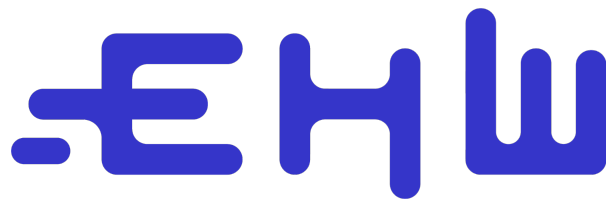
# Scrutineering Checklists

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European Hyperloop Week

Tech Committee

December 22, 2023



EUROPEAN  
HYPERLOOP  
WEEK

## Changelog

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- 1.0 - First released version. Includes all inspection points during the scrutineering processes. Will be updated in 2024 with more specific information.
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December 22, 2023, the EHW Committee

## Foreword

Dear Participants,  
this document intends to give further insights into the Scrutineering processes during the EHW in July. Even though it is still subject to changes, it gives a good representation of what can be expected from the Scrutineering process. More details on logistics will be provided later in the year.

In previous editions, teams used to test their demonstrators upon arrival at the EHW location, and since these demonstrators had not been scrutinized yet, it led to unsafe situations. For this reason, this year, it will not be allowed to test the systems (or subsystems) at the EHW location until these have been scrutinized. The teams will be allowed to start scrutineering approximately one week before the EHW week. This will give time for teams to debug their demonstrators, or test them in case damage has occurred during transport.

The following scrutineering stages are proposed:

- [Mechanical Inspection](#)
- [Magnets Inspection](#)
- [Battery and Low-Voltage Inspection](#)
- [Software & Sensors Inspection](#)
- [Power Electronics Inspection](#)
- [Demonstration Test.](#)

A team applying for a complete system must complete all these stages successfully in order to demonstrate their prototype. Teams applying for promising subsystem awards will only need to complete the stages that apply to them; these will be roughly indicated by the EHW technical committee in the ITD feedback session in January. Due to the nature of the competition and the variety of proposals, the specific points for each team are subject to change depending on what teams intend to bring to the competition. Bear in mind that not all the inspection points contained in this document are contained in the R&R. These come from what the EHW Committee believes is necessary in order to have a safe prototype and ensure a successful demonstration. We therefore encourage teams to think themselves what potential risks their systems pose, and how they can mitigate them. Even if a system complies with all the inspection points in these lists, if it is not considered safe, it will not be allowed to demonstrate.

In addition, the possibility to perform a vacuum test is provided by the EHW. You can find more details in the R&R and in [section 7](#).

Best of regards and good luck!

The EHW Technical Team

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# 1 Pre-Scrutineering

**Aims:** Before the first scrutineering phase, the safety equipment of the team will be inspected.

Team	
Verdict	Pass Fail

Prior to the start of the inspections, there will be a safety briefing aimed at guaranteeing the safety of all individuals involved. During the competition, all team members must respect the following when working with the prototype:

- No jewelry, no rings
- No cell phone
- No badge / no necklace
- No sources of distraction

Once the safety briefing is done, the following will be checked:

- Safety shoes
  - Safety/steel-toed boots
  - Rated dielectric footwear
- Do people around heavy items or high voltages wear the appropriate footwear?
- Safety glasses (minimum of three (3)): Do safety glasses have side shields?
- Fire extinguisher: Two (2) certified and up-to-date 1st class powder fire extinguishers.
- Do people working on high voltage wear suitable footwear?
  - Safety/steel-toed boots
  - Rated dielectric footwear
- Do people working on high voltage have suitable equipment?
  - Insulating gloves (minimum of two (2) pairs) rated for the maximum expected voltages.
  - Basic set of insulated tools
- Helmets.
- Reflective equipment (like vests).
- Datasheets of critical components such as contactors or pneumatic valves must be prepared in digital or physical format (will be checked on the respective scrutineering stages).

## 2 Mechanical Inspection

**Aim:** Check if the mechanical side of the system adheres to the Rules and Regulations and is safe to operate.

Team	
Verdict	Pass Fail

During this inspection, the definition of assembly points and exit paths in the case of an emergency will be checked. Furthermore, the team must perform the proposed procedures [Filling of pneumatic system](#) and [Emptying of pneumatic system](#) if applicable.

### 2.1 Inspection Checklist

The points checked during the scrutineering stage are contained in the following table. The team must fulfill all points that apply to their demonstrator to be considered passed in the stage.

General		
MEC.1	The prototype bears a resemblance to the proposed FDD concept.	
MEC.2	Enough space to place the scrutineering sticker in a visible spot.	
MEC.3	The safety factor of all the structural elements in the worst-case scenario is higher than 2 (Contrasted with FDD).	
MEC.4	There are no sharp edges.	
MEC.5	There are no loose parts (all parts are correctly fastened).	
MEC.6	The quality of the welds is sufficient.	
MEC.7	The bolts are secured tight to the required pretension.	
MEC.8	Nuts are prevented from coming loose by either using positive locking mechanisms or (nylon) lock nuts.	
MEC.9	A minimum of two full threads must project from any lock nut.	
MEC.10	All lock nuts are marked ( <a href="#">Figure 1</a> ).	
MEC.11	There are no significant changes between CAD models and manufactured parts.	
MEC.12	Manufactured processes are coherent with documents provided.	
Comments:		
Thermal Management		
MEC.13	There is a system in place to prevent components from overheating. If not, the team must have implemented measures to prevent this or be able to explain why it can not happen.	



MEC.14	(If applicable) Visual check of the system.	
MEC.15	(If applicable) The system does not leak.	
MEC.16	(If applicable) The system is watertight.	
MEC.17	(If applicable) The system is vacuum-proof.	
MEC.18	(If applicable) All parts are rated for the working pressures.	
MEC.19	(If applicable) Data sheets for cooling fluid or provided.	
MEC.20	(If applicable) If the cooling fluid can be harmful to people or the environment, proper procedures must be implemented to reduce risks of damage.	

### Comments:

#### Pneumatic/Hydraulic System

MEC.21	(If applicable) Visual check of the system.	
MEC.22	(If applicable) Pneumatic/Hydraulic system is drawn with accompanying specifications.	
MEC.23	(If applicable) Vessels and enclosures are marked with a certification name-plate with all the certified maximum allowable pressure (MAWP) ratings being provided (At least most critical components like pressurized tanks).	
MEC.24	(If applicable) The operation conditions of team-made pressurize systems must meet the design ratings with a safety factor higher than 2.	
MEC.25	(If applicable) In case of power or connection loss, the system can be vented (vents are present).	

### Comments:

#### Braking System

MEC.26	In a neutral, not powered state, the emergency brakes apply the required braking force for an emergency stop at full speed.	
MEC.27	The team can explain how braking forces are applied in a symmetrical way on the track.	
MEC.28	The team can explain how, in case of power loss, the state of the pressurized system is safe.	
MEC.29	The team can explain how, in case of connection loss, the state of the pressurized system is safe.	
MEC.30	The actuator movement doesn't affect any surrounding system.	
MEC.31	(Electromagnetic braking) Generated/Recuperated energy is handled properly.	

### Comments:

#### Wheels

MEC.32	The wheels are in good condition (not damaged).	
MEC.33	The axles of the wheels are in good condition.	

MEC.34	The hardness of the wheels' material is lower than the track's.	
MEC.35	If there are springs or dampers, they are in good condition and safely attached.	
MEC.36	The wheels do not bend in undesired axes.	
MEC.37	Rotational symmetry is met (the wheels are balanced).	
MEC.38	Bearings and wheel contact surfaces withstand the rotational speeds, as well as frictional head loads and deformations.	
<b>Comments:</b>		
<b>Custom Track</b>		
MEC.39	The length of the track is within the specified dimensions.	
MEC.40	The track is well aligned. (The team must justify the tolerance used.)	
MEC.41	There is a buffer stop at both ends of the track.	
MEC.42	It is not possible for the pod to leave the track when the buffer end stop is attached.	
MEC.43	The track is well anchored to the ground - Can withstand strong weather conditions, won't be able to move during a run...	
MEC.44	The stability of the infrastructure is great enough to avoid rollover in the worst-case scenario.	
MEC.45	Safe/danger are zones well-defined and marked (with, for example, tape on the ground). Safety perimeter and assembly points are well-defined.	
MEC.46	(If applicable) The path to get out of the tent safely in case of an emergency is cleared and well-defined.	
MEC.47	The custom track is provided with sufficient electrical grounding, to prevent harm or injury to people.	
MEC.48	If the track contains electrical components, no hazardous components shall be exposed.	
<b>If the custom track includes a tube-like structure</b>		
MEC.49	The track is not made of flammable materials.	
MEC.50	The team can explain the extinguishing plan in case of a fire inside the tube.	
<b>Comments:</b>		

The following procedures must be performed after the inspection in front of the scrutineers to ensure every step is performed safely.

## 2.2 Procedure: Filling and emptying of pneumatic system

- Does everyone stay in the safe designated zones at all times?
- Are there high risks taken while performing the procedure?

- Is the system leak-tight?

### 3 Magnets Inspection

**Aims:** Check the adherence of the permanent and electromagnets to the Rules and Regulations, their safety, and overall quality.

Team	
Verdict	Pass Fail

This scrutineering inspection is necessary for those teams that use permanent or electromagnets. Upon arrival at the EHW location, the permanent magnets of the prototype must be covered at all times until the inspection takes place. This means, that the magnets must either be:

- A. Mounted on the pod, and at all times have their magnet cover box on.
- B. Stored in a transport crate box which satisfies a  $1\text{ mT}$  requirement on its surface. In this case, the team must perform the proposed procedures [Mounting of magnets](#) and [Dismounting of magnets](#) respectively).

After inspection, whenever the permanent magnets are mounted on the demonstrator and are not being used, they must be covered with their respective magnet cover box.

#### 3.1 Inspection Checklist

The points checked during the scrutineering stage are contained in the following table. The team must fulfill all points that apply to their demonstrator to be considered passed in the stage.

General		
MAG.1	The demonstrator bears a resemblance to the proposed FDD concept.	
Magnetic Cover		
MAG.2	The permanent magnets are sufficiently covered.	
MAG.3	The magnetic flux density does not exceed $1\text{ mT}$ anywhere on the surface of the cover or storage box of any permanent magnet.	
MAG.4	There are warning stickers on the outside of the magnet cover that indicate a magnet danger.	
Permanent Magnets		
MAG.5	The permanent magnets do not present (visible) damage to them.	
MAG.6	The magnetic flux density does not exceed $0.5\text{ mT}$ at a distance of one meter or more from the pod's outer perimeter.	
MAG.7	The team can explain if the magnets are at risk of demagnetizing, and if any actions have been taken to reduce this risk.	

MAG.8	If applicable, the team can explain how the permanent magnet will not hit the track at any point in time	
<b>Electromagnets</b>		
MAG.9	The team can explain how the coils have been wound. The coils have been wound in an orderly manner.	
MAG.10	There is no solder present in the high current path	
MAG.11	The coils are isolated from the chassis, and have sufficient clearance with any other conductive surface (at least twice the arcing distance)	
MAG.12	The coils are prevented from moving.	
MAG.13	If applicable, the team can explain how the electromagnet will not hit the track at any point in time	
MAG.14	The team can explain how the electromagnet is kept from reaching extreme temperatures (could be limited on time of use, a cooling system, etc.).	
<b>Comments:</b>		

In case the team plans to mount or dismount the permanent magnets from their prototype, the following procedures must be performed after the inspection in front of the scrutineers to ensure every step is performed safely.

## 3.2 Procedure: Mounting and dismounting of magnets

Great attention will be put to safety aspects related to magnets.

- Are the people involved in the procedure magnet safe? (no phone, chains, watches...)
- Are the people involved in the procedure wearing the respective PPE?
- Is the area clean of loose tools, bolts, nuts, or other elements that can snap onto the magnet?
- Is the magnet being carried safely?
- Is there a clear path from the magnet storage box to the demonstrator?

## 4 Battery and Low-Voltage Inspection

**Aims:** Check the adherence of the batteries and the low voltage systems to the Rules and Regulations, their safety, and overall quality.

Team	
Verdict	Pass Fail

This scrutineering inspection is necessary for those teams that use batteries or electronics of any kind. In this inspection, both the low and high-voltage batteries will be inspected, as well as the low-voltage installation. Upon arrival at the EHW location, the team is not allowed to test with their batteries until this inspection is passed. This means, the batteries must be safely stored and discharged.

After inspection, the team can test their low-voltage systems using their batteries. However, the use of high voltage is prohibited until the prototype has passed both the [Sense & Control Inspection](#) and the [Power Electronics Inspection](#).

Furthermore, the team must perform the proposed procedures [Mounting & dismounting of LV Battery](#), [Charging of LV Battery](#), and [Charging of HV Battery](#) if applicable.

**Note:** The inspection of the high-voltage battery at this stage will allow teams to start testing their high-voltage battery management systems at this point.

### 4.1 Inspection Checklist

The points checked during the scrutineering stage are contained in the following table. The team must fulfill all points that apply to their demonstrator to be considered passed in the stage.

Low Voltage Battery		
BAT.1	The maximum rated voltage of the low voltage battery is under 50 V.	
BAT.2	The battery possesses a battery management system.	
BAT.3	The positive and negative terminals of the battery can be easily identified.	
BAT.4	There is a mechanism to avoid wrongly plugging the positive and negative terminals.	
Custom Battery		
BAT.5	The team can explain how the battery has been produced.	
BAT.6	The batteries have been produced in a safe way.	
BAT.7	The positive and negative terminals of wires are prevented from shorting.	
BAT.8	The wires are connected properly (will not come loose during a run).	

<b>Comments:</b>		
<b>High Voltage Battery</b>		
BAT.9	The battery possesses a battery management system.	
BAT.10	The positive and negative terminals of the battery can be easily identified.	
BAT.11	There is a mechanism to avoid wrongly plugging the positive and negative terminals.	
<b>Custom Battery</b>		
BAT.12	The team can explain how the battery has been produced.	
BAT.13	The batteries have been produced in a safe way.	
BAT.14	The positive and negative terminals of wires are prevented from shorting.	
BAT.15	The wires are connected properly (will not come loose during a run).	
<b>Comments:</b>		
<b>Low Voltage Installation / Wiring</b>		
BAT.16	There are no loose connectors on the sensor and communication networks.	
BAT.17	There are clear identifiers of where each wire is connected (tags or color code)	
BAT.18	All low voltage wires can withstand the weight of the battery by themselves.	
BAT.19	All boards are anchored to the vehicle with no mechanical stress.	
BAT.20	The anchoring for the boards is not conductive (nylon screws or similar).	
<b>Comments:</b>		

The following procedures must be performed after the inspection in front of the scrutineers to ensure every step is performed safely.

## 4.2 Procedure: Mounting & dismounting of LV Battery

This procedure is necessary since the low-voltage battery must be mounted and anchored to the vehicle in the intended way during the final demonstration. Then, it must be dismantled and put in the team's charging station.

Great attention will be put to the placement of the charging station, such as:

- Is the battery state visible at all times by a responsible?
- Is the battery charging zone delimited?
- Is the battery charging zone far enough from the rest of the working zones (mounting of the track, power electronics testing)?
- In case of electric fire, is the material needed such as protective gloves and fire extinguisher available for the responsible?

## 5 Software & Sensors Inspection

**Aims:** Check the adherence of software and sensors to the Rules and Regulations, its safety, as well as its overall quality.

Team	
Verdict	Pass Fail

This inspection intends to check that the sense and control subsystem contains all safety implementations before any high-voltage systems are used. In addition to inspection points, the team must perform the proposed procedures [Power On](#), [State Machine Transitions](#), and [Power Off](#) if applicable.

### 5.1 Inspection Checklist

The points checked during the scrutineering stage are contained in the following table. The team must fulfill all points that apply to their demonstrator to be considered passed in the stage.

General		
SC.1	The demonstrator bears resemblance with the proposed FDD concept.	
GUI		
SC.2	Safe range for monitored variables is clearly indicated.	
SC.3	The demonstrator can break using a physical button of the Control Station.	
SC.4	GUI monitors the speed of the demonstrator.	
SC.5	GUI does not display outdated values.	
SC.6	Stop command is implemented on the GUI.	
SC.7	Person monitoring the speed of the demonstrator has quick access to the emergency breaks.	
SC.8	Demonstrator's health must be visible to an external viewer using colored visual indicators.	
SC.9	Test cut off battery command and verify correct result.	
SC.10	Test emergency command and verify correct result.	
SC.11	All safe actuations must be tested (brakes, contactors, relays, valves)	
Comments:		
Low Voltage Battery		
SC.12	The GUI logs individual cell voltage of 100% of low voltage Cells.	
SC.13	The GUI logs data of at least 25% of cell temperatures.	



SC.14	The GUI logs SOC of the low voltage battery.	
SC.15	The GUI logs individual cell voltage of 100% of low voltage Cells.	
<b>Comments:</b>		
<b>Sensors</b>		
SC.16	The demonstrator enters Fault State after sensor disconnection	
SC.17	The demonstrator enters Fault State after reading out-of-range values (provoke them by manipulating movement sensors. If not possible, the team is responsible for manually triggering the protection system with code.)	
<b>Comments:</b>		
<b>State Machine Transitions</b>		
SC.18	The demonstrator breaks after entering Fault State	
SC.19	The demonstrator opens relays after entering Fault State	
SC.20	The demonstrator enters in Fault State after a disconnection.	
SC.21	The demonstrator logs data in Fault State.	
SC.22	The demonstrator can be restarted from Fault State.	
<b>Comments:</b>		

The following procedures must be performed after the inspection in front of the scrutineers to ensure every step is performed safely.

## 5.2 Procedure: Power On & Off

The control systems of the demonstrator must be powered on in the intended way during the demonstration. The jury may then require additional validation of the state machine to ensure the safety of the vehicle. Finally, the control systems of the demonstrator must be powered off in the intended way during the demonstration.

Great attention will be put to the placement of the control switch, such as:

- Is the switch accessible for an operator in case of an emergency?
- Is the switch protected from accidental collisions that may turn the vehicle off?

## 6 Power Electronics Inspection

**Aims:** Check if the mechanical side of the system adheres to the Rules and Regulations and is safe.

Team	
Verdict	Pass Fail

Only after this inspection will the teams be allowed to operate high voltage on the EHW location. Furthermore, the team must perform the proposed procedures [Mounting of HV Battery](#), [Power On, State Machine Transitions](#), [Power Off](#), and [Dismounting of HV Battery](#) if applicable.

### 6.1 Inspection Checklist

The points checked during the scrutineering stage are contained in the following table. The team must fulfill all points that apply to their demonstrator to be considered passed in the stage.

General		
PE.1	People working on high voltage wear insulating gloves (rated, used along with leather/cloth linings for shock protection).	
PE.2	Insulated tools of the correct rating are used when working with high voltage.	
PE.3	High voltage and low voltage wires are separated from each other.	
PE.4	HV wires are well recognizable from the outside (they are coloured orange).	
PE.5	The HV wires have the correct Voltage and Power ratings.	
PE.6	All HV isolation distances are appropriate to the Voltage levels used (+buffer) (for Vacuum if applicable)	
PE.7	The HV connections have good insulation.	
PE.8	If there are HV connections with screws, they tightened to the correct level.	
PE.9	There are visual indications (LEDs) signaling the presence of high voltage outside the battery.	
Comments:		
Manual Insulation Disconnects (MIDs)		
PE.10	The MID isolates at least one pole of the battery pack when removed.	
PE.11	The MID is placed on the high voltage line and independent of the low voltage electronics.	
PE.12	The MID is removable without any tools.	

PE.13	The MID is accessible if the pod/subsystem is stuck.	
PE.14	The MID is attached through positive locking mechanisms preventing disconnection through external forces.	
PE.15	There are no conducting surfaces on the MID apart from the electrical connection.	
PE.16	The MID can disrupt short currents.	
PE.17	Is there a mechanism to stop short-currents (eg. fuse) and is it rated correctly?	
PE.18	Is the insulation of all HV cables physically intact?	

**Comments:****Insulation Monitoring Device (IMD)**

PE.19	Each high-voltage pack features a separate Insulation Monitoring Device, monitoring high-to-chassis and low-to-chassis insulation.	
PE.20	There are visual indications (LEDs) signaling proper insulation.	

**Comments:****Power Electronics**

PE.21	If there are high capacitive loads connected, there is a proper precharge circuit with related precharge time.	
PE.22	If the propulsion system regenerates energy into the batteries, this energy is properly treated.	
PE.23	If the guiding system regenerates energy into the batteries, this energy is properly treated.	
PE.24	If the braking system regenerates energy into the batteries, this energy is properly treated.	

**Comments:**

The following procedures must be performed after the inspection in front of the scrutineers to ensure every step is performed safely.

## 6.2 Procedure: Mounting & dismounting of HV Battery

The high voltage battery must be mounted and anchored to the vehicle in the intended way during the final demonstration.

Then it must be dismounted and put in the teams charging station. Great attention will be put to the placement of the charging station, such as:

- Is the battery state visible at all times by a responsible?
- Is the battery charging zone delimited?
- Is the battery charging zone far enough from the rest of the working zones (mounting of the track, power electronics testing)?

- In case of electric fire, is the material needed such as protective gloves and fire extinguisher available for the responsible?

## 7 Vacuum Test

**Aims:** Check if the demonstrator can operate under a low pressure environment.

Team	
Verdict	Pass Fail

In this section, the term 'vacuum' is frequently employed, indicating a condition of reduced pressure.

The capability of the system to withstand a vacuum is an important aspect of a hyperloop system. If the team's demonstration does not include a vacuum, but they would like to prove vacuum compatibility, the possibility of performing a vacuum test is offered. It is not compulsory to undergo such a test and only those teams that have accounted for vacuum conditions in their design will be allowed to participate in this stage. In addition, the team must have successfully passed all previous inspections. Failure to pass this stage will award 0 points in the vacuum section of the respective application, independent of the FDD or any previous video shown in the POD.

There are several aspects to take into account when operating a system in a vacuum, both for the system's health as well as the vacuum chamber's. It is therefore important that the team can show that the components of the vehicle can withstand a vacuum. This can be done in several ways, which include:

- Providing a video proof of individual subsystems being tested under vacuum conditions.
- Providing data sheets of components (especially electrical components, which may contain gas trapped inside and may explode under low-pressure environments).
- Showing the appropriate calculations done to ensure a proper operation under vacuum and their respective implementation (for example, calculating the arcing distance, and then showing the actual distance of the components).

To find more information regarding the tube itself and other specifications, please consult [EuroTube](#). A description of what the team would like to test inside the chamber shall be provided in the FDD and detailed in the SPD.

Pre-Vacuum Check		
VAC.1	The team shows proof that their electrical components on PCBs must be rated for vacuum <sup>1</sup> or must have been tested under such conditions.	
Vacuum check		
VAC.2	Does the vehicle structure withstand the low-pressure environment?	

<sup>1</sup>Pay special attention to components like relays that may contain gas inside which may explode under vacuum

VAC.3	Is the temperature reading coherent? Are temperatures within acceptable operating values?	
VAC.4	Is there accurate logging of vehicle data and events?	
Custom track		
VAC.5	Is the track properly sealed?	
VAC.6	Is there a proper vacuum procedure? In case of leaks, is there any remedy?	
Comments:		

## 8 Demonstration Test

**Aims:** Check if the demonstrator adheres to the Rules and Regulations and is safe to be operated during Demonstration Day.

Team		
Verdict	Pass	Fail

This test is the final test before the demonstration on Saturday the 20th of July. All systems must pass this test to be able to demonstrate. To participate in this stage, all the (applicable) previous stages must have been passed. This test will be performed at the track (or respective test bench area) where the team will perform in the same way that they will on Saturday (Demonstration Day). Once this test has been passed, it is not possible to make any changes to the vehicle. Otherwise, this stage will have to be approved again.

To start this test, the system will be in a ready-to-start state, with magnets, and batteries already mounted with all respective procedures performed. This test will start by turning on the low voltage on the system and performing the procedures necessary to perform the demonstrations. The jury will look especially at safety during the run and the procedures around it. Apart from this, some other things will be inspected, including:

General		
DEM.1	(If a system uses high voltage) Visual indications (e.g., LEDs) are placed, signaling proper insulation (IMD).	
DEM.2	(If a system uses high voltage) Visual indications (e.g., LEDs) are placed, signaling the presence of high voltage on the connectors (i.e., relays closed).	
Comments:		

## A Additional information



**Figure 1:** If the nuts are marked in this way with, for example, a white permanent marker, it will be clear if any have slipped. This is a quick and easy way to inspect your prototype before and after a test.