
Competition Outline & Infrastructure Specifications

European Hyperloop Week 2025

Technical Committee

October 11, 2024



EUROPEAN
HYPERLOOP
WEEK

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October 11, 2024, the EHW Committee

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1 Introduction

With the next edition of the European Hyperloop Week being at the European Hyperloop Center several new opportunities exist for teams to demonstrate their ability to develop hyperloop technology.

This document serves as an overview of the current thoughts with regards to the competition set-up and demonstration possibilities for the teams such that they can incorporate adequate information in their internal decision-making process.

If any teams have any questions, or ideas or require additional information we highly recommend them to contact Hardt and the EHW organization through: marinus@hardt.global and info@hyperloopweek.com. Please include the following as the email subject: "Query EHC Infrastructure Possibilities".

The document starts with an outline of the demonstration possibilities (and technologies) that are possible for teams to work with. After this more detailed information regarding the European Hyperloop Center infrastructure is shared.

We wish you the best of luck in your preparations and look forward to seeing your innovations come to life during the European Hyperloop Week 2025.

2 Demonstration Possibilities

This section provides teams with an overview of demonstration possibilities (incl. technologies within the EHC) for the competition.

2.1 General Possibilities and Limitations

In general, two main options are available for teams:

1. Demonstrations within the European Hyperloop Center, considering:
 - (a) Operations will be limited to the straight section, first 100-110 meters.
 - (b) Likely no speed limit, but a requirement on maximum braking distance.
 - (c) Vacuum operations (static and/or dynamic) only if time permits.
 - (d) Separate structure of tracks (6-meter length) available on-site for teams to test on prior to demonstrations within EHC.
2. Demonstrations within self-brought infrastructure, considering:
 - (a) Limited to 50 meters in length (or less depending on available space and number of tracks).
 - (b) In accordance with to be released updated rules and regulations but will likely not limit teams with respect to previous years (goal is to guarantee safety).
 - (c) Placement only outside European Hyperloop Center.

It is currently not planned to provide an I-beam track based on the previous SpaceX competitions for the teams, however teams would be allowed to bring it as their self-brought infrastructure.

2.2 European Hyperloop Center Possibilities and Limitations

The overview below aims to summarize the possibilities and limitations for demonstrating within the European Hyperloop Center infrastructure. Detailed information about the infrastructure can be found in the "EHC Specifications" section below.

Function / Aspect	Technical Options	Limitations	Remarks
Levitation / Vertical Support	EMS-based magnetic levitation through laminated electrical steel tracks.	Contact with levitation tracks should be prevented, but possible with limited impact force.	Levitation tracks can have up to 85 mm gaps to accommodate for thermal expansion in the infrastructure.

Function / Aspect	Technical Options	Limitations	Remarks
	Alternatively, Wheel-based / sliding-based suspension through "safety track".	Contact with "safety track" is allowed, with limited impact force.	"Safety track" offers continuous support.
Guidance / Lateral Support	EMS-based magnetic guiding through laminated electrical steel tracks.	Contact with guidance tracks should be prevented, but possible with limited impact force.	Guidance tracks can have up to 85 mm gaps to accommodate for thermal expansion in the infrastructure.
	Alternatively, Wheel-based / sliding-based suspension through "safety track".	Contact with "safety track" is allowed, with limited impact force.	"safety track" offers continuous support.
Propulsion	Linear Reluctance Motor System through track compromising individual laminated steel track blocks.	Contact with propulsion tracks is allowed at top and bottom, with limited impact force.	Propulsion tracks can have up to 85 mm gaps to accommodate for thermal expansion in the infrastructure.
	Alternatively, it is being considered to add an aluminum profile to the top-center of the infrastructure to allow the possibility of teams using a Linear Induction Motor.		
	Alternatively, various surfaces of the "safety track" can be used with wheel-based propulsion systems.		

Function / Aspect	Technical Options	Limitations	Remarks
(Emergency) Braking	EDS-based braking is possible through the stainless steel "safety track". Alternatively, the "safety track" allows for mechanical contact with friction pads through multiple surfaces and offers continuous support.	There are limited forces allowed on the "safety track" but it is suspected these are higher than what teams would require (see detailed specifications).	
Vacuum	Depending on the interest from teams, EHC infrastructure can be used to demonstrate vacuum compatibility.	Due to the size of the infrastructure, assuming no modifications are made to the number of pumps and/or size of the facility pump down times would roughly be as follows: • To 600 mbar: 1 hour • To 300 mbar: 2 hour and 45 min • To 100 mbar: 5 hour and 30 min • To 50 mbar: 7 hours • To 10 mbar: 9 hours and 30 min • To 1 mbar: 12-15 hours	

We understand that developing a vehicle for the European Hyperloop Center infrastructure seems complicated, but we believe that for teams already familiar with EMS suspension it is feasible to achieve in one year. The infrastructure also provides the option to focus on single sub-systems, for example only doing levitation and guidance, or only developing a propulsion system and using wheels to drive on the safety track. Additionally, it should be possible to create low-cost testing rigs that teams can use to test their vehicle combined with a lot of testing time during the EHW 2025 to increase the chance teams can demonstrate at the event.

3 EHC Specifications

This section intends to provide the information relevant for technical compliance of any hyperloop testing vehicle with the facility on a mechanical front. The information in this section is organized in the following manner

- Overview of the Infrastructure
- Detailed design of each track type
- Definition of vehicle / keep-out zones
- Track-to-track transitions
- Maximum allowed (impact) loads per track

3.1 Infrastructure Overview

Each pipe contains attachments that support four sets of tracks, whose positioning is specified in Figures 1, 2, and 3. From top to bottom:

- **Blue, "Levitation Tracks"**: a set of plain rectangular tracks, made of electrical steel (M470-50A) and measuring roughly 1 meter per segment.
- **Red, "Propulsion Tracks"**: a set of tracks, each consisting of a row of magnetically separated, electrical steel blocks, which each measure 17 cm in length. A layer of HMPE sits against either side of these rows of blocks.
- **Green, "Guidance Tracks"**: another set of plain rectangular tracks, made of electrical steel and measuring roughly 1 meter per segment.
- **Orange, "Safety Tracks"**: set of tracks consisting of a weldment of two plates and a hollow section, all made of stainless steel 304L (1.4307). Additionally, a 25 mm thick layer of HMPE sits on the top face of this sandwich.
- **Purple, "Switch Floor"**: only present inside the switch pipes.
- **"LIM Track"**: Currently now shown, but is considered to be added in the top center in between the two blue levitation tracks.

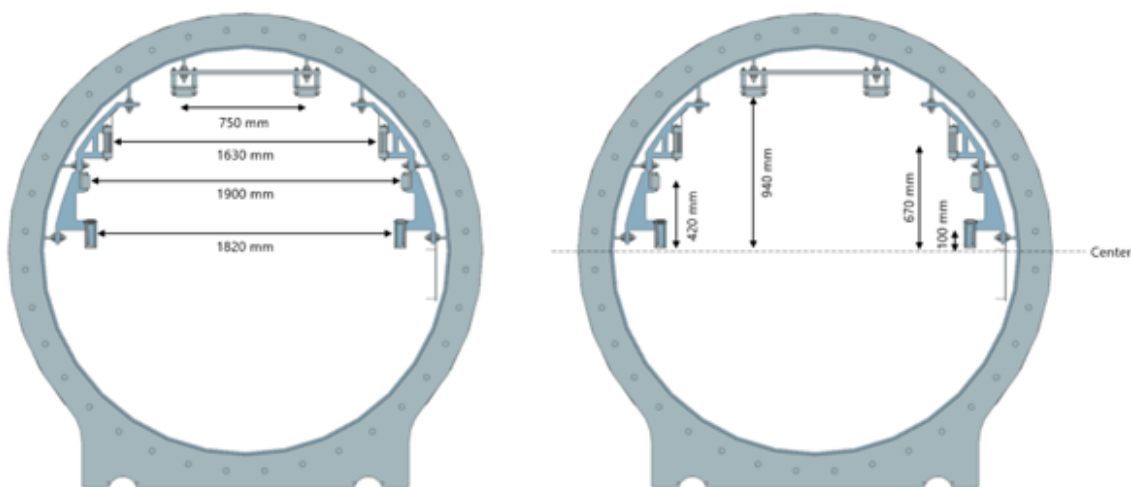


Figure 1: Track position with respect to each other and center

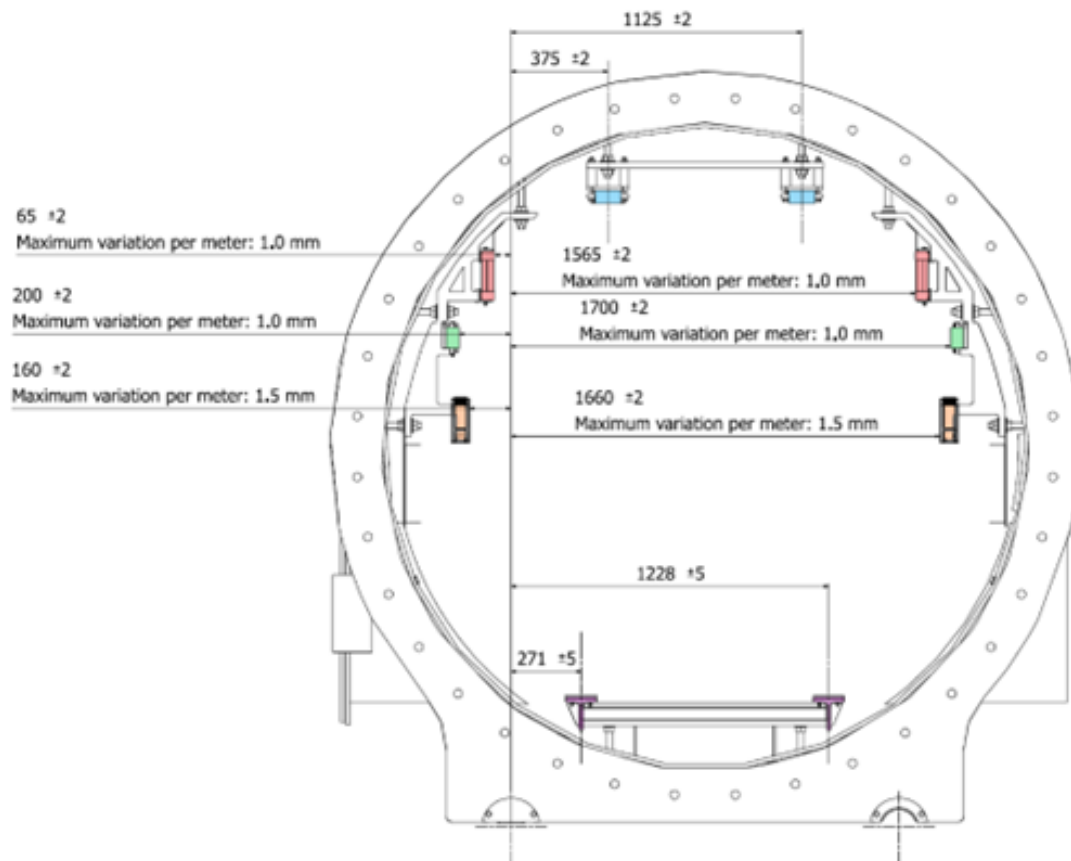


Figure 2: Lateral positioning of tracks within a pipe cross section

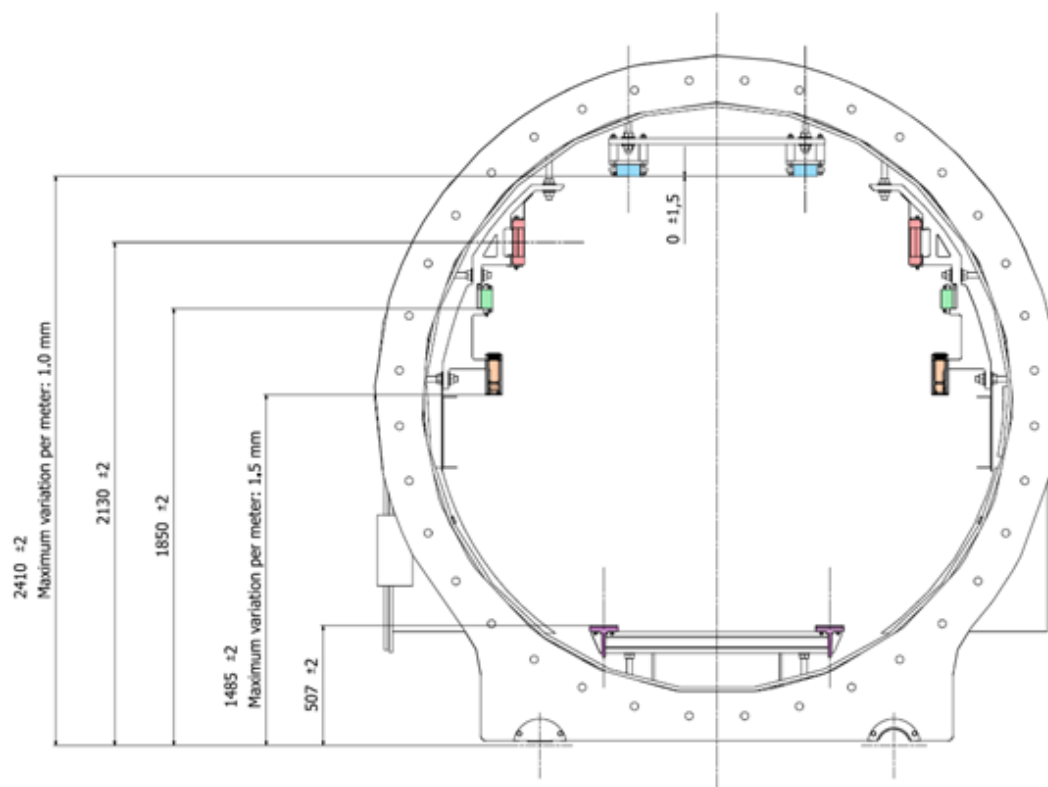


Figure 3: Vertical positioning of tracks within a pipe cross section

3.2 Detailed Track Design

This section provides more information per track set about dimensions and the used materials.

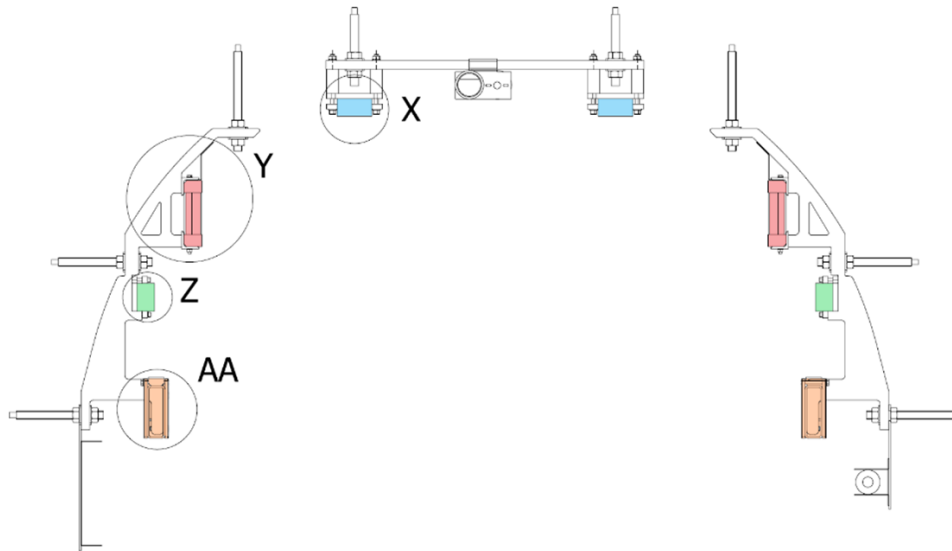


Figure 4: Overview of the track closeups to be discussed in this section

Blue Track – Levitation Track

Figure 5 provides a closeup of the blue track. Features include:

- Track segment length: 1 meter.
- Topology & materials: rectangular track made of M470-50A, laminated as indicated in purple.
- Points of possible contact (orange): needs to be avoided by design, as these tracks are prone to delamination. However, an on-board feature does need to be present in case contact is possible to mitigate circumstances in the unlikely event of contact between the vehicle and this track. Requirements for such features include:
 - The material hardness shall be no greater than 121 HB / 70 HRB
 - A shallow chamfer shall be present on the on-board feature in the directions of travel, with the chamfer angle being no greater than 20 degrees.
 - The on-board feature shall have a surface roughness of no greater than $3.2 \mu\text{m}$ Ra.
 - The material shall prevent forming any permanent bond with the track because of sustained contact.
 - Abrasion of the on-board material shall not lead to any significant fire or respiratory hazard

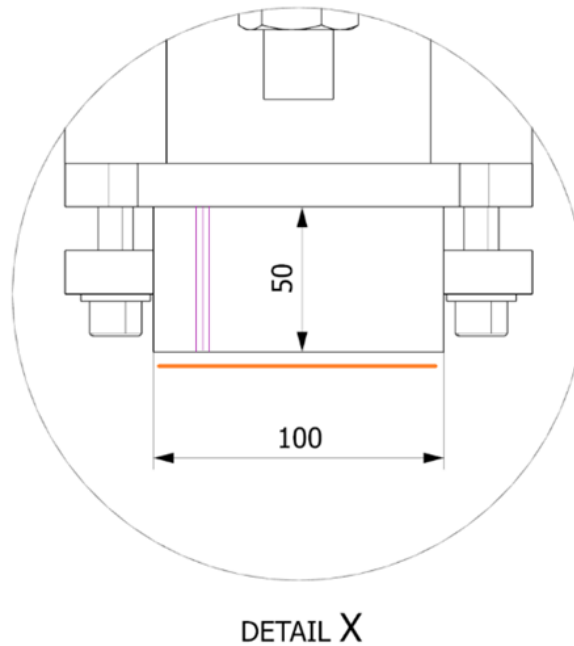


Figure 5: Closeup of the blue levitation track.

Blue Track – Levitation Track

Figure 6 provides an isometric view of a red track segment, which is comprised of various components that are shown in a closeup in Figure 7. Features include:

- Track segment length: 4 meter.
- Topology & materials:
 - Magnetically separated track blocks made of M470-50A, whose individual dimensions are presented in Figures 8 and 9. The blocks are placed at a 200 mm pitch, as shown in Figure 10.
 - A 35 mm wide layer of HMPE that sits on either side of the track blocks and protrudes 1 mm from the surrounding components.
 - The track is accompanied by a 2 mm thick flange up top made of stainless steel 304L. Barcode stickers and encoder lines are present on the blue surface across the entire track, which can be used for position measurements at reduced and high speeds.
 - The collective is supported by two stainless steel L-brackets which are located behind the layers of HMPE.
- Points of possible contact (green): contact is permitted exclusively with the layers of HMPE. Direct contact with the electrical steel track blocks needs to be prevented by design. Requirements for any vehicle features that may come in contact with the HMPE include:
 - A shallow chamfer shall be present on the on-board feature in the directions of travel, with the chamfer angle
 - The on-board feature shall have a surface roughness of no greater than $3.2 \mu m$ Ra.
 - The temperature at the contact patch shall never exceed 80 degrees Celsius, given a temperature of 30 degrees Celsius as initial condition.
 - Abrasion of an on-board material shall not lead to any significant fire or respira-

tory hazards.

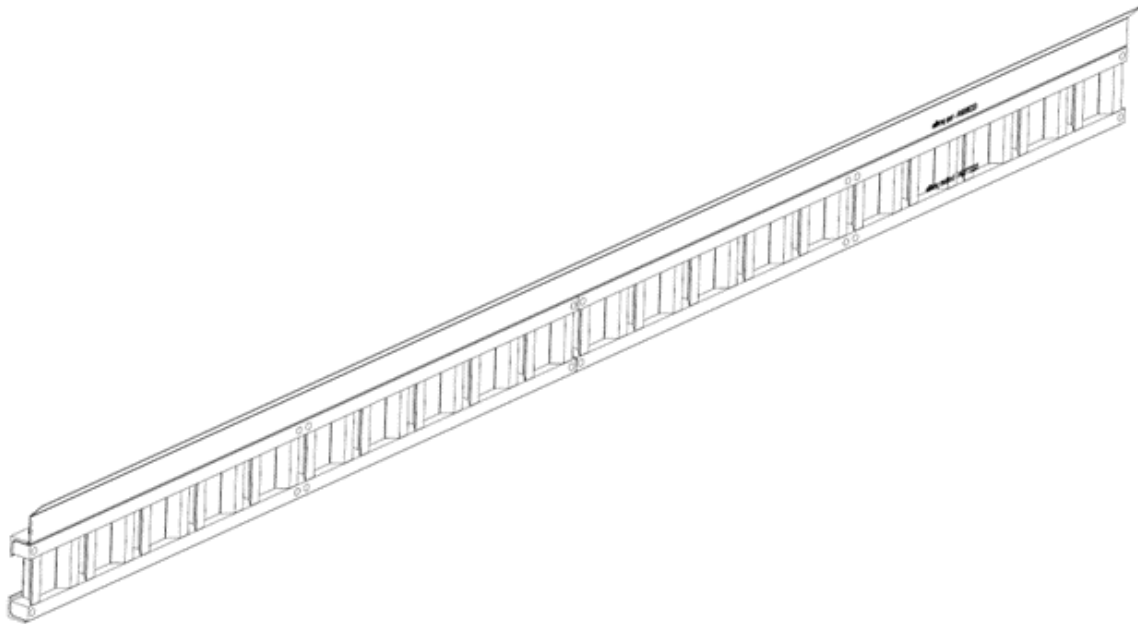


Figure 6: Isometric view of a red track segment

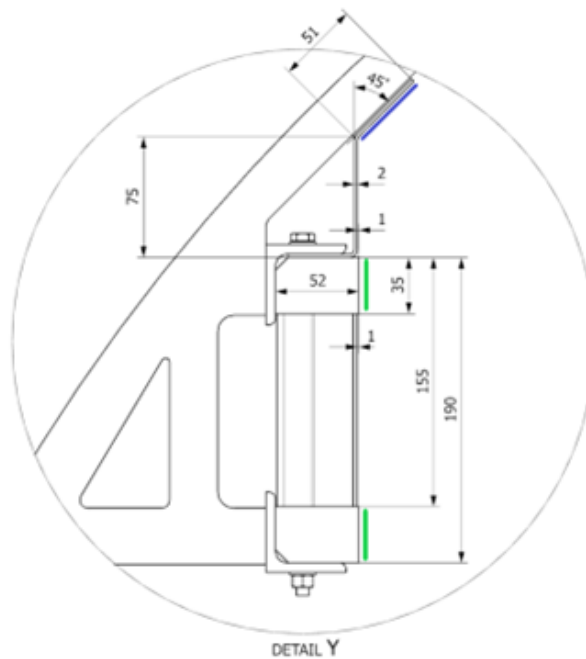


Figure 7: Closeup of the red track

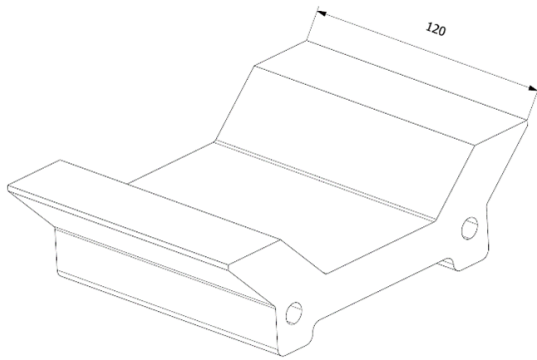


Figure 8: Isometric view of a track block

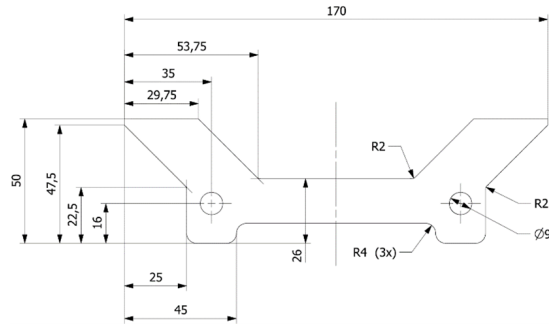


Figure 9: Dimensioning of a single layer in the track block laminate

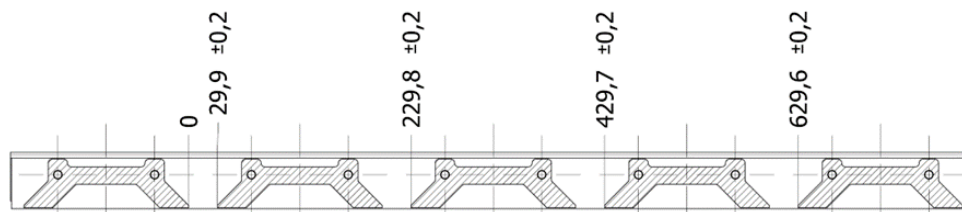


Figure 10: Cross section of the layout of electrical steel track blocks along the red track

Green Track - Guidance Track

Figure 11 provides a closeup of the green track, which is analogous to the blue track. Features include:

- Track segment length: 1 meter.
- Topology & materials: rectangular track made of M470-50A, laminated as indicated in purple.
- Points of possible contact (orange): needs to be avoided by design, as these tracks are prone to delamination. However, an on-board feature does need to be present in case contact is possible to mitigate circumstances in the unlikely event of contact between the vehicle and this track. Requirements for such features include:
 - The material hardness shall be no greater than 121 HB / 70 HRB.
 - A shallow chamfer shall be present on the on-board feature in the directions of travel, with the chamfer angle being no greater than 20 degrees.
 - The material shall prevent forming any permanent bond with the track as a result of sustained contact
 - Abrasion of the on-board material shall not lead to any significant fire or respiratory hazard.

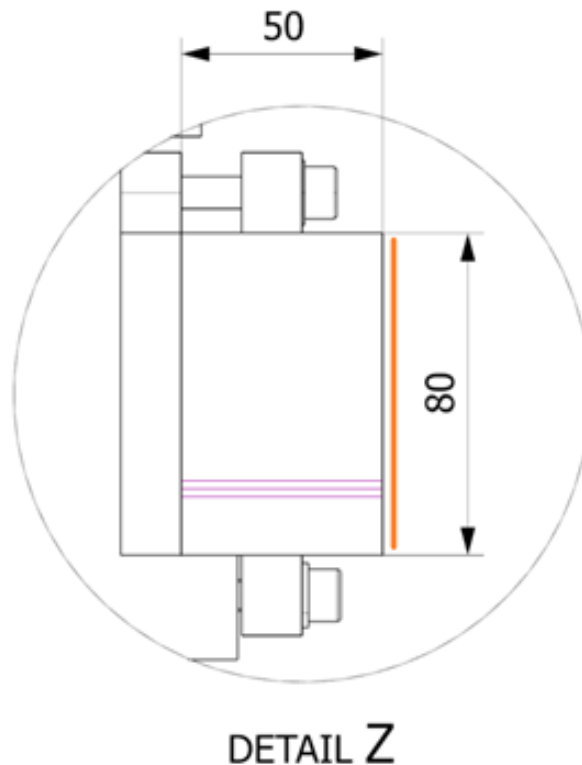


Figure 11: Closeup of the green track

Orange Track - Safety Track

Figure 12 provides a closeup of the orange track. Features include:

- Track segment length: 3.5 meter.
- Topology & materials:
 - Gray: steel track attachment.
 - Orange: hollow section made of SS 304L.
 - Blue: plates made of SS 304L.
 - Green: 45 mm wide layer of HMPE that protrudes 5 mm from the stainless-steel plates.
- Points of possible contact (green):
 - On the top face, contact is permitted exclusively with the HMPE. For this contact area, requirements are identical to those stated for the red track, namely:
 - A shallow chamfer shall be present on the on-board feature in the directions of travel, with the chamfer angle being no greater than 20 degrees.
 - The on-board feature shall have a surface roughness of no greater than $3.2 \mu m Ra$.
 - The temperature at the contact patch shall never exceed 80 degrees Celsius, given a temperature of 30 degrees Celsius as initial condition.
 - Abrasion of an on-board material shall not lead to any significant fire or respiratory hazards.
 - On the remaining faces, contact is permitted with the stainless-steel components with a few remarks:
 - On the bottom face momentary contact is permitted, however continuous contact is not.

- Anywhere outside the switch section, contact with the outboard face is permitted but not preferable. The next section on vehicle/ keep-out zones will clarify how far up the outboard face contact is permitted.
- Requirements for vehicle features that contact the stainless-steel track components include:
 - The material hardness shall be no greater than 170 HB / 87 HRB.
 - A shallow chamfer shall be present on the on-board feature in the directions of travel, with the chamfer angle being no greater than 20 degrees.
 - The material shall prevent forming any permanent bond with the track because of sustained contact (galling of particular relevance here).
 - Abrasion of the on-board material shall not lead to any significant fire or respiratory hazard.

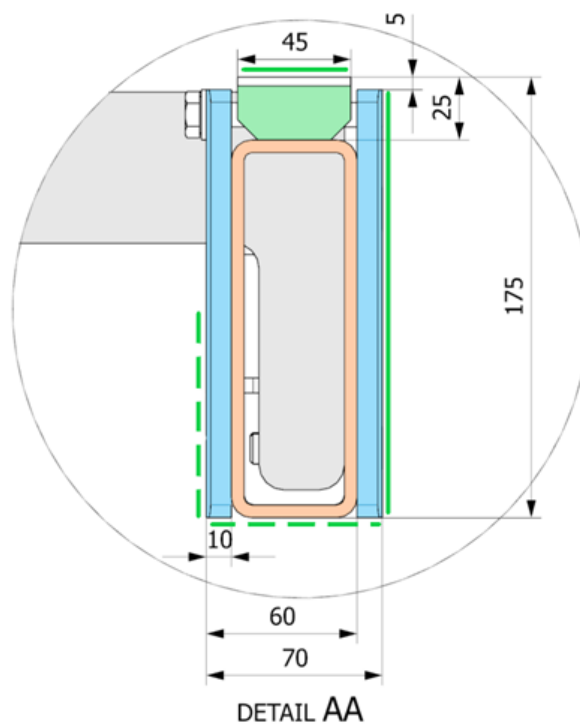


Figure 12: Closeup of the orange track

3.3 Vehicle Keep Out Zones (Preliminary)

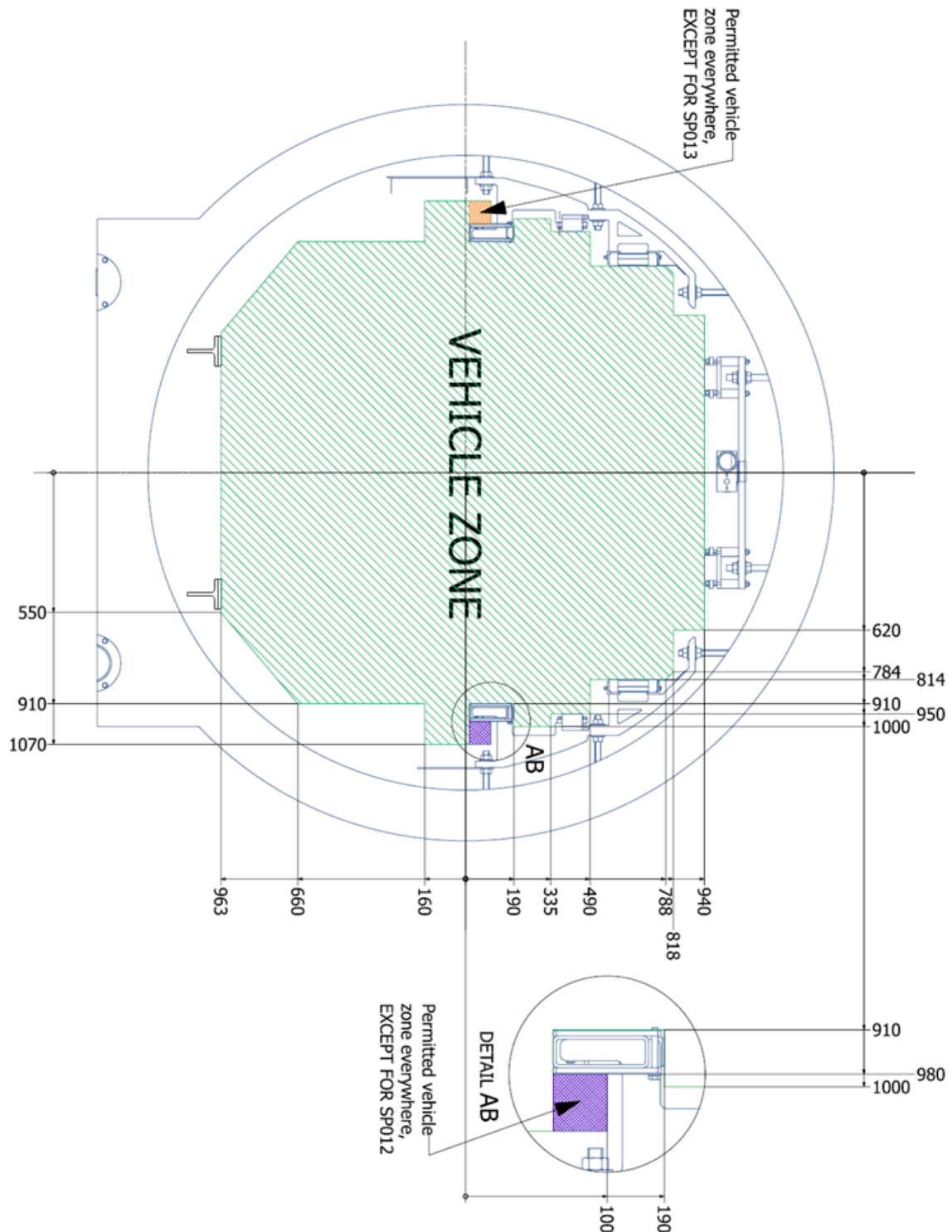


Figure 13: : Indication of the zone in which the vehicle is allowed to operate. Any area outside this zone is off-limits for vehicles.

3.4 Track-to-track transitions

This section contains information about absolute misalignments, angular misalignments, chamfer definitions and the size of transition gaps between tracks for which the vehicle's design needs to account.

Blue, red and green tracks

Features include:

- Absolute (step) misalignment: 1.0 mm
- Angular misalignment: 0.02 degrees
- Transition gap in the direction of travel: 0 - 84 mm
- Chamfers on track ends: not present

Orange Track

Features include:

- Absolute (step) misalignment: 1.0 mm
- Angular misalignment: 0.02 degrees
- Top & bottom face:
 - Transition gap in the direction of travel: 0 - 84 mm
 - Chamfer on track ends: 1.5 mm x 10 degrees
- Inboard face:
 - Transition gap in the direction of travel: also 0 - 84 mm, but the track geometry allows for continuous support, given that the vehicle-side support is sufficiently wide (see [Figure 14](#))
 - Chamfer on track ends: 1.5 mm x 20 degrees
- Outboard face:
 - Transition gap in the direction of travel: also 0 - 84 mm, but the track geometry allows for continuous support, given that the vehicle-side support is sufficiently wide (akin to [Figure 14](#))
 - Chamfer on track ends: not present

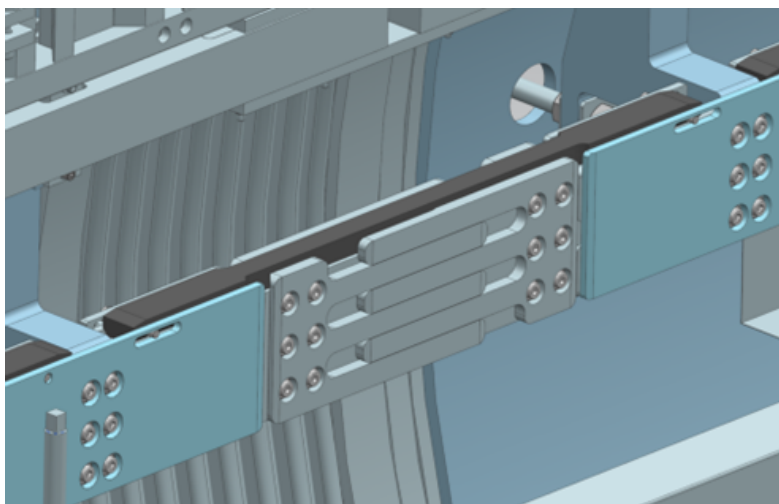


Figure 14: Track transition of orange safety track.

3.5 Maximum allowed (impact) loads per track

Figure 15 provides a legend for the maximum allowed impact loads which are presented in Table 1. Some important remarks:

- A vehicle may impact a track on several locations at once. In that case, a point load as high as the value presented in Table 1 may be reached on each point of contact, as long as said contact points are spatially separated by at least 1000 mm.
- The Y and Z forces as presented in Table 1 should not be combined for impact load calculations involving simultaneous impact in two directions.
- For impact calculations the tracks may be simplified to springs with the stiffnesses provided in Table 2.

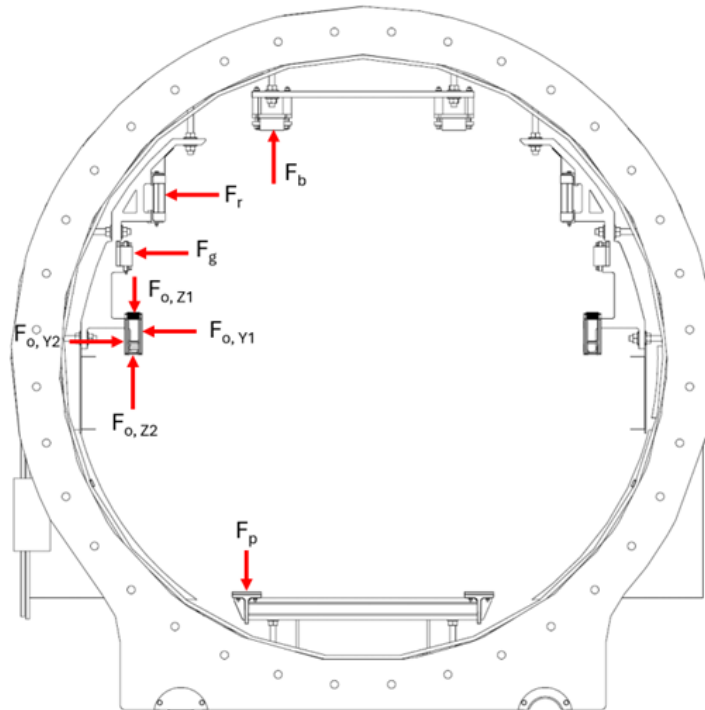


Figure 15: Pipe cross-section with impact load force vectors

Load	Maximum Load [kN]	Effective track stiffness in impact direction [N/m]
F_b	N.A. (18.3)	$6.6 * 10^7$
F_r	24.8	$5.3 * 10^8$
F_g	N.A. (20.8)	$8.3 * 10^8$
$F_{o,y1}$	18.9	$6.9 * 10^8$
$F_{o,y2}$	18.9	$6.9 * 10^8$
$F_{o,z1}$	21.3	$2.5 * 10^8$
$F_{o,z2}$	14.5	$2.5 * 10^8$
F_p	35.2	$7.1 * 10^6$

Table 2: Maximum allowed impact loads for each track