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Title: BS EN IEC 63281-2-2 E-Transporters

Part 2-2: Safety requirements and test methods for autonomous cargo e-transporters

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Date: xx/xx/20xx	Document: ISO/DIS xxxx

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex **(e.g. 3.1)**	Paragraph/Figure/ Table/Note	**Type of comment**	**Commend (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations on each comment submitted**
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

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125/88/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:	
IEC 63281-2-2 ED1	
DATE OF CIRCULATION:	CLOSING DATE FOR COMMENTS:
2023-10-27	**2024-01-19**
SUPERSEDES DOCUMENTS:	
125/56/NP, 125/71A/RVN	

IEC TC 125 : E-TRANSPORTERS	
SECRETARIAT:	SECRETARY:
Belgium	Mr Bram Rotthier
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐
	Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY

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TITLE:

E-Transporters – Part 2-2: Safety requirements and test methods for autonomous cargo e-Transporters

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SAFETY REQUIREMENTS AND TEST METHODS FOR AUTONOMOUS CARGO E-TRANSPORTERS

E-TRANSPORTERS – PART 2-2:

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FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

This International Standard has been developed to cope with the rapidly evolving autonomous driving ‘cargo’ e-transporters; ACeTs which mainly using in public road environments including public access spaces and those are autonomously using robot technologies, but partly human piloted at situation of over the operational design domain to be set by the manufacturer of ACeTs. The global market sizes and applications are expected to grow significantly due to the appearance of autonomous driving cargo e-transporters. However, some products can reach speeds of up to 25 km/h or 30km/h. This means that different hazards need to be considered than with conventional e-transporters that are used under the precondition of human piloted devices. So, in order to protect safety for persons and public facilities, besides basic safety requirements, comprehensive safety requirements and test methods such as autonomous driving devices safety for people, and road structures and specific signs for cargo e-transporters shall also be considered. Based on the current situation, this international standard provides comprehensive safety requirements and corresponding test methods for autonomous driving cargo e-transporters, which is convenient for manufacturers and test departments to use. This international standard is specific for cargo e-transporters with autonomous driving function.

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SAFETY REQUIREMENTS AND TEST METHODS FOR AUTONOMOUS CARGO E-TRANSPORTERS

1 Scope

This international standard specifies that it applies to electrically powered autonomous driving cargo e-transporters; ACeTs that do not intended to drive by on boarded driver, that are primarily electrically/electronically controlled for speed and/or steering autonomously without human intervention, and that operate in an Operational Design Domain(ODDa)-designated public road environments specified by a manufacturer and include a public access space where is not public road environment such as big shopping mall, airport facilities, big building corridor.

ACeTs do not include non-autonomous driving e-transporters that are driven by an on-board driver or that transport only passengers without a driver. In addition, ACeTs do not have the function to loading and unloading cargo by itself, but the user has to loading and unloading cargo on the halted ACeT.

However, ACeT includes use cases where a remote monitoring operator is direct operate remotely by an authorized user using wireless system and/or supplemental operating devices from the outside ~~(in this case, ACeTs do not drive autonomously without human intervention)~~.

ACeTs are design to purpose for direct delivery of cargo to personally and it may be for private or commercial use. This standard is intended to cargo delivery devices and services provided user themselves and by service providers and not covered to purpose for ACeTs sharing service applications.

ACeTs might need to adhere to additional standards and regulations, where appropriate, e.g. hazardous goods that require special controls may be transported, or the environment in which they operate may be subject to special regulations.

Hazardous materials requiring special controls are explosive materials, radioactive controlled materials, biohazardous materials, pressure vessels and high heat source objects, opioid such as morphine and toxic substances.

Electrically powered control product such as e-trailers equipped with propulsion drive and steering functions intended for cargo transport include hybrid assist or propelled power input driving is not covered by this standard. Also electrically powered bicycles, mopeds, motorcycles and driver cars are not covered by this document because they are handled by other TCs:

— ISO TC 22

— IEC TC 69

— ISO TC 110

— ISO TC 149

— ISO TC 299

2 Normative references

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329 IEC 61000-6-1: Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity
330 standard for residential, commercial and light-industrial environments

331 IEC 61508-1: Functional safety of electrical/electronic/programmable electronic safety- related
332 systems - Part 1: General requirements

333 ISO 13849-1: Safety of machinery -- Safety-related parts of control systems -- Part 1: General
334 principles for design

335

336 ISO 7176-21: Wheelchairs — Part 21: Requirements and test methods for electromagnetic
337 compatibility of electrically powered wheelchairs and scooters, and battery chargers

338 ISO 8124-1: Safety of toys Part 1: Safety aspects related to mechanical and physical properties

339 ISO 12100: Safety of machinery — General principles for design — Risk assessment and risk
340 reduction

341 ISO 13482: Robots and robotic devices — Safety requirements for personal care robots

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
Autonomous e-transporters
e-Transporter that can operate in autonomous driving mode or semi-autonomous driving mode, and it drives within defined operational preconditions such as ODDa (3.6).

3.2
Autonomous cargo e-Transporter (ACeT)

Autonomous e-transporters traveling without human intervention in carrying loads of parcels and goods to designated locations including public road environments and public spaces (e.g., walkway, pedestrian road, big building's corridors) coexisting with unspecified humans with a maximum speed not exceeding specified speed.

Even if in case of over the operational preconditions, an authorized users can operate remotely for the ACeTs manually via an external systems or supplementary telecommunication control devices.

3.3
intended use
use for which a product or service is intended according to the specifications, instructions and information provided by the manufacturer

[SOURCE: ISO/IEC Guide 63:2019, 3.6, modified — Note 1 deleted.]

3.4
Safety-related object
Objects on traveling path of an ACeT including that at proximity of its traveling path, or moving objects that may interfere with the traveling path those would cause a hazard or property loss if ACeT contacts or collides with these objects

3.5

Operational design domain for ACeTs (ODDa)
A specific domain and limits based on which the autonomous driving system of an ACeT or features thereof is designed and intended to be functioned, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or requisite for presence or absence of specific traffic elements e.g., pedestrian walkways or any other road structures.

Note: The ODDa differs from the ODD used for road vehicles, which is being considered as ISO 34503, in that it is separated into two operational criteria. The two operational levels mean that the ODDa can be used on public roads where it is mixed with other vehicle traffic, and in areas such as pedestrian zones where it does not interfere with the flow of pedestrians who have priority over ACeTs.

3.6
Environmental use conditions
Weather and other atmospheric conditions including telecommunication connectivity, and other vehicle and pedestrian traffic flow density

3.7
Minimal Risk Manoeuvre (MRM)
Operational maneuverer of PeTs triggered and executed by the autonomous driving function (ADF) to achieve the Minimal Risk Condition (MRC).

3.8
Minimal Risk Condition (MRC)
A safe state that ACeTs ultimately aim for when an event occurs that prevents safe driving due to malfunctions of the autonomous driving function or exceeding from the intended ODDa. In general, it refers to the stopping state of ACeTs at a safety level where the risk of collision with a safety-related object in acceptable.

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3.9

Autonomous driving function (ADF)

Function of automated driving system that uses both hardware and software to perform dynamic driving task (DDT) associated with traveling the ACeTs within a defined ODDa conditions set by the manufacturer without human direct interventions.

Note: ACeTs can activate DDT and travel autonomously within the ODDa conditions set by the manufacturer. If it is difficult for the ACeTs' system to continue executing the DDT, the system shall notify the user (e.g., remote monitoring operator or Operation Manager) to continue operation and automatically perform the MRM of the ACeTs is required.

3.10

Dynamic Driving Task (DDT)

All operational and tactical functions that need to be performed in real time when operating ACeTs. Strategic functions are not included. See Figure 1

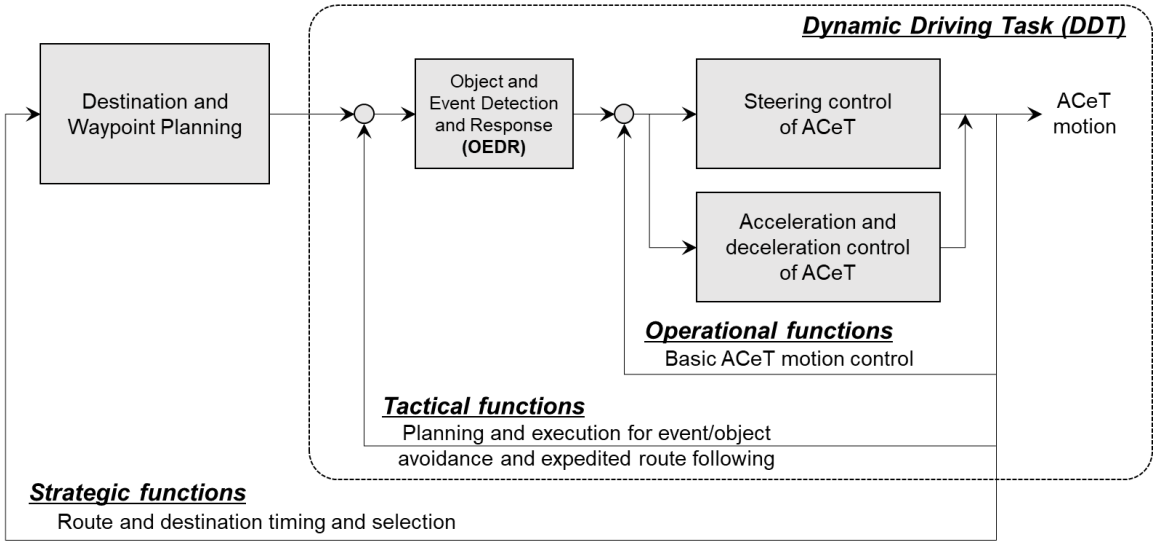

Figure 1 – Diagram of the relationship between strategic/tactical processing functions of ACeTs for autonomous driving

Note1: Operational functions refer to the motion control of the ACeTs in the rolling/yawing direction by steering and the motion control in the pitch direction by acceleration/deceleration.

Note2: Tactical functions refer to the detection and response of objects and events. Strategic functions refer to the decision and adjustments of whether or not to operate the ACeTs, when, where, and by what pass route.

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3.11
Object and Event Detection and Response (OEDR)
sub-task of the dynamic driving task (DDT), includes monitoring the driving environment (detecting, recognizing, and classifying objects and events, and preparing for the necessary reactions) and executing appropriate reactions of ACeTs to those objects and events.

3.12
Remote monitoring operator
An authorized personnel who exists remotely from ACeTs monitors the operation status of it using a remote operation control system using telecommunication technology without touching the body of ACeTs. If necessary who can switch the operation mode and remote operation control of ACeTs directly.

4 Classification of ACeT

4.1 General

ACeTs are classified in one or more of the following three classes, dependent upon their intended use.

ACeTs are classified into the following three major classes 'A' to 'C' according to the environment in which they are intended to be used, and further classified into two sub-classes according to the structural characteristic (means inherently stable design or self-balancing control design).

Furthermore, when ACeTs are operated autonomously, the required reliability of the autonomous functions varies depending on whether the number of ACeTs monitored by the remote monitoring operators are one or multiple. Therefore, sub-class codes are added to the type code as shown in Table 2 – Sub-class code of monitored level for ACeTs.

Class A to C and sub-classes are assigned as shown in Table 1 to Table 3.

Table 1 – Major classes code of ACeTs

Classes	Intended use fields					Maximum design speed (km/h)	Maximum width (mm)	Maximum length (mm)	Maximum design gross weight including loads (kg)
	Indoor Flat surface only	Public road environments							
		Pedestrian zone	Bicycle lane	Vehicle road					
				No separation	Separate with sidewalk				
	~~Yes~~	~~Yes~~	~~No~~	~~No~~	~~No~~	6	700	1200	30
	No	Yes	Yes	Yes	No				300TDB
						15			
	No	*	Yes	Yes	Yes	25 or 30	N/A	N/A	N/A
						over 25 or 30			

Class A and Class B refer to an acceptable safety levels that do not cause critical hazard to humans when even if the ACeT collides with a human at maximum speed, in case of collision avoidance function has failed.

Class C may occur unacceptable hazard in case of collision with a human being when operated at high speed, therefore, ACeTs are required to be equipped with sufficiently safety functions to avoid collision with humans and safety-related objects.

* If Class C in case for use in the Pedestrian zone, it is mandatory that the ACeT is operated in Pedestrian mode with a maximum speed of 6 km/h.

— Class A: compact, lightweight ACeTs up to 30kgf(TBD) not intended to use on public road environments, and to use on flat surface floor (including slow slopes/ramps) not necessarily capable of going across outdoor fixed obstacles such as gaps, steps and steep ramps.

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— Class B: Low-speed ACeTs over 30kgf up to 300kgf(TBD) gross weight with limitation of external dimensions, intended to be use in outdoor coexisting with human environments including public road (such as side roads, pedestrian crossings) and some indoor facilities, and ACeTs capable of going across intended outdoor gutter gaps, slopes, step ramps, and some fixed obstacles.

— Class C: High-speed ACeTs mainly use in low-speed public road environments (such as residential roads, bicycle lane), including across to a pedestrian walk by using pedestrian modes, usually larger in size, not necessarily intended for indoor use but capable of traveling over longer distances and avoid collisions with safety related objects.

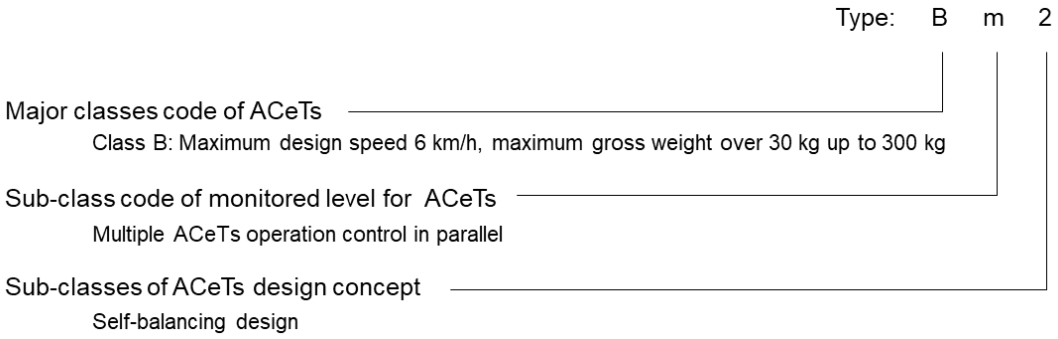
Table 2 – Sub-class code of monitored level for ACeTs

Classes	Sub-class code for number of monitored ACeTs by remote monitoring operators control	
	Single ACeT operation	Multiple ACeTs operation control in parallel
Class A	As	Am
Class B	Bs	Bm
Class C	Cs	Cm

Table 3 – Sub-classes of ACeTs design concept

Classes	Design concept of ACeTs	
	Inherently stable design (without self-balancing)	With self-balancing
Class Ax	Type: Ax1	Type: Ax2
Class Bx	Type: Bx1	Type: Bx2
Class Cx	Type: Cx1	Type: Cx2

Examples of designations with the ACeT type code as following,



5 Clarifying the use environment and its conditions for ACeTs with ODDa

5.1 General

The manufacturer shall specify adequate operation conditions and appropriate operating environment by ODDa concretely that will cover the intended use of the ACeTs. ODDa is provided in this clause as information to support the coverage of use cases of ACeTs, not as a usage limitation.

The ODDa is divided into two operational levels for use on public roads mixed with other traffic and in pedestrian zones where does not interfere with the flow of pedestrians who have priority

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over ACeTs. The two operational levels of ODDa is separated by a boundary of 6km/h, with Pedestrian mode for speeds below 6km/h and High speed mode for speeds above 6km/h.

The ODDa does not include requirements related to the proper safety operation and management of ACeTs, such as the period during which the safety-related functions of ACeTs can be maintained (including cases where such functions are guaranteed by performing periodic maintenance to maintain performance) and the operation of ACeTs (including maintenance) by trained and authorized personnel.

They are preconditions of the ODDa, and the user of ACeTs may be responsible for their implementation. These preconditions of ODDa (shown in Clause 18) may be defined and documented by the manufacturer (or SIer) as specific conditions required separately from the ODDa and provided the document to ACeTs users.

Note 1: By limiting the upper driving speed limit in ODDa to low speeds as up to 6km/h (same as walking speed), the risk of collisions for ACeTs with safety related objects include other traffic participants can be reduced and the safety performance requirements for ACeTs, such as obstacle detection range and braking performance, can be reduced.

Note 2: When considering the safety of the operational environment of ACeTs, it is possible to reduce the number of unintended hazardous events on its use cases to be assumed by limiting the pass routes to be operated to only predefined pass routes and by limiting the DDTs that ACeTs may support. Furthermore, by using these predefined pass routes as functionally driving spaces, it may be possible to simplify the various safety requirements for ACeTs. That functionally driving space where ACeT is operated, there may be defined in which infrastructure and other facilities are developed and maintained according to the needs of the operating parties to support smooth and safe operating conditions of the ACeT. Examples of infrastructure improvements include color-coded floor displays of the driving routes of automated ACeTs, sound notifications and active optical projection using the dynamic signs of approaching ACeTs.

Note 3: A practical way to realize automated driving services of ACeTs could be to create a space that is physically excluded from other traffic participants. However, since such a space can be regarded as a "non-public road, means public access spaces", it is not appropriate to provide a space that physically excludes other traffic participants in the ODDa of ACeTs, which is intended to be only used on public roads. On the other hand, it is essential for the early realization of automated driving services in ACeTs to simplify the technical requirements for such ACeTs by actively limiting the ODDa to a restricted space through the provision of infrastructure such as a functionally driving space in locations other than public road environments.

The risk assessment of ACeTs (including external operational support systems) may be executed in conjunction with the ODDa for the ACeTs.

5.1.1 ODDa considering factors

It is appropriate to refer to Table 4 for the limitation of use cases for ACeTs by ODDa.

Table 4 – Factors to consider when designing ODDa of ACeTs

Categories	Items to be taken into consideration
Way of change operating authority about autonomous driving according to ODDa	– Limit the DDT of ACeTs themselves to the ODDa, and in events that it becomes difficult to continue of the DDT for ACeTs autonomously, the ACeTs Operating Control System ensures that a remote monitoring operator of the ACeTs (including an operation manager) automatically transfers operational authority and achieve the MRC(minimal Risk Condition).
Limitations of the premises of travel range	– Travel only within a geographically limited and pre-verified area – Provide exclusive driving lanes for ACeTs – By reducing the ACeTs to a low speed of 6 km/h or less, which is equivalent to human walking speed, · the risk of a collision with a safety-related object occurring can be significantly reduced. · the performance requirements for the detection range of safety-related obstructive objects can be mitigated. · MRC can be achieved with "quick stops". · the pedestrian's intuition for guessing the direction of travel of the ACeTs will be enhanced. – By setting up a pre-defined route of ACeTs, it is possible to restrict the use cases that should be assumed. Depending on the need, infrastructure facilities (e.g. human presence sensor information in the area beyond the blind corner) can be proactively developed and reflected in the ODDa as "functional driving space"

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	– Eliminate the use of ACeTs on slippery surfaces
Restrictions of ACeTs operation by an authorized service provider	– ACeTs restricted to operate by a skill-full service provider that has been safety-certified by an objective third-party certification body to ensure that ACeTs can continue to maintain the ability to keep appropriate and safety operation of ACeTs.

In addition to the above those ODDa factors, as a means of restricting the use case of ACeT, it is effective to describe requirements of operational managements measure as Information for use to add the following a) to c) that supplement of the ODDa for ACeTs users.

a) Restrict to the area that is guaranteed to meet the operational environmental conditions of the ACeT's as specified by the manufacturer.Restricting those who may serve as users and operators to personals with specific knowledge and abilities

b) Restricting the period during which the safety-related performances of ACeT are maintained

Note 1 Use of the ACeT may be further restricted within the scope of the intended use. If these restrictions are implemented physically, then the risk assessment can be conducted based on the assumption that by restricting the use, the hazards have been eliminated (see 6.1). If these restrictions are only through labelling or only mentioned in the instructions for use, the risk assessment can be conducted based on the assumption that by restricting the use, the hazards have been reduced (see 6.1)). Only mentioning the restriction in the instruction for use without proper labelling on the device, will be assumed to have minimal hazard reduction effects.

Note 2 Restriction of the use of the ACeT corresponds to restriction of machinery specified in 5.3 (Determination of restriction of machinery) of ISO 12100.

Means of controlling the ACeT in response to any of the aforementioned means a) to c) include the following d) to f).

c) Maintaining the environment to ensure the restrictions of the environmental conditions under which the ACeT is to be used

d) Providing education and training to ensure that those who may serve as users and operators are restricted to personals with specific knowledge and abilities

e) Conducting periodic inspection and adequate maintenance to maintain the safety-related performances of ACeT until the design lifetime is exceeded

Note 3 If use of the ACeT is controlled by the aforementioned means d) to f), intentional use of the ACeT by the user or operator that exceeds such restrictions is not included in the scope of reasonably foreseeable misuse.

As an ODDa definition needs to be testable, ODDa attributes and its definition play a key role in scenario based testing. It is important to highlight that ODDa and scenarios are two distinct but related constructs.

5.1.2 ODDa and scenario relationship

While ODDa describes the entire operating conditions of the ADF, a use case scenario describes the behaviour of the traffic participants and the desired behaviour of the ACeTs itself in a concrete motion of an ODDa (or outside of an ODDa).

The ODDa definition may be used as one of the inputs for the engineering framework of scenario based testing. Therefore, one of the first steps in a V&V process of an ADF would be to identify the designed ODDa (or operating conditions) of the ADF to create a set of test scenarios.

Second step would involve identifying the desired behaviour of the ADF via a behaviour competency library. A concrete motion of the ODDa together with an expected behaviour and the description of the traffic participant behaviour according to events and triggers will provide a qualitative scenario definition for the ADF.

Qualitative scenario can then be further detailed into logical and concrete scenarios to create a scenario library.

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Furthermore, the ODDa definition can be used for a plausibility check, whether individual scenarios are inside, outside or on the boundary of an ODDa. Such scenarios also enable the test for activation and deactivation (due to violation of ODDa) of the ADF depending on ODDa. It is important to test against scenarios outside the ODDa in order to ensure any that the ADF is not misused in situations for which it is not designed for. Also, a comparison between scenario set and the ODDa definition may be performed to analysis the test space coverage.

5.1.3 ODDa requirements and application

Based on the taxonomy and definition format in this document, an ODDa definition may be developed and agreed by stakeholders, either individually or in consultation, for the safe operation of the ADF.

An ODDa may be defined from the perspective of an end user or a system specifier. Depending on the perspective, the abstraction of the ODDa definition may vary.

Stakeholders may include local authorities, regulators, service providers, manufacturers, developers of an ADF or suppliers of components and sub-components. A purchaser of ACeTs (e.g., delivery service providers) may develop an ODDa definition as part of a procurement specification for an ADF mobility service, while a manufacturer may develop an ODDa definition in order to convey the ADF' capabilities and limitations and create the corresponding safety case. Different stakeholders may develop their ODDa definition with varied level of detail.

~~The abstraction hierarchy (for each attribute) to be used for the ODDa definition may be at the discretion of the stakeholder Irrespective of the abstraction level chosen, stakeholders may specify the ODDa attributes used for informing the safety case for the ADF.~~

~~A stakeholder who defines an ODDa choosing an attribute at a higher abstraction level shall ensure that all the sub-attributes are also within the ODDa definition, even if they have not been explicitly mentioned in the ODDa definition.~~

~~The ODDa definition may be extensible in a way that allows new attributes or sub-attributes to be added as a result of stakeholder consultation and ensuring consistency with the existing attributes.~~

While performing the DDT, the ODDa attributes may be monitored by the ADF.

So that the ADF can compare the external conditions with the defined ODDa.

This is necessary to an understanding about the triggering of the minimal risk manoeuvre (MRM) or issuing transition demand.

During trials, the monitoring of the ODDa attributes may be performed by the safety operator or remote monitoring operator.

ODDa attributes may have interdependence and their relationship may be defined in a prescribed format; for example, an ADF may have a maximum allowable speed of 15km/h in the absence of rainfall, and a reduced maximum allowable speed of 6km/h in the presence of rainfall.

The remote monitoring operator or the ADF itself may decide, for example, to reduce the maximum allowable speed when it is raining as compared to sunny conditions.

Defining an ODDa boundary is up to the manufacturers' discretion and may involve a temporal element to it. For example, an ODDa boundary may be defined as up to 2 minutes of heavy rainfall by adding a relevant sub-attribute. ODDa attributes may allow awareness on the part of the ADF, so that the ADF remain within the designed and defined ODDa attribute definition.

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In case of an imminent ODDa use limit of the ACeT, the ADF may trigger a transition to a Minimal Risk Condition (MRC) or issue a request transition demand to the fall-back ready user or change the operating mode to a degraded mode, i.e., lower speed mode.

While the role of the human operator/remote monitoring operator is not part of the ODDa definition, the ODDa may be defined in a way that it is understandable to the user (operator/remote monitoring operator) to enable them to take into account the ODDa limits for the safe use of the ADF feature.

As part of the ADF development cycle, the ODDa definition may be an iterative process with a gradual increase in ODDa attributes and attribute value coverage. An ODDa definition is one of the steps in developing a safety case for an ADF. As part of the scenario-based testing process of an ADF (see ISO 34502), test scenarios may be identified from according to the constraints given by the ODDa definition. As part of the process to show compliance with the defined ODDa, test procedures may be demonstrated for the specific defined ODDa attributes.

6 Risk assessment

6.1 General

For the risk assessment of ACeTs all requirements of ISO 12100 applying for various use cases (such as use in restricted private space where limited personal who have safety literacy of ACeTs can access to, and in non-restricted public spaces where any person include small children can access without limitation) shall apply. This clause provides requirements and guidance in performing risk assessment, including risk analysis based on hazard identification. In performing the risk assessment, the decision of whether a risk is acceptable or not depends on the application and the intended use of the ACeT.

Where appropriate, use restrictions for the ACeT may be used as a risk reduction in the risk assessment for specific hazards.

ACeTs might need to adhere to additional standards and regulations, where appropriate, e.g. hazardous goods that require special controls may be transported, or the environment in which they operate may be subject to special regulations.

Hazardous materials requiring special controls are explosive materials, radioactive controlled materials, biohazardous materials, pressure vessels and high heat source objects, opioid such as morphine and toxic substances.

Also, when the environment in which the product is used is subject to special controls, it refers to an operating environment that requires strict electrical emission and immunity restrictions that are different from general household appliances.

To implement risk assessment and risk reduction for the ACeT including its use cases the manufacturer shall take the following actions, in the order given below:

a) determine the limits of the ACeT, which include the intended use and any reasonably foreseeable misuse thereof;

b) identify the hazards and associated hazardous situations;

c) estimate the risk for each identified hazard and hazardous situation;

d) evaluate the risk and take decisions about the need for risk reduction;

e) eliminate the hazard or reduce the risk associated with the hazard by means of protective measures.

Actions a) to d) are related to risk assessment and e) to risk reduction.

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ISO 12100 includes general lists of hazards for machinery, from which the list of significant hazards for ACeTs presented in Annex A is derived.

It is assumed that, when a residual risk on ACeTs is present, a hazard will sooner or later lead to harm if no protective measure or measures have been implemented. Examples of 'typical situations in which ACeTs cause harm' are given in Annex B.

Protective measures are the combination of the measures implemented by the manufacturer and the user in accordance with ISO12100, Figure 1 – Schematic representation of risk reduction process including iterative three-step method. Measures which can be incorporated at the design stage are preferable to those implemented by the user and usually prove more effective as well.

If examination of the ACeT shows that hazards not fully addressed in annex A might arise, then risk assessment is required. It shall be carried out and documented to achieve at least a tolerable risk by an iterative process described in this clause.

For the risk assessment of ACeT all requirements of ISO 12100 applying for various use cases shall apply. This clause provides requirements and guidance in performing risk assessment, including risk analysis based on hazard identification. In performing the risk assessment, the decision of whether a risk is acceptable or not depends on the application and the intended use of the ACeT.

Where appropriate, use restrictions for the ACeT may be used as a risk reduction in the risk assessment for specific hazards.

But also, in cases where multiple ACeTs are operated in parallel, there is a high need for appropriate operation management, risk assessment shall be mandatory.

7 General safety requirements and protective measures

7.1 General

ACeTs shall conform to the safety requirements of this International Standard. Once the hazards associated with an ACeT application have been identified using the methods described in Clause 6, the ACeT shall be designed to ensure that the risk from those hazards is below a tolerable level.

When risks can be eliminated or reduced by measures that are not described in this International Standard, other requirements shall be applied as determined by risk assessment. These measures shall achieve at least the same level of risk reduction as the measures described in this International Standard.

Measures shall be taken to protect any exposed person and, where relevant, any safety-related objects near the ACeT from any hazards, and to ensure the user's safety for continuous use of the ACeT as much as reasonably practicable.

ACeTs might need to adhere to additional standards and regulations, where appropriate, e.g. non-type approval vehicle regulations when ACeTs are operating on public roads.

An ACeT shall be designed according to the principles of ISO 12100 for all hazards identified for its application, comprising the following:

a) inherently safe design;

b) protective measures;

c) information for use.

NOTE ISO 12100 is indispensable for the application of this International Standard. It is advisable that users are familiar with ISO 12100 before they apply or use this International Standard.

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The use of inherently safe design measures is the first and most important step in the risk reduction process because such inherent characteristics of the ACeT are likely to remain effective, whereas experience has shown that even well-designed safeguarding measures can fail or be violated, and information for use may not be followed.

Inherently safe design measures avoid hazards by reducing or eliminating risks through a suitable choice of design features of the ACeT itself, and/or interaction between the exposed persons and the ACeT. Requirements for inherently safe design measures are provided in each earlier requirements as much as possible.

Adding safeguards, and/or protective measures is the second step of the risk reduction method. As a large number of risks arise due to the possible dynamic interactions between safety-related objects and the ACeT, a protective control function of the ACeT might significantly reduce a particular type of risk. Requirements for protective measures are provided in 2nd level requirements as much as possible.

When risk reduction is achieved by the use of essential safety-related control functions, the requirements of Clause 8 apply.

Information about the residual risks, after inherently safe design and protective measures have been incorporated, shall be provided in the information for use as user's instruction manual or handbook.

7.2 Hazards due to ACeTs shape

7.2.1 General

ACeTs are intended to be used for autonomous driving without human interventions and need to be use transporting loads of parcels and goods to designated locations including public road environments and public spaces (e.g., walkway, pedestrian road, big building's corridors) coexisting with unspecified humans. Intended use case scenarios to perform intended tasks by the ACeT shall be considered in the design of the overall shape of the ACeT, and of its external parts, to avoid the potential for accidents due to rollover and/or collision with human that could cause, for example, crushing, cutting, or severing injuries.

Where the shape of load being carried can lead to additional hazards, appropriate instructions to deal with these risks shall be given by the user of ACeTs. Warnings and instructions mitigating shape-related risks shall conform to ISO 12100 and ISO 7010(Graphical symbols — Safety colours and safety signs — Registered safety signs).

7.2.2 Mechanical instability and protect against rollovers during storage of ACeT

ACeTs shall be designed to have sufficient stability to allow them to be used in their specified conditions of during use of ACeT.

Mechanical stability shall not be affected in any phase of the life cycle of ACeTs (including installation and dismantling).

The ACeT shall conform to mechanical stability following requirements appropriate to its intended purpose.

The ACeT shall be designed so that no extraordinary actions or procedures are required by the user in order to maintain its mechanical stability during storage.

Stability during storage shall be maintained against static and dynamic forces from any loads of the ACeT.

The following Inherently safe design measures shall be applied where appropriate:

a) designing the ground support area to be as large as reasonably practicable;

a) designing the centre of gravity of the ACeT to be as low as reasonably practicable;

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b) designing the masses of moving parts to be as low as reasonably practicable.

c) designing the ACeT to ensure that mechanical resonance effects during storage cannot lead to instability;

The following Safeguarding and complementary protective measures shall be applied where appropriate:

d) use of stability equipment (e.g. movable stand);

e) use of docking station;

Any supplemental systems performing the above functions shall comply with required safety performance, in accordance with the ACeT (including its system) risk assessment.

The information for use shall contain limits of use for the ACeT concerning slope of travel surface, speed, payload, etc.

7.2.3 Instability during travel

ACeTs shall be designed to ensure that it does not cause any hazardous rollovers, runaways, or drops of its body parts or loads being carried during travel. This shall be achieved for all intended travel patterns (e.g. forward/backward travels, rotations, turns/U-turns, accelerations, and decelerations) in its specified operating environments, which is determined depending on its specific application type and design.

For ACeTs whose stabilities vary depending on configurations and loads, maximum speeds and accelerations shall be determined for each intended situation.

The ACeT shall be designed to restore its posture and not to roll over; this requirement shall apply to instability that occurs within the scope described in the specifications of ACeT with ODDa. As factors causing instability, the following shall be taken into consideration.

— Operational environment

— Failures

— Travel patterns

— Functional safety and/or protective equipment may be applied to reduce risks to acceptable levels.

Note Table 5 lists examples of operational environments and travel patterns that could be factors that cause instability while the ACeT is travelling and the instability events caused by such factors. The probability of occurrence increases especially when two or more of these factors are combined. Therefore, conditions combining these factors shall be given due consideration in the design as well.

Table 5 – Example of instability events and its factors during travel of ACeT

Category	Examples of factors	Examples of instability events caused by the factors
Operational environment	Slopes	· The ACeT travels backward when travelling uphill or moves down after entering a stopped state. · The ACeT becomes uncontrollable when travelling downhill and becomes unable to restore its posture.
	Bumps on floor surfaces	· The ACeT stumbles over a bump and becomes unable to restore its posture
	Openings or grooves on traveling surfaces	· Dropping
	Continuous irregularities on traveling surfaces	· The ACeT becomes unable to restore its posture
	Wet ground surfaces	· Slipping, spinning, or overrun · The ACeT becomes unable to restore its posture

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	Foreign objects caught in wheels	· The wheel becomes locked and the ACeT becomes unable to restore its posture
	Critical edges e.g., stairs and unfenced openings are examples of critical edges	· Falls down
Failures	Faulty drive wheel motors	· The wheel becomes locked and the ACeT becomes unable to restore its posture
Travel patterns	Sudden acceleration or deceleration (sudden stops)	· The ACeT becomes unable to restore its posture
	Sharp turns or U-turns	· Slips, spinning, overrun, rollovers

Especially, ACeTs that travel autonomously, the control system shall be designed to ensure, as far as reasonably practicable, travel stability under foreseeable conditions. In this case, any human near the ACeT shall be protected from the ACeT falling or rolling over. Risk assessment shall consider potential hazards due to incorrect positioning of loads in or on ACeTs.

For all class of the ACeT, the following Inherently safe design measures shall be applied where appropriate:

a) design of the mass distribution within the ACeT to ensure that ACeT cannot fall, rollover or overturn, even when travelling at maximum acceleration/deceleration or turning at maximum speed on the worst case travel surface gradient identified within the intended environment specified for the ACeT;

b) design of the travel actuators (e.g. wheels) shall ensure that sufficient adhesion with the terrain is maintained over all terrain types, even on slippery surfaces, etc., as defined in the specification of intended environmental conditions for the ACeT;

c) design of the stability of the ACeT to ensure that it does not fall, rollover or overturn when travelling over uneven terrain, up to the worst case limits defined within the intended environmental conditions specified for the ACeT.

d) Adopting adequate power to maintain the stability when starting on a slope with an inclination of maximum specified angle

e) Adopting adequate power to maintain the stability when starting to travel straight uphill on a slope with an inclination of maximum specified angle

Any control systems performing the following safeguarding and complementary protective measures or functions shall be applied where appropriate in accordance with the risk assessment.

f) restriction of the dynamics (e.g. speed, acceleration and centre of mass) of the ACeT within limits that ensure the ACeT will not overturn, even when attempting to turn on a worst-case travel surface gradient identified within the intended environment specified for the ACeT;

g) availability of lashing belts for fixing of parcels and goods;

h) continuous sensing of parcels and goods positioning for safe transport in ACeTs and appropriate reaction (e.g. a protective stop) if incorrect position is detected;

i) use of warning signals, e.g. audio, visual, vibrations, or any combination of signals.

If the ACeT equip with remote piloted function, the following safeguarding and complementary protective measures shall be applied where appropriate in accordance with the risk assessment:

j) travel surface sensing as described in 8.5;

k) the ACeT shall be able to plan a travel path to perform its intended task by ODDa based on environmental sensing technology;

l) If the ACeT have the function to turn on the spot, which shall be designed so that it can maintain its stability even when it keeps turning on a slope specified in its specifications.

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m) The ACeT shall be designed so that it can maintain its stability even when it keeps turning on a slope specified in its specifications.

n) The ACeT shall be designed so that it can maintain its stability when pushed or shaken by the user.

o) When a fall-prevention measure (e.g., auxiliary wheels) is applied in a direction that the ACeT is likely to rollover, the risks shall be reduced to acceptable levels under the least unfavourable design conditions if the cargo setting position by the user can be moved, or by means of protective safety measure design if control is used.

p) If no fall-prevention measure (e.g., auxiliary wheels) is applied, the ACeT shall be evaluated in the least favorable rollover mode (e.g., when the ACeT rollover for user's direction where are no auxiliary wheels) and designed to meet the required design level specified based on the injury value obtained by evaluation.

q) If the ACeT has a function that stops the ACeT on a slope with an inclination of 6°, the ACeT shall have a structure that prevents it from rolling over even if it stays within a radius of 300 mm for 30 seconds when the user operates the ACeT or commands the autonomous driving function.

r) There shall be no unacceptable risks when the ACeT is allowed to travel forward and pass over a 20-mm bump.

s) There shall be no unacceptable risks when the ACeT is stopped with the wheel in contact with a 20-mm bump and allowed to pass over the bump.

t) There shall be no unacceptable risks when the ACeT is allowed to travel forward and/or backward and pass over a 40-mm-wide groove.

u) The ACeT shall be structured so that it can travel uphill without causing any unacceptable risks on a 1.2-m-wide S-shaped track on a slope with an inclination of 6°. Figure 5 shows the S-shaped track.

v) The ACeT shall be structured so that it can travel without causing any unacceptable risks on a 1.2-m-wide straight track on a slope with an inclination of 3°.

Information for use shall specify conditions of the environment under which the ACeT can operate. For environmental conditions that might lead to hazardous situations but are likely to be found in situations where the ACeT performs its tasks, the information for use shall contain warnings.

7.2.3.1 Acceleration Limitation

Self-balancing design, ACeTs need at any moment have enough power to control the balance of the ACeT. Limiting the power of a self-balancing design ACeT risk the inability to keep the balance at any moment.

The acceleration of ACeT shall be smooth without shocks and limited to 2 m/s^2 in order to avoid unstable riding conditions.

7.2.3.2 Instability during loading/unloading for cargo loads by a user

ACeTs shall be designed to ensure that do not roll over or run away while a carrying loads to ACeT is putting on or putting off by a user under intended use situations. In addition, manufacturer shall specify the limit of cargo specifications taking into account the dimensions and the deviation of its maximum load.

The following inherently safe design measures shall be applied where appropriate:

a) The mass distribution and shape of the ACeT shall be designed that loading of cargo under the most severe conditions specified by the manufacturer will not cause it to overturn;

b) The shape of the cargo bed of the ACeT shall be designed to keep horizontally level to prevent it from falling.

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The following safeguarding and complementary protective measures shall be applied where appropriate:

c) Design of the braking performance of the ACeT to prevent runaway during loading of cargo under the most severe conditions specified by the manufacturer.

d) The Class xx2 (self-balancing design) ACeT shall be designed to include measures for active stability control that are capable of adjusting the balance of the ACeT to counteract any fluctuations to the centre of gravity during loading of cargo under the most severe conditions specified by the manufacturer;

e) The Class xx2 (self-balancing design) ACeT shall be designed to detect the load of cargo in the correct driving position in or on the ACeT before start of travel can be enabled.

Information for use shall contain instructions about loading for cargo procedures by a user and precautions to be undertaken by the user. It shall also contain information about the necessary configuration of the ACeT loading for cargo,

f) The Class xx2 (self-balancing design) ACeT shall be provided with an indication to notify the user that the ACeT is ready for loading for cargo.

7.2.3.3 Instability while carrying cargo loads

Changes in the kinematic properties of the ACeT due to the cargo load shall not cause any hazard.

The risk assessment shall take into account the maximum dimensional shape of the cargo specified by the manufacturer that the ACeT can transport.

Any human near the ACeT shall be protected from falling safety-related objects when the ACeT performs tasks, as well as while carrying empty to up to maximum loads. This shall include uneven cargo loads and movable loads (e.g. fluids sloshing in storage containers).

Risk assessment shall consider the consequences of dropped loads and any actions required by ACeT in the aftermath of any such event.

For maximum load operation of the ACeT, the maximum deceleration rate shall be commensurate with emergency stop dynamic criteria including the requirements for load stability and retention.

The following inherently safe design measures shall be applied where appropriate:

a) the load holders, placement areas, racks, etc., on the ACeT shall be designed to avoid the potential for lost loads;

b) limiting devices to avoid handling of loads exceeding the maximum rated payload.

The following safeguarding and complementary protective measures shall be applied where appropriate:

c) loads shall be tied or locked down by bolting or latching devices, or held by a gripping device;

d) the maximum speed and acceleration shall be commensurate with requirements for load stability during normal operation;

e) for normal operation, including a protective stop or an emergency stop, the deceleration rate shall be commensurate with requirements for load stability.

If use any stability control functional safety systems required performance level (PL) or safety integrity level (SIL) of the control system functions of an ACeT shall be determined by its risk assessment, and shall conform to either ISO 13849-1 or IEC 62061.

Information for use shall contain information about maximum size and/or weight and type of loads (if appropriate), and their limits that may be carried. Where loads require fastening, instructions shall be provided.

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7.2.3.4 Instability in case of collision with static obstacle

A collision between the ACeT and any other safety-related object should not cause instability of the ACeT.

a) Risk assessment shall determine the allowable maximum values of the appropriate parameters (e.g. contact force) that have an influence on the risk caused by contact over the entire operational range.

b) An ACeT shall be designed to ensure that it does not cause any hazardous rollovers, runaways, or detachment of its body parts, even when it receives any collision forces or safety- related object detection signals during its motion, up to the limits specified for its intended operation.

The following inherently safe design measures shall be applied where appropriate:

c) design of the mass distribution and shape of the ACeT so that unintended collisions within the maximum expected limits do not result cause instability of the ACeT;

d) use of soft materials to absorb forces which lead to hazardous instability of the ACeT.

The following safeguarding and complementary protective measures shall be applied where appropriate:

e) use of seat belts to prevent harm, in case of hazardous instability of the ACeT;

f) design of braking stability performance of the ACeT under a collision of the maximum expected force;

g) use of safety-related stability control accordance with clause 8.2 to minimize instability and high impact forces during collisions.

The information for use shall contain details of all parameters that evaluate the extent of potentially hazardous forces and collision scenarios that can be tolerated.

7.2.3.5 Instability of the ACeTs while parking

When the ACeT is not traveling, it must maintain stability not only against its own center of gravity but also against the force of a person leaning/stepping on it. However, this does not apply if the risk of the ACeT falling over is acceptable level.

A ACeT having a mass of 25kg or more shall not fall over when a force equal to 20% of the weight of the unit, but not more than 250N, is applied in any direction except upwards, at a height not exceeding 2 m from the floor. This external force input includes the most unfavorable position of doors, handles, etc. that may from operation by users including person around the ACeT. The following measures as inherently safe design shall be applied where appropriate: [Source; IEC60950-1:2005 Clause 4.1 modified]

Where appropriate, a caution for prohibiting human around the ACeT from leaning against the ACeT shall, where appropriate, be included in the user manual or indicated on the ACeT itself.

the following tests shall be conducted where appropriate.

a) Stability when the ACeT tilts while in a stopped state

– Test method On a slope having an inclination angle 110% of the manufacturer-specified maximum inclination or 5° , whichever is greater, set the ACeT by fixing the wheels by servo locking or other means so that the ACeT does not move. Set the ACeT in the direction in which its center of gravity is least balanced.

– Judgment criterion The ACeT shall not roll over.

b) Stability when a load is applied

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– Test method On a slope with the manufacturer-specified maximum inclination, set the ACeT by fixing the wheels by servo locking or other means and apply a force to the ACeT from all directions taking into consideration the expected load and the case in which a person leans against the ACeT. Set the ACeT in the direction in which its center of gravity is least balanced. Arrange any doors and drawers that may move during use in the least favorable positions within the scope of the intended use.

– Judgment criterion The ACeT shall not roll over.

7.2.4 Hazards due to tire failures

This requirement only applies for the ACeT equipped with pneumatic tires.

The ACeT shall be designed so as not to cause unacceptable risks when a tire blows out or comes off.

The tires of the ACeT shall be designed so that even when any of them blow out or come off the wheels, the ACeT does not immediately roll over and can continue to travel before becoming stable stop in a safe state.

Note Measures to prevent the tires from blowing out include, for example, using tubeless tires, tires that do not easily develop air leaks, double tires, solid tires, and run-flat tires.

The ACeT shall be provided with auxiliary wheels to prevent it from falling down when deemed necessary by risk assessment result.

Information for use shall include information on the risks caused by a tire blowing out, periodic inspection for preventing the tires from blowing out, avoiding having the ACeT travel over surfaces that are rougher than what is intended, and tire replacement.

7.2.5 Protection from hazardous environmental conditions for fully assembled ACeTs

7.2.5.1 General

The enclosure protection grade of ACeTs shall not be inferior to IP54(TBD).

ACeT shall be designed in such a way that foreseeable environmental conditions during the intended use do not lead to hazards.

ACeT shall be protected from causing hazards due to the presence or build-up of sand or dust in the environment. Where there is a risk of any hazard caused by dust contamination of the ACeT (as determined by risk assessment) then all affected parts, components or subsystems of the ACeT shall be designed to achieve a minimum protection rating of IP 5X(TBD) or more, as defined in IEC 60529.

ACeT shall be designed so that water and moisture ingress does not cause any risk. Where there is a risk of any hazard caused by water or moisture in the ACeT (as determined by risk assessment) all parts, components, subsystems and internal enclosures of ACeT shall be designed to achieve a minimum protection rating of IP X4(TBD) or more (resistant to pressurized water sprays for three minutes), in accordance with IEC 60335-1:2012, 15.1.and/or IEC 60529.

If an ACeT is intended to operate in cold external environments, then it shall be designed to be tolerant of snow and ice conditions. Moving parts and electrical components shall be prevented from failure due to ice build-up. Moving parts shall be designed to be tolerant of water, moisture, dust, and sand. Electrical components shall either be sealed against water or moisture, or installed inside enclosures that provide this protection. Electrical power supplies and batteries shall be protected against short circuits caused by immersion in water or build-up of moisture.

If a given ACeTs might foreseeably operate in coastal areas, in other locations near oceans, seas, other salt water bodies, or in shipboard environments, then its risk assessment shall consider the effects of high salinity atmospheres and salt-water sprays. If salt corrosion is

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assessed to be potentially hazardous, ACeTs shall be provided with sufficient protection to ensure an acceptable level of risk.

The following Inherently safe design measures shall be applied where appropriate:

a) dust-resistant materials for moving parts;

b) selection of materials and adoption of measures for inherent protection against extreme temperatures (see 7.5.1.2);

c) water- or moisture-resistant materials;

d) saline-resistant material;

The following Safeguarding and complementary protective measures shall be applied where appropriate:

e) sealing of joints and other moving parts;

f) coating or sealing of electrical components;

g) filters at the enclosure openings;

h) saline-resistant coatings, e.g. paints, varnishes or organic coatings.

i) mechanisms to prevent dust build up (e.g. forced ventilation or washing mechanisms);

j) dust detection and warning indications to instruct the user to perform the necessary actions;

k) active detection of snow/ice/cold air conditions, and execution of a protective stop before snow/ice levels build up to unacceptable levels; the ACeT shall make an appropriate indication to the user as to the reason for the stop;

l) the ACeT shall incorporate a safeguard function that ensures the periodic stopping or shut down for maintenance (which will typically include inspection and either cleaning or parts replacement); the ACeT shall provide indication to the user that it is shutting down for this purpose: for the purposes of this requirement, the period between shutdowns shall be based on the time required for unacceptable risk levels being reached due to, for example, corrosion, build-up of sand, dust or snow.

Where any action by the user is required for the prevention of risks, all necessary actions as well as appropriate materials (e.g. tools, cloths, fluids) shall be provided in the information for use. This may include:

– inspection, e.g. with respect to salt corrosion or sand abrasion;

– cleaning for the prevention or removal of sand, dust, snow and ice;

– drying;

– maintenance and replacement of parts.

In addition, If the manufacturer permits the use of ACeT for partial use in partial water immersion environments, the ACeT shall meet the following:

m) The ACeT shall not cause hazard such as electrical leakage or battery fire, and the enclosure shall not electrical leakage in accordance with 16.4.8

n) The manufacturer shall be provided specific use limits in the information for use (instruction manual) and notify the user.

Test method for the enclosure protection class of ACeTs shall meet the requirements of IEC 60529.

7.2.5.2 Operating temperature

Manufacturer of the ACeTs shall define the recommended operation temperature range and the upper and lower limits of the its specifications.

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The low and high temperature operation test shall be carried out in accordance with 16.4.6.2 and 16.4.6.3. After the test, samples shall not lose their normal driving function, and the electrical parts shall function normally. according to 16.4.13

Note to entry in case of high temperature operation, high humidity conditions shall be added according with 16.4.6.3.

The ACeTs shall comply with those specified in 5.4.1.4, IEC 62368-1; 2018.

The materials suitable for components and ACeTs structure shall be selected to ensure that the temperature of ACeTs will not exceed its temperature limit when working under normal load. After tested according to the method specified in 16.4.9, the measured temperature limits of materials and components of ACeTs shall comply with those specified in5.4.1.4.3, IEC 62368-1;2018; and the measured temperature limits of accessible parts in the user-accessible area shall comply with those specified in 7.5.1.2, IEC 62368-1;2018. In addition, the ACeTs shall not ignite or explode, and the enclosure shall be free of rupture or leakage during test.

7.2.5.3 Maximum storage temperature

Manufacturer of the ACeTs shall define the recommended storage temperature range and the upper and lower limits of the its specifications.

The low and high temperature storage test shall be carried out in accordance with 16.4.6.4 and 16.4.6.5. After the test, samples shall not lose their normal driving function, and the electrical parts shall function normally. according to 16.4.13

7.2.6 Mechanical strength

7.2.6.1 Cargo bed frame strength

The cargo bed frame structure with maximum permissible design payload times a safety factor of 2.5 to the center of cargo deck shall be capable of the intended behaviour moving part(s) such a as steering system, suspension system, cargo door, and it shall not crack, break, collapse or expand the structure with sufficient lifetime.

NOTE 1 The minimum mass of 100 kg represents a maximum permitted payload marked on the ACeT of 40 kg multiplied by a safety factor of 2,5.

NOTE 2 For a permissible payload of 120 kg, the total mass “m” is 300 kg.

7.2.6.2 Impact resistance strength

7.2.6.2.1 Frontal impact resistance

In case of ACeTs are using faster than walking speed that collide with a strong wall, road curb and/or high gap there shall be no visible cracks or fractures in any part of the frame and there shall be no separation of any elements of the suspension system and human accessible part of the ACeT body shall be free of obvious damage and hazardous electrical leakage including main battery.

If the ACeT have cargo door mechanism, there shall be no visible cracks or fractures in any point of the cargo door mechanism. The assembly remains operational even if significant clearances are found. These clearances are acceptable if they do not involve the safety of the user including usability.

In particular, the locking of the cargo door system, if any, shall be checked when the cargo door is closed. If applicable, the cargo door mechanisms shall remain locked.

After the test, the ACeTs shall have normal functions, and not ignite or explode, and the enclosure shall be free of rupture or leakage. And the ACeT shall employ the test probe as specified in IEC 8124-1 Articulated accessibility probe B or IEC 61032 Test probe Auto-18 for testing and shall not touch the internal sharp edges or electrical circuits.

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The frontal impact resistance test shall be carried out in accordance with 16.6.1.

7.2.6.2.2 Dropping/falling impact resistance

The ACeT shall not cause unacceptable damage from falling from a specified height.

After the drop test is carried out according to 16.6.1.1, crack or rupture may exist on the enclosure of ACeTs, but the main load-bearing structure of human accessible part of the ACeT body shall be free of obvious damage and hazardous electrical leakage including main battery.

After the test, the ACeTs shall have normal functions, and the enclosure shall be free of rupture or leakage including main battery. And the ACeT shall employ the test probe as specified in IEC 8124-1 Articulated accessibility probe B or IEC 61032 Test probe Auto-18 for testing and shall not touch the internal sharp edges or electrical circuits.

7.2.6.2.3 Drop load impact resistance

In the case of equipped of loading deck, floor, container, or other loading mechanism, The ACeT shall be ensuring that no damage including main battery system will occur to loading mechanism of ACeTs, taking into account the possibility of a user of ACeTs dropping of the cargo load at a time of loading as following conditions according to 16.6.1.2.

There is no body structure on the upper side of the loading mechanism, such as a cargo deck, floor or container, a load of 2 times the maximum weight (or more than 40kg) in a box with specified external dimensions specified by the manufacturer shall be dropped from a height of 0.5m or more.

If the cargo space is of a shape that does not have the height of 0.5 m due to structural restrictions of ACeTs, the load should be dropped from a position 10 mm below the maximum height of the box of the specified external dimensions.

7.2.7 Physical stress and posture hazards

Risk assessment shall identify hazards due to physical stress and posture of ACeTs users, and the ACeT design including remote control systems for ACeTs shall ensure that any such risk is minimized. This may be achieved by, but may not be limited to, the following requirements:

a) ACeTs shall be designed to minimize or reduce physical stress or strain to its user due to continuous use, including but not limited to uncomfortable posture, operational environments that would directly cause physical discomfort, e.g. fatigue and tendon inflammation.

b) The design of the ACeT shall take into account typical body sizes of the intended user population in order to avoid physically demanding body postures or to ensure easy operation. ISO 14738 describes how principles of ergonomic factors, by construction of workstations and machinery, should be applied. This should be considered when designing of user's action for loading or unloading a load into or off the ACeT, or when operating various ACeT operation.

This may include, but not be limited to, the following inherently safe design measures:

c) the design and location of manual control devices (such as cargo door handle), which should ensure that they can be operated without physical stress or discomfort;

d) the proper ergonomic design and location of the movable parts pf ACeT, which should ensure that good posture can be maintained during operation of the ACeT;

e) command devices that are detachable or hand-held instead of being permanently attached to the ACeT in an inappropriate position.

This may include, but not be limited to, the following Safeguarding and complementary protective measures:

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f) use of shock absorbing mechanisms;

g) use of electronically power supports.

The information for use shall contain instructions about the correct way to operate the manual control devices and how to use the ACeT. The information for use shall include the need for proper training to avoid operator travel time being longer than recommended.

7.3 Fall protection

The ACeT that is not allowed to fall off, verification of protective means against falling off is based on the manufacturer's risk assessment. The adequacy of measures is determined by conducting a test based on the verification method determined by risk assessment in order to check whether the protective means is activated when necessary and to confirm that the ACeT does not fall off.

7.4 Hazards due to electric fires

[Prepare the draft for the next CD phase by JPN. Copy from JIS B 8446-1 Clause 5.17 and modify according to manner of NP56]

The ACeT shall be designed and constructed such as to prevent any risk of fire resulting from foreseeable abnormal use.

During the use of the ACeT, the ACeT and the batteries shall not emit any flames, molten metal or release any toxic or flammable gas in hazardous amounts. Protective enclosures shall show no damage when checked visually.

The ACeTs shall be designed to prevent dust-related fires due to high temperature components The ACeTs shall be designed to prevent hazardous electrostatic charge build-up, to prevent dust building up on charged outer surfaces.

7.5 Hazard due to contact with human and ACeTs

7.5.1 General (Enclosure)

Intended use case scenarios to perform intended tasks by the ACeT shall be considered in the design of the overall its shape, and of its external parts, to avoid the potential for accidents that could cause, for example, crushing, cutting, or severing injuries.

The hazardous part such as electrical enclosure, fire enclosure, mechanical enclosure and environmental enclosure of the ACeTs shall be designed to be opened only by special tools, and not opened by hand alone excluding intended accessible parts.

7.5.1.1 Sharp edges and appearance of ACeTs

To avoid sharp corners and edges that could create a potential safety hazard to persons or equipment, during the design and manufacturing of components and parts ensure the radius or chamfer of accessible components and parts is at least 0.3mm (radius or chamfer of more than 0.5mm is preferred).

Tubes and rigid components in the form of projections which constitute a puncture hazard to the user and third parties shall be protected. These requirements are intended to address the hazards associated with the users and third parties, touching on projections or rigid components (e.g. handlebars, levers) on the ACeT possibly causing internal injury or skin puncture.

Note If the ACeT is operating in a public access space (e.g., on a pedestrian walkway or in a public open space) it is important to consider the access of small children who are not under parental supervision.

Limiting the load being carried to objects which are not sharp or pointed.

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The following safeguarding and complementary protective measures shall be applied where appropriate:

a) cushioning on sharp edges and points shall be provided to eliminate shearing, stabbing, cutting hazards and reduce impact hazards;

b) use of fixed or movable guards to cover hazardous moving parts;

c) adjustment of the ACeT speed and behaviour, if hazardous loads (e.g. sharp or pointed objects) are being carried.

The information for use shall contain instructions for protective equipment (e.g. gloves) needed for handling, using, or operating, etc., the ACeT.

Compliance is checked by inspection, or measurement.

7.5.1.2 Protection from Extreme temperatures

ACeTs user shall be protected from extreme temperatures (either high or low temperatures) of the ACeT or its components that might cause burns, chilblains, stress, discomfort, or similar disorders of any kind. To achieve this requirement, the ACeT shall conform to ISO 13732.

NOTE Surface temperatures between 10 °C and 43 °C are normally not considered to be extreme.

The following Inherently safe design measures shall be applied where appropriate:

a) elimination or avoidance of extreme heat sources within the ACeT;

b) choosing materials and their textures with appropriate thermal conductivities.

The following safeguarding and complementary protective measures shall be applied where appropriate:

c) reducing (or increasing) the surface temperature with an appropriate cooling (or heating) system;

d) isolation or the application of guards (see ISO 13732-1; Hot surfaces, ISO 13732-3; Cold surfaces)

Information for use shall contain warnings and markings on the hot/cold parts having extreme temperatures in compliance with ISO 3864-1. If necessary, instructions for taking precautions during use, handling, maintenance and disassembly of the ACeT shall be given.

7.5.1.3 Hazardous energy parts

ACeTs shall be designed and constructed so that all hazards related with its energy are prevented.

The electrical equipment of ACeT shall be designed and constructed in compliance with the relevant requirements of IEC 60204-1 for electrical equipment, of ISO 4414 for pneumatic equipment and of ISO 4413 for hydraulic equipment.

Any exposed person shall be protected from direct or indirect contact with live parts on the ACeT.

A means of isolating any hazardous 7.5 (e.g. electrical, mechanical, hydraulic, pneumatic, chemical and thermal) shall be provided. Such hazardous energy sources shall be clearly identified, and the isolators shall be capable of being locked if reconnection leads to a hazard.

The following inherently safe design measures shall be applied where appropriate:

a) use of safe extra-low voltage sources for electrical equipment according to IEC 61140 (below 25 V AC and 60 V DC);

b) use of low pressures for pneumatic/hydraulic equipment.

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Other types of stored energy shall be kept to a level as low as reasonably practicable, to minimize the hazard.

Where guards or enclosures are used to protect from hazardous energy parts, their design shall conform to appropriate IP class as defined in IEC 60529 for electrical hazards and safety distances of ISO 13857 for other hazards as determined by risk assessment.

Where excessive heat is present, heat dissipation measures shall be applied (e.g. heat sinks, air f low). If fans are used, fan control devices are recommended.

Warning markings shall be put on the ACeT complying with ISO 7010, and their meaning shall be explained in the information for use.

7.5.1.4 Electro-static discharge

The ACeT shall be designed to avoid all harm to humans and safety related objects caused by electrostatic potential and discharge.

Electrostatic discharge (ESD) protection shall be sufficient that no personal protective equipment is required by users.

Any build-up of harmful electrostatic potential shall be discharged.

The ACeT shall be designed to avoid harmful malfunction due to electrostatic potential discharge.

The ACeT shall be designed to avoid all harm to humans and safety related objects caused by electrostatic potential and discharge.

Electrostatic discharge (ESD) protection shall be sufficient that no personal protective equipment is required by users.

Any build-up of harmful electrostatic potential shall be discharged.

The ACeT shall be Inherently safe designed to avoid harmful malfunction due to electrostatic potential discharge.

Use of covers of the electrical equipment shall be in compliance with IEC 60204-1 to avoid contact with live parts.

Necessary relevant warning signs for ESD from ISO 7010 shall be provided together with the information for use.

7.5.1.5 Hazardous materials and substances

An ACeT user shall be protected from emissions of any poisonous or noxious materials, or from solvents from the ACeT body surface or from even within its body if the solvent is highly volatile, which might cause burns or any kind of irritation (e.g. see ISO 14123-1);

The ACeT shall be designed so that no hazardous substances and fluids (e.g., brake fluid, battery electrolyte) are emitted. The ACeT shall be designed such that during normal operation no protective equipment needs to be worn by the user.

No material that might cause allergies should be used at a surface which comes into contact with human skin during normal use of the ACeT.

NOTE Nickel, chromium and some types of rubber might cause allergic reactions.

Non-metal materials such as non-metal enclosures, connectors, etc. of ACeTs not related to electrical circuitry shall meet the requirements for flame-retardancy. The flammability rating of non-metal enclosures and circuit boards shall be at least V-1 and that of non-metal components

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and parts in the enclosure of connectors shall be at least V-2, and the assessment method should be in accordance with IEC 60695-11-10.

Note 1 to entry: This requirement is not applicable to decorative parts and other parts that cannot be ignited or are unlikely to spread flames generated in the equipment.

7.5.2 Clearance between moving parts

To prevent crushing of fingers the distance separating accessible moving parts from other moving parts or from fixed parts of the PeTs shall, either be less than 5 mm, or greater than 18 mm in any position.

This requirement does not apply to the wheel with its support systems, or to the rear brake/braking system, if any, or to brake actuating levers.

Compliance is checked by measurement.

7.5.3 Contact with moving components

Hazards from moving parts are related to products and rigid parts of products that move in use. A finger may be crushed, cut or even severed if the fingers become trapped between parts of a product that move.

Compression points may exist if one component can move relative to another part reducing the distance between the components. This risk is more severe if parts move under loads such as body weight, component weight or the application of powered mechanisms.

Shearing hazards occurs when two parts move relative to each other and act like scissors. This risk is more severe if parts move under loads such as body weight, component weight or the application of powered mechanisms.

ACeTs shall be designed so that the risk of hazards caused by exposure to components such as motor shafts, gears, drive belts, wheels, linkages, cargo door are acceptable.

ACeTs shall be designed in compliance with ISO 13857 in order to prevent hazard zones being reached by parts of the body.

The following Inherently safe design measures shall be applied where appropriate:

a) the ACeT shall be designed with the minimum number of accessible moving parts;

b) the ACeT shall be designed with moving parts in which components such as motor shafts, gears, drive belts, wheels, linkages are not exposed.

Hazards due to moving parts shall be prevented either by safeguards and complementary protective measures fixed guards or by movable guards, depending on the foreseeable frequency of access, in accordance with ISO 14120.

Appropriate method(s) shall be chosen from the following.

c) Where fixed guards are used, the following measures shall apply:

1) fixed guards shall be installed so that they can be opened or removed only with tools;

2) their fixing system shall remain attached to the guards or to the ACeT when the guards are removed, if deemed necessary by risk assessment;

3) where possible, guards shall be incapable of remaining in place without their fixings.

d) Where movable guards and cargo door are used, the following measures shall apply:

1) movable guards and door shall be designed so that they cannot be removed easily, and once opened, remain attached to the ACeT;

2) movable guards and door shall be interlocked with the hazardous movements in such a way that hazardous movements come to a stop; the control system performing this

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