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Road vehicles — Traffic accident analysis —

Part 2:
Guidelines for the use of impact severity measures

Véhicules routiers — Analyse des accidents de la circulation —

Partie 2: Lignes directrices pour l'utilisation des mesures de gravité des chocs

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12353-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 12, *Passive safety crash protection systems*.

ISO 12353 consists of the following parts, under the general title *Road vehicles — Traffic accident analysis*:

— *Part 1: Vocabulary*

— *Part 2: Guidelines for the use of impact severity measures*

Introduction

Any considered approach to road safety requires some concept of *impact severity*, which is normally thought of as the physical violence of a vehicle crash.

A government or other regulatory body implementing traffic-calming measures looks for a reduction in the severity of impacts on the modified roads; similarly, in introducing vehicle crash test regulations, it needs to know how the impact severity of the test configuration compares with the severity of impacts occurring on public roads.

Vehicle manufacturers seeking to improve the crashworthiness of their products also require some definition of impact severity, since the design changes that work best to provide occupant protection at low speeds are not necessarily — or even usually — also the best at high speeds.

Researchers and other investigators of real accidents provide data and advice to governments, manufacturers and other interested parties, and are required to produce measures of impact severity based on the evidence available to them after a crash has occurred.

Impact severity focuses on the vehicle, not the vehicle occupant, and in this context it is conventional to distinguish *the first* from *the second* collision. Typically, in a crash that results in occupant injuries there is first a collision between the vehicle and some other object, such as another vehicle, tree, or post: this is referred to as the *first collision*. A very short time later, some part of the interior passenger compartment, usually including a restraint system, is loaded by the occupant: this is referred to as the *second collision*.

Although these two collisions are not the same, they are obviously closely related, as the first collision creates most of the relevant conditions for the second. Prominent among these conditions is the direction and rate of vehicle deceleration, and the magnitude and rate of passenger compartment deformation.

Impact severity pertains to the violence of the first collision, and therefore does not directly determine the injury outcome. This leaves it possible to speak of low severity impacts that result in high injury levels, and vice versa. Generally, however, for a particular impact configuration, greater impact severity is associated with more severe injuries. The final outcome of the crash depends on the characteristics of the injury-reducing measures used, the human kinematics and the tolerance of the human body itself.

Measures of impact severity tend to be vehicle speed, velocity, acceleration or crush parameters. Some are easier to assess than others, and some are more relevant than others in particular accident circumstances. For this reason, a variety of measures is widely used.

Even when the impact severity parameters taken under consideration are correlated to the injury outcome, they are not necessarily responsible for injuries in terms of a causal reason. Other factors can also contribute to injury causation.

A description of these parameters, the information required to calculate them, and the methods by which they are assessed are given in Annex A.

The model shown in Figure 1 is an attempt to subdivide the sequence between the initial dose (physical input) and the response, defined as injury consequences. The parameters above the upper horizontal line are part of the pre-crash phase and constitute factors such as how the vehicle and the occupant appear in normal traffic immediately before impact. The dose, defined as the input into the complete system that cannot be affected by the vehicle, is the closing velocity. The parameters listed between the two horizontal lines occur during the crash phase (as defined in ISO 12353-1).

A complex dose–response system such as a vehicle impact can be divided into several different subdose–response systems according to the question under study. The different subdose–response systems may be seen within or between the shaded areas in Figure 1. Some of the factors influencing the injury outcome are hidden in the dynamic sequence, such as dynamic deformations, occupant trajectory and contact speed, while others, such as contact areas, change of velocity and final deformations of the vehicle, can be reconstructed or measured. In some cases, the dose–response model used depends on what it is possible to observe, estimate or measure, meaning that substitutes for better measurements are often used.

Clause 4 of this document is related to response in terms of injury, and Clause 5 is related to the vehicle response (e.g. deformations or interior damage).

Road vehicles — Traffic accident analysis —

Part 2:
Guidelines for the use of impact severity measures

1 Scope

This part of ISO 12353 describes the suitability of various measures for the determination of impact severity in road vehicle accidents. It also summarizes the main characteristics of the methods used for determining impact severity.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12353-1:2002, *Road vehicles — Traffic accident analysis — Part 1: Vocabulary*

ISO 6813, *Road vehicles — Collision classification — Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12353-1 and ISO 6813 and the following apply.

3.1
impact severity
changes in physical parameters of a specific vehicle due to a crash

See Figure 1.

NOTE This document deals with impact severity. Accident severity, crash severity and collision severity are different terms related to other vehicle and environment characteristics. Impact severity (or crash severity or collision severity) is not to be confused with injury outcome, which may be a consequence of impact severity. See also ISO 12353-1:2002, Clause 4.

4 Evaluation of impact severity relating to injury outcome

4.1 Overview of different severity parameters and measures

The severity of an impact can be described according to the sequence of accident events, as shown in Figure 2. Main severity parameters are shown in ovals. The squares describe information needed to be obtained and evaluated to reach the next level of severity measures.

NOTE 1 Each of these ovals has been used to describe impact severity. The suitability of measurements for predicting injury relating to each of these ovals is discussed in 4.2.

NOTE 2 Some of the needed information in the squares would be more difficult to obtain and evaluate than other information.

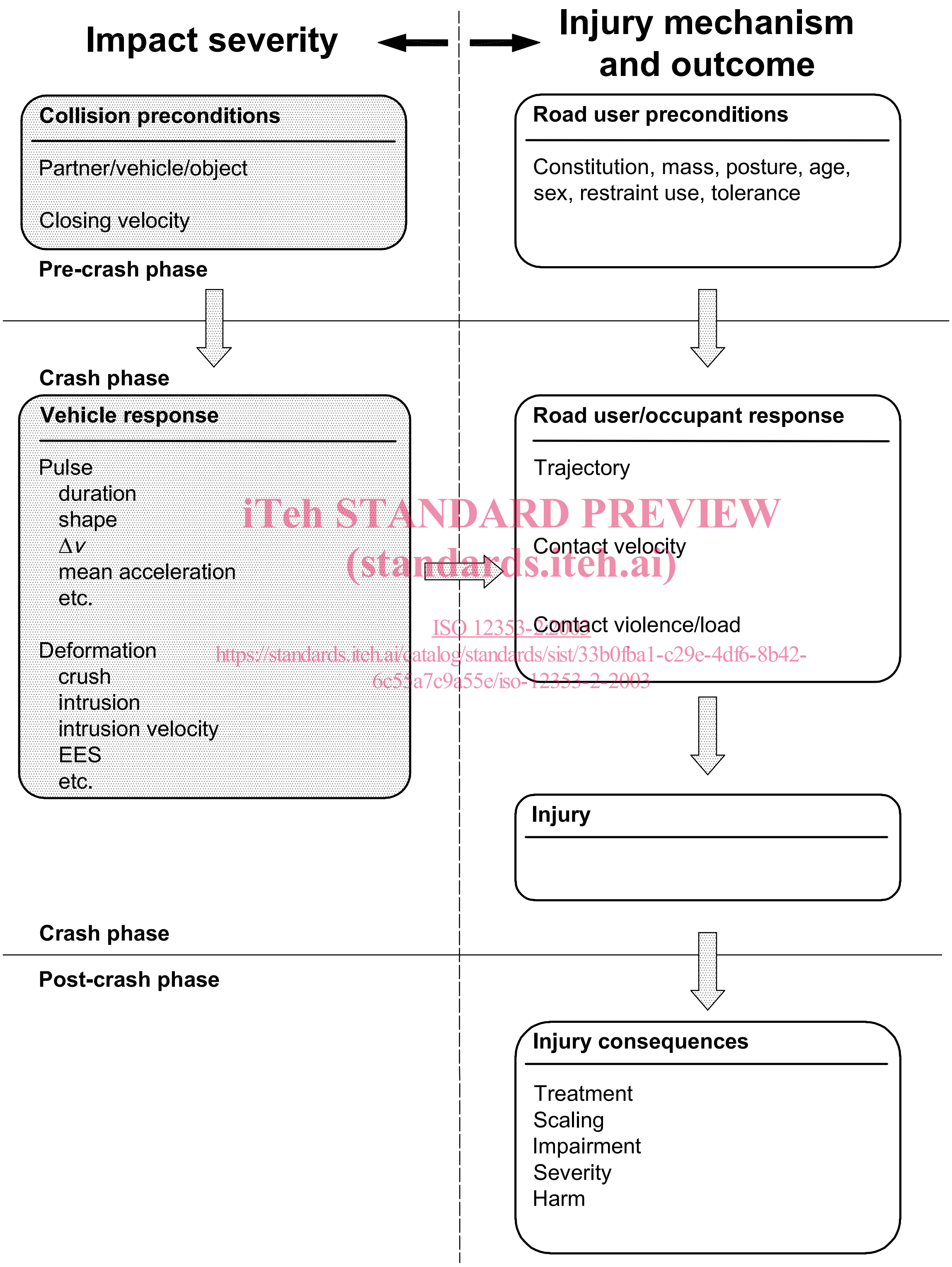

Figure 1 — Impact severity and injury mechanism/outcome (dose–response model)

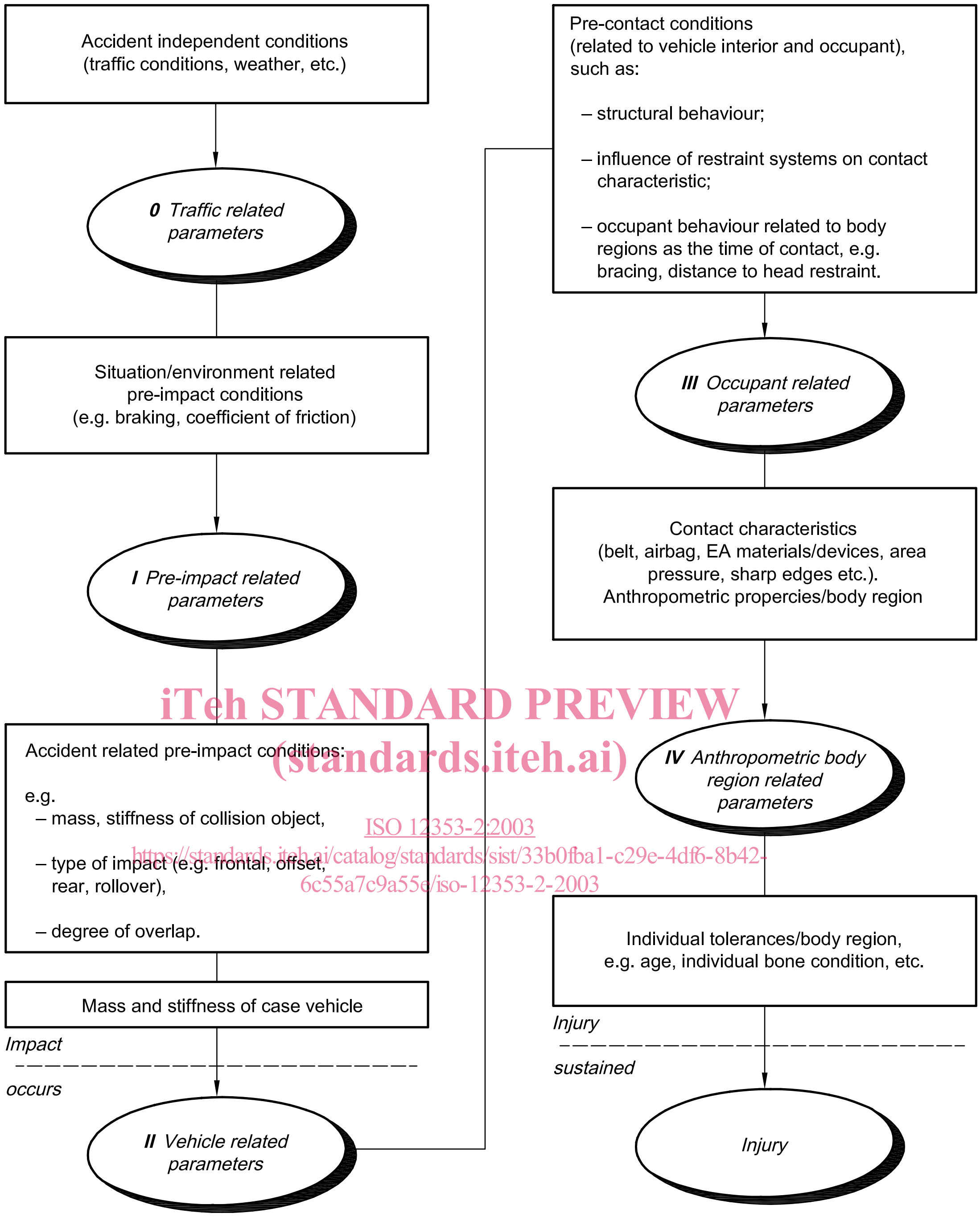

Figure 2 — Main severity parameters (ovals) and additional information to be obtained and evaluated (squares)

4.2 Suitability of parameters for description of impact severity

A number of parameters could potentially be used as measures of impact severity. These are summarized in Table 1 in categories that relate to pre-impact conditions, vehicle-related parameters, occupant-related parameters, etc.

Some of these parameters, such as the speed limit applicable to the accident site, are not considered to be suitable as measures of severity for any impact type. Others are considered to be suitable, but not necessarily for all impact types, as detailed in 4.3. For example, the change of velocity during impact, delta-v (Δv), might not be a sufficient impact severity parameter for crash types where compartment intrusion is a dominant injury factor or where mean acceleration is relatively low (intrusion velocity would be more appropriate).

NOTE Even where impact severity parameters are suitable for use and do correlate with injury, the relationship may not be causal. The extent of side door intrusion, for example, is considered to correlate with chest injuries not because it directly causes the injuries, but because it correlates with one of the causal factors (intrusion velocity).

Table 1 — Suitability of various parameters for describing impact severity

Main severity description[a]	Severity parameters	Suitability as an impact severity parameter	+ Advantage – Limitation	Comments
0 *Traffic related parameters*	• Speed limit • Travel speed	◊ No ◊ No	– Too remote from injury outcome	Active safety (road construction, traffic policy, risk exposure, traffic control devices)
I *Pre-impact related parameters*	• Impact velocity[b] • Closing velocity[c]	∗ Yes ∗ Yes	– Parameters from *II* are needed	Could be used for exposure data Representative crash test speeds for crash ratings and for development of vehicles (*collision* severity based)
II *Vehicle related parameters*	• Δv • EES • Damage extent, e.g. CDC[d] • Intrusion extent • Intrusion velocity • Mean acceleration • Crash pulse[e] derivatives	∗ Yes ∗ Yes ∗ Yes, partial ∗ Yes, partial ∗ Yes ∗ Yes ∗ Yes	+ Correlation with injury, but not necessarily causing injury – Vehicle dependent	To make crashworthiness comparisons possible between a case vehicle and other vehicle models, the impact severity parameter should ideally be independent of the characteristics of the case vehicle (Δv, for instance, also depends on the mass of the case vehicle).
III *Occupant related parameters*	Contact velocity and contact velocity history (between occupant body regions and vehicle interior or exterior, or objects)	◊ No, not vehicle-specific	+ Correlation with injury, but not necessarily causing injury – Vehicle and design dependent	Could be used • to improve safety design, • as a contact severity measure, • as a measure of impact severity for pedestrians.
IV *Anthropometric body region related parameters*	Load measurements in different body regions, e.g. HIC, VC, TTI	Not applicable	+ Correlation with injury severity – Vehicle and design dependent – Body region dependent	Comparison with dummy loads Biomechanical tolerances

[a] Crash sequence is defined in ISO 12353-1:2002, 5.2.

[b] See Clause A.3 and ISO 12353-1:2002, 5.9.

[c] See Clause A.4 and ISO 12353-1:2002, 5.12.

[d] See Clause A.1 and ISO 12353-1:2002, 4.3.11.

[e] See Clause A.9 and ISO 12353-1:2002, 5.22.

4.3 Suitability of measures and methods related to different impact types

Several impact severity measures can be relevant to study in the analysis of an impact. Some are more relevant than others when relating to injury outcome in a specific impact type.

Table 2 shows the impact severity measures concluded to be relevant for consideration with specific impact types.

Table 2 — Suitability of measures relating to impact types

Impact type	Impact severity measure								
	Damage extent	**EES**	**Impact velocity**	**Closing velocity**	Δv	**Mean acceleration**	**Intrusion extent**	**Intrusion velocity**	**Crash pulse**
Frontal impact, occupant at intrusion position	E	X			E	E	E	**XX**	E
Frontal impact, occupant not at intrusion position	E	E			X	X			**XX**
Side impact, occupant at intrusion position	E		E	X			E	**XX**	E
Side impact, occupant not at intrusion position	E	E			X	E			**XX**
Rear impact	E	E			E	X			**XX**
Unprotected road user struck by vehicle			X	**XX**					

XX = Preferred measure (if available) for impact type

X = Best if preferred measure is not available

E = Expected relationship

5 Evaluation of impact severity relating to vehicle response

In order to evaluate vehicle response, it is essential to know the closing velocity between the involved vehicles or between the vehicle and the object. It is also necessary to know all crash preconditions (impact angles, vehicle mass, contact points, etc.).

The response of the vehicle provides some input relating to the occupant response. Characteristics showing vehicle response (see also Figure 1) are

— crash pulse,

— parameters derived from the crash pulse, and

— dynamic and residual deformations.