

TECHNICAL REPORT

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Road vehicles — Risk of thoracic injury associated with Hybrid III sternal deflection due to shoulder belt loading

*Véhicules routiers — Risque de blessure au thorax associée à la déflexion
du sternum de l'Hybrid III due à la charge de la ceinture d'épaule*



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ISO/TR 13219, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee 12, *Restraint systems*.

This document is being issued as a type 3 Technical Report for the reasons given in the Introduction.

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Case Postale 56 • CH-1211 Genève 20 • Switzerland

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Introduction

A diagonal shoulder belt is used in many vehicle restraint systems to restrain the torso of the occupant during collisions. In most accidents, the shoulder belt provides excellent restraint. However, if the accident is severe enough, the loads applied to the torso by the shoulder belt can injure the thorax. One goal of the restraint engineer is to optimize the design of the shoulder belt to reduce the risk of belt-induced thoracic injuries. To assess this risk, restraint system tests are conducted that simulate various frontal accident collision severities. The Hybrid III dummy [1] [2] is used as the occupant surrogate and sternal deflection is used as the measure of thoracic injury risk. For a given simulated collision severity, the belt restraint design that gives the lowest sternal deflection is judged to have the lowest risk of inducing thoracic injury.

Mertz *et al* [3] conducted a study to develop a relationship between the risk of significant thoracic injury ($\text{AIS} \geq 3$) and Hybrid III sternal deflection for shoulder belt loading. An analysis was made of Association Peugeot-Renault accident data [4] of occupants who were restrained by three-point belt systems that used a shoulder belt with a force-limiting stitching. For 342 of these occupants, the magnitude of the shoulder belt load could be estimated from the amount of force-limiting stitching tearing. Hyge sled tests were conducted with a Hybrid III dummy to reproduce the various degrees of stitching tearing. A linear relationship existed between the shoulder belt loads that produced various levels of stitching tearing and the corresponding Hybrid III sternal deflections. The resulting Hybrid III sternal deflections were correlated to the frequencies of $\text{AIS} \geq 3$ thoracic injury observed for similar stitching tearing in the accident data. These results were subjected to two different statistical analyses, Probit and bounded analyses to obtain curves of the risk of $\text{AIS} \geq 3$ thoracic injury as a function of Hybrid III sternal deflection for shoulder belt loading. These analyses produced risk curves that were closely matched and both were within the calculated error bounds : see figure 1.

Foret-Bruno and Bendjellal [5] also conducted sled tests with the Hybrid III dummy using the APR force-limiting belt system. Their results were in agreement with those of Mertz *et al*. Horsch *et al* [6] compared the injury risk curve of Mertz *et al* to other published data [7]. They found similar estimates of risk based on their analysis.

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Road vehicles — Risk of thoracic injury associated with Hybrid III sternal deflection due to shoulder belt loading

1 Scope

This Technical Report provides a curve of the risk of AIS ≥ 3 thoracic injury as a function of Hybrid III sternal deflection for shoulder belt loading. This curve can be used to assess the risk of belt-induced thoracic injury for restraint systems that use a shoulder belt. The risk curve only applies to Hybrid III sternal deflection measurements, that is provided by Hybrid III anthropometric test device as defined in [1] and [2].

2 Injury risk curve

The Probit analysis developed by Mertz *et al* [3] was chosen for the injury risk curve. This curve and its 95th confidence limits are shown in figure 2. The curve can be used to give an estimate of the risk of a shoulder belt-induced AIS ≥ 3 thoracic injury for simulated frontal accident collisions conducted using a Hybrid III dummy where sternal deflection is measured.

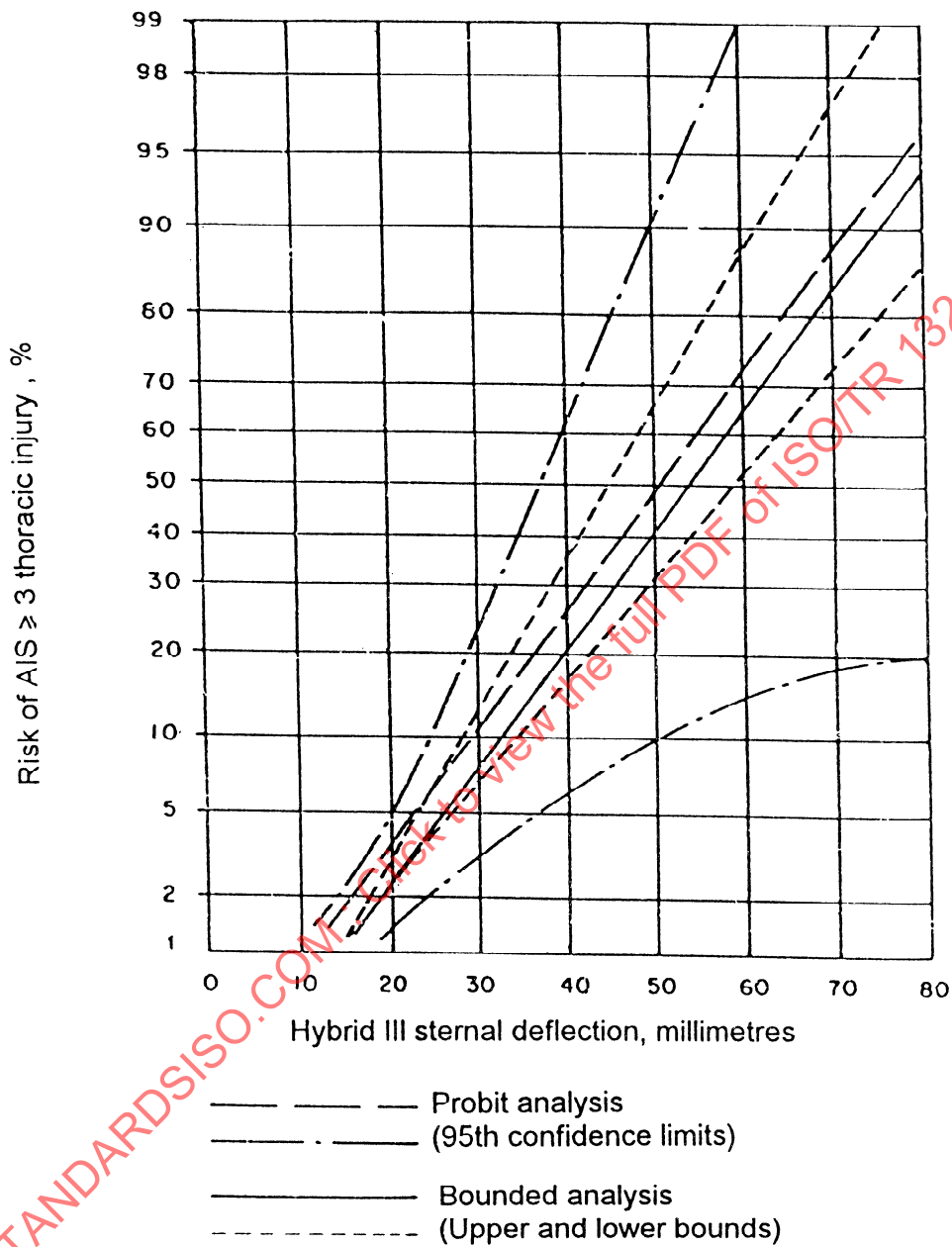


Figure 1 - Risk of AIS ≥ 3 thoracic injury as a function of Hybrid III sternal deflection due to shoulder belt loading
(curve obtained by Probit analysis and bounded analysis)

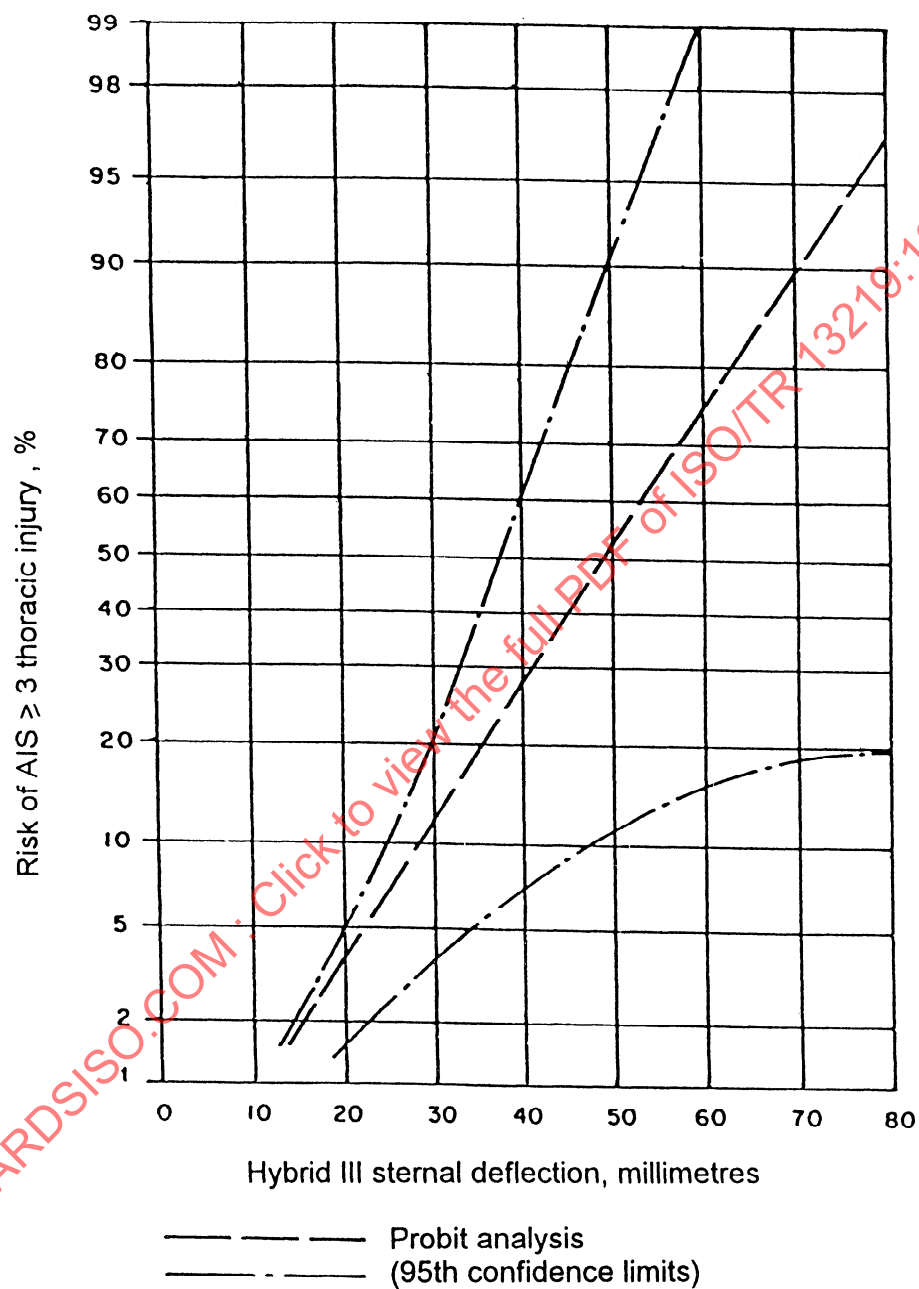


Figure 2 - Risk of AIS ≥ 3 thoracic injury as a function of Hybrid III sternal deflection due to shoulder belt loading (curves obtained by Probit analysis)

Annex A

(informative)

Bibliography

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