7TH WCTR
SYDNEY AUSTRALIA
1 9 9 5

TOPIC 22
HIGH SPEED RAIL

STATUS OF THE NEW STANDARD FOR SAFETY REQUIREMENTS FOR THE HIGH-SPEED MAGLEV TRAINS BEING DEVELOPED IN GERMANY

RÜDIGER VOM HÖVEL
TÜV Rheinland Sicherheit und Umweltschutz, ISEB
Institute for Software, Electronics, Railroad Technology
Cologne, GERMANY

HERBERT JANSEN
TÜV Rheinland Sicherheit und Umweltschutz, ISEB
Institute for Software, Electronics, Railroad Technology
Cologne, GERMANY

Abstract

In March 1991 TUV Rheinland published the first issue of safety requirements for high-speed Maglev trains. The revision of these requirements started in 1993 and is still going on. The experience gained by running the Maglev system at TVE, the TRANSRAPID trial field in Emsland, Germany and discussions with experts from US DOT are also included in this new document.

INITIAL SITUATION

When a licence is issued in Germany for the conveyance of passengers, it must satisfy a whole hierarchy of laws, ordinances and technical regulations. While the situation for railways, tramways and other forms of public transport is clearly regulated, a number of important stipulations applicable to high-speed Maglev systems are still not in place at the present time.

Article 73, clause 6a of the Constitution (Grundgesetz) [1] declares that the Federal Government has "exclusive responsibility for legislating on the operation of railways which belong wholly or in the majority to the Federal Government (the Federal Railways), the construction, maintenance and operation of the tracks of the Federal Railways and on the levying of charges for the use of those tracks". "Concurrent legislative powers" are established in Article 74, clause 23 of the Constitution (Grundgesetz) in respect of "rail systems which are not Federal railways, with the exception of mountain railways". On the basis of Article 73, clause 6a, the Federal Railways Agency Act of December 13, 1951 [2] (now valid only to a limited extent), the Railways Reorganizing Act [3], and the General Railways Act [3] among others, have been passed up to the present time. The General Railways Act [3], the Passenger Transport Act [4] and the Land Railway Acts applying in the individual Länder are based on Article 74, clause 23. As a whole series of commentators define railways in general as transport routes with a fixed track, one may assume that high-speed Maglev systems can be included in this category. But this does not apply.

Even though magnetic high-speed rail systems are clearly carried and guided magnetically along a fixed track, it became apparent the very first time such a system was to be licensed for the carriage of passengers, on the demonstration line at the International Transport Exhibition (IVA) in Hamburg in 1979, that the existing legislation for tracked passenger conveyance systems did not adequately satisfy the special features of magnetic support and guidance. An expert report in 1977 (Jansen 1977) accordingly recommended the application of the Pilot Plants Act (Versuchsanlagengesetz) [5]. It was consequently not necessary to classify the TRANSRAPID 05 in one of the ordinary passenger transport systems (tramway, railway, etc.), as the Act is generally applicable to the construction and operation of experimental installations for the testing of technologies for tracked transport.

A common feature of the laws applicable to passenger transport (the Passenger Transport Act, the Land Railway Acts, the General Railways Act) is that they lay down only general objectives with regard to safety. Thus, for example, Section 4, "Safety regulations", of the General Railways Act [3] states that "the railways are obliged to conduct their operations safely, to construct the railway infrastructure, rolling stock and equipment safely and to maintain them in an operationally safe condition". No technical requirements are laid down in the Act. That is the task of the subordinate regulations. In this connection, Section 26 of the General Railways Act stipulates that legally binding regulations are to be issued for public railways which "shall uniformly regulate the requirements to be set for the construction, equipment and method of operation of the railways in accordance with the requirements of safety, the latest technical knowledge and international agreements". Such regulations for railways are to be found in the form of the Railway Construction and Operation Order (EBO), the Railway Signalling Order (ESO) and the Railway Traffic Order (EVO). These regulations contain a series of technical specifications for installations, rolling stock, operation and staff, which on the one hand are intended to contribute to harmonisation within one category of means of transport and on the other to enact regulations appropriate to the means of transport in the matter of safety and good order. To this end, reference is made as far as possible to the acknowledged rules of technology (eg standards and norms) in order to meet the requirements with regard to safety and good order.

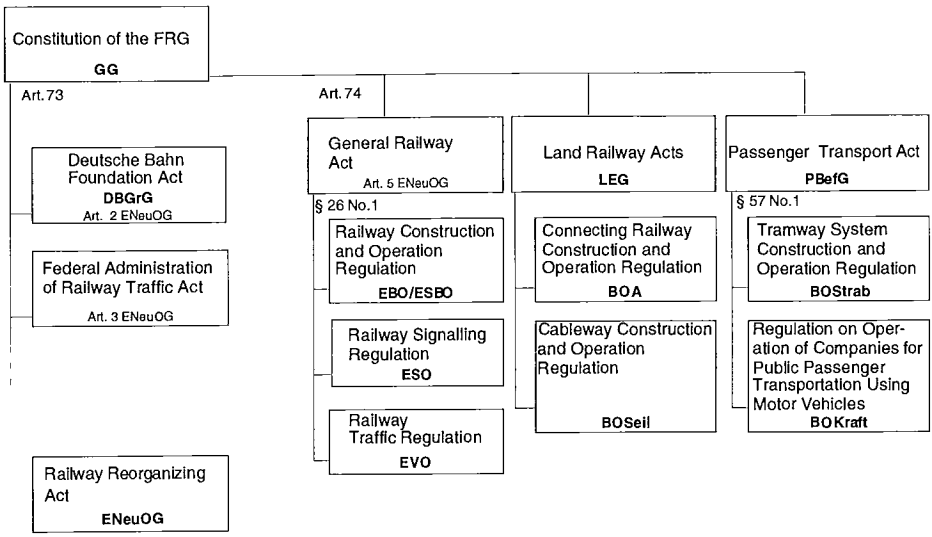

Figure 1 Laws and regulations for construction and operation of public passenger conveyance in the FRG

THE PILOT PLANTS ACTS

As the existing laws and regulations described the specific features of the various means of transport in too much detail, they could not be applied either to the above-mentioned installation at the International Transport Exhibition in Hamburg or to the TRANSRAPID test facility in Emsland (TVE). The Pilot Plants Act allowed the maximum possible freedom for an innovative system such as the TRANSRAPID. No rules are set out in it for the safety equipment of the installation. The only requirement is that operating instructions must contain provisions which are to be drawn up for the method of operation of the pilot plant in the interests of safety and good order, including protection against immissions. The operating instructions are to be submitted to the highest competent Land authority for approval. Operation may not commence until the highest competent Land authority or the organisation appointed by it has approved the operating instructions.

Such far-reaching freedom is of course accompanied by far-reaching obligations. In each individual case it must be ascertained whether a given technical solution is sufficiently safe. The advantage is that one is free to examine new solutions, but on the other hand one has a reduced security of planning. In each individual case it must be established whether there are comparable provisions in other regulations, or whether recognised rules of the art have already specified a particular level of requirements. If there are not yet any rules governing a particular technical solution, one must establish what the state of the art is in similar cases (eg not in the transport area) and use that as a reference.

FIRST EDITION OF THE RULES FOR HIGH-SPEED MAGNETIC LEVITATION TRAINS

In order to reduce this uncertain situation, a start was made early on, in parallel with the technological development of high-speed Maglev system engineering at the Emsland test facility, on the elaboration of a set of technical rules for this technology. To this end, a working group on "Rules for high-speed Maglev systems" was set up in 1987, which was to bring together the

experiences of all those groups in Germany that were involved in the development, construction and operational testing of high-speed Maglev systems. The results of this work were published by TÜV Rheinland, Cologne, in March 1991 under the title "Regelwerk Magnetschnellbahnen, sicherheitstechnische Anforderungen" (Rules for high-speed Maglev systems. Safety engineering requirements for high-speed Maglev systems). In the course of the investigations for licensing of a high-speed Maglev system in Florida, this document was translated into English by the US Department of Transportation (DOT) and published there [7].

FURTHER DEVELOPMENT OF THE RULES

Further development of TRANSRAPID technology and the experience gained as a result, together with feed-back from the cooperation with the US DOT, revealed the need for a revision of the existing set of rules and an extension of its area of application, bearing in mind the use of TRANSRAPID for a public service. In 1993 funds for a revision were made available by the then Federal Ministry for Research and Technology, now known as the Federal Ministry for Education, Science, Research and Technology. This set of rules will be completed by the end of 1995. Unlike the first edition, the rules will be divided into Part 1: Safety engineering requirements (RW MSB-1) and Part 2: Safety engineering proofs (RW MSB-2).

Part 1 of the set of rules contains requirements for the safe operation of high-speed Maglev systems (safety targets), which are specific to the system and are not covered by other sets of technical rules already in existence . In addition it gives references to safety engineering rules that are generally mandatory in railway engineering.

Part 2 of the set of rules indicates what evidence is to be produced in order to satisfy the requirements according to Part 1. It thus details the validation and verification means to cover all the technical requirements and their observation which is a precondition for the issue of operating licences.

A high-speed Maglev system coming within the area of application of these rules is considered to be technically safe and suitable for licensing when the proofs according to Part 2 showing compliance with the requirements according to Part 1 have been produced for it. Questions of approval under building regulations are not covered by this set of rules.

These rules incorporate the experience accumulated by the organisations concerned in Germany in the course of the development, construction and testing of high-speed Maglev systems up to the present day. To that extent the rules reflect the current situation with regard to safety engineering and are to be given the status of a recognised rule of technology. They will be applicable as from 1.1.1996. At that time the Rules for high-speed Maglev systems, safety engineering requirements, first edition, March 1991 will expire.

Dyckerhoff & Widmann
Siemens Erlangen
Siemens Braunschweig
Thyssen Henschel
Deutsche Bahn AG
Versuchs- und Planungsgesellschaft für Magnetbahnsysteme
Industrieanlagen Betriebsgesellschaft
Eisenbahn-Bundesamt
Institut für Bahntechnik
TÜV Bayern Sachsen
TÜV Hannover/Sachsen-Anhalt
Dornier
Leadership: TÜV Rheinland Sicherheit und Umweltschutz GmbH

Figure 2 Organisations involved in discussion and revisions of RW MSB

SCOPE

The area of application of these safety engineering requirements covers high-speed Maglev systems using magnetic levitation technology with long-stator propulsion of the "TRANSRAPID" type. Distinctive features of vehicles used in this transport system are the integrated, non-contacting load-carrying, guidance and propulsion function implemented by several autonomous functional units of the load-carrying and guidance system and the battery-buffered on-board power supply system with linear induction generator feed. The guideway is constructed at ground level and/or elevated and consists of a foundation, pillars and load-bearing beams, on which the lateral guide rails are fitted at the sides. The stator packs with the long stator winding are located on both sides underneath the upper track (see Figure 3). The vehicle is wrapped around the guideway girder and is suspended magnetically on it and guided magnetically on both sides. Service and special-purpose vehicles required for assembly, inspection and maintenance purposes or for use during the commissioning process are not subject to this standard. These vehicles are governed by the normal construction and operation regulations and by the occupational health provisions of the Berufsgenossenschaften (Industrial Injuries Insurance Institutes).

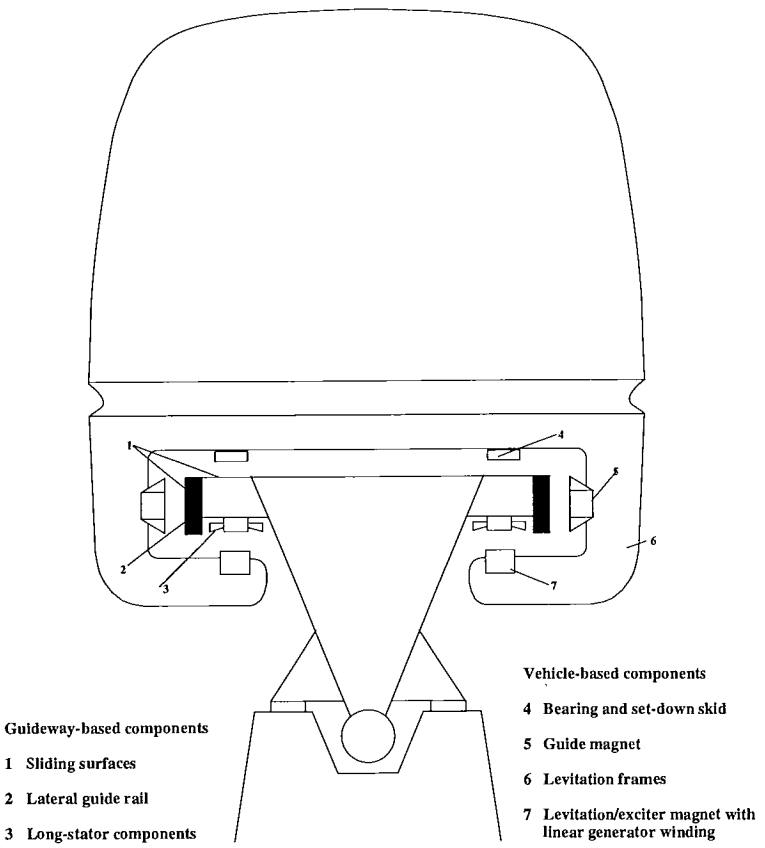

Figure 3 Essential features of the magnetic levitation technology

Under functional headings, the rules define all the safety engineering requirements and the proofs that must be observed, and constitute the precondition for the issue of an operating licence for a high-speed Maglev system.

The proofs mentioned in these rules constitute, when taken as a whole, the safety case for a high-speed Maglev system. This involves the proof that no impermissible safety risks arise from the operation of the high-speed Maglev system and its associated equipment. At the same time, the load assumptions for the civil engineering structures are defined and the rules to verify them, ie the influences and combinations of influences affecting the dimensioning of the civil engineering components are described.

STRATEGY FOR CERTIFICATION

In order to bring a high-speed Maglev system to readiness for certification, both so-called "higher-ranking" proofs and individual proofs, covering all sub-systems and components having an impact on safety, have to be produced. The higher-ranking proofs are specified in folio 1 of the set of rules; individual proofs for sub-systems and components—in detail described in the following folios—may form constituent parts of the higher-ranking proofs, ie for system safety. In order to identify the sub-systems that are relevant for safety, however, the complete system had first to be broken down appropriately. Because of the complexity of a high-speed Maglev system and its specific characteristics, a break-down was made to 14 subsystems. In this set of rules, folios 2 to 15 examine the 14 relevant sub-systems, which in turn are made up of components. This sub-division into higher-ranking proofs and individual proofs for sub-systems and components was introduced on the basis of the system-specific features and has to that extent been undertaken entirely from the point of view of engineering and practicability.

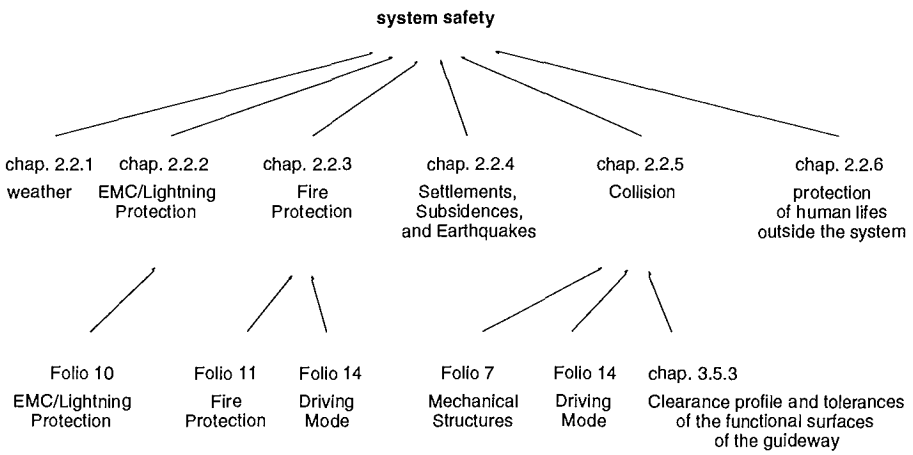

Figure 4 Requirements for system safety from external impacts with reference to chapters of folio 1 and dedicated folios

The methods applied for testing and certification, in particular the interaction between the manufacturer and the independent body, can take a wide variety of forms, without an optimum solution from every point of view being apparent. For railway applications European developments envisage an individual testing and certification procedure conducted by the so-called nominated bodies for the various national constituents of the high-speed railway network, ie the so-called part-systems, which eg also include the rolling stock. The components are to be dealt with by the nominated bodies in accordance with the modular system the of EC conformity assessment procedure. These procedures are to be transferred as appropriate to high-speed Maglev systems as far as the sub-systems and components are concerned, the "nominated body" being replaced by "independent body", as long as there are no nominated bodies in the European railway sector.

EXAMPLES FOR TRANSRAPID-SPECIFIC REQUIREMENTS

A typical higher-ranking requirement for TRANSRAPID technology is, without any doubt, the principle of "safe hovering". From this a large number of requirements for the sub-systems is derived. The concept of "safe hovering" characterises the ability of the high-speed Maglev system to maintain its hovering function, even in the severest fault and emergency situations that can be assumed, at least long enough to permit limited and brief further movement until a stopping point can be reached. "Safe hovering" thus means the impossibility of grounding above a predetermined speed.

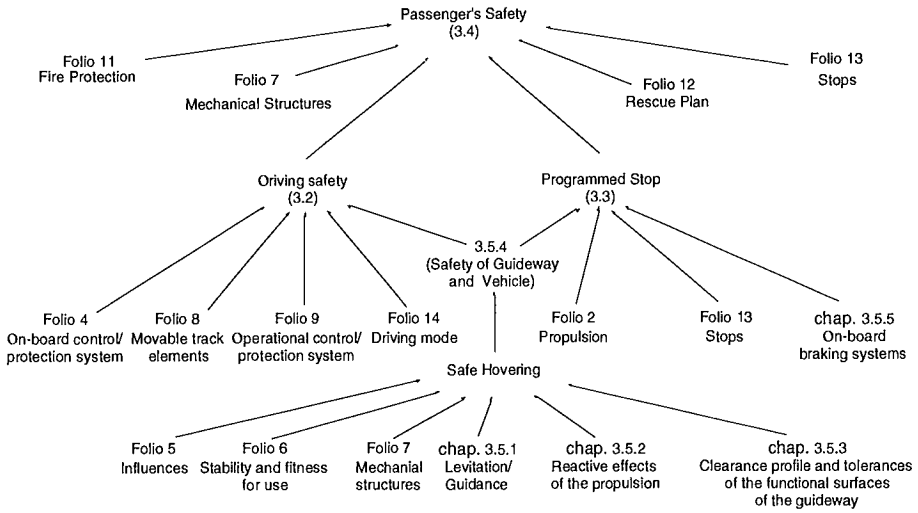

Figure 5 Intrinsic Requirements of High-Speed Maglev Systems with reference to chapters of folio 1 and dedicated folios

Based on "safe hovering", the so-called "stop concept" can be achieved, which is the unconditioned ability to reach predetermined stopping points and basis for a specific rescue strategy. Even if the traction current fails at any point along the line, the vehicle must be able to continue running to its preselected stopping point, drawing on its instantaneous kinetic and potential energy and with braking from a safe supplementary brake that is fundamentally independent of the drive system. If a fault or emergency situation arises, the vehicle must be brought to a halt at this predetermined stopping point by the application of the controlled emergency brake (or combination of brakes).

This so-called "stop concept" means that, from the safety engineering point of view, not only the maximum speed but also the minimum speed must be monitored. This requires a so-called "permissible speed range" (see Figure 6).

In order to ensure "safe hovering", the following incidents must be excluded with a sufficient degree of probability:

- loss of the levitation/guidance function (levitation/guidance system itself or induced by the drive system),
- damage of the vehicle clearance envelope.

From this higher-ranking TRANSRAPID-typical requirement a series of requirements affecting the sub-systems is derived which, according to their type, are well known from conventional tracked systems but whose range of functions is adapted to suit TRANSRAPID.

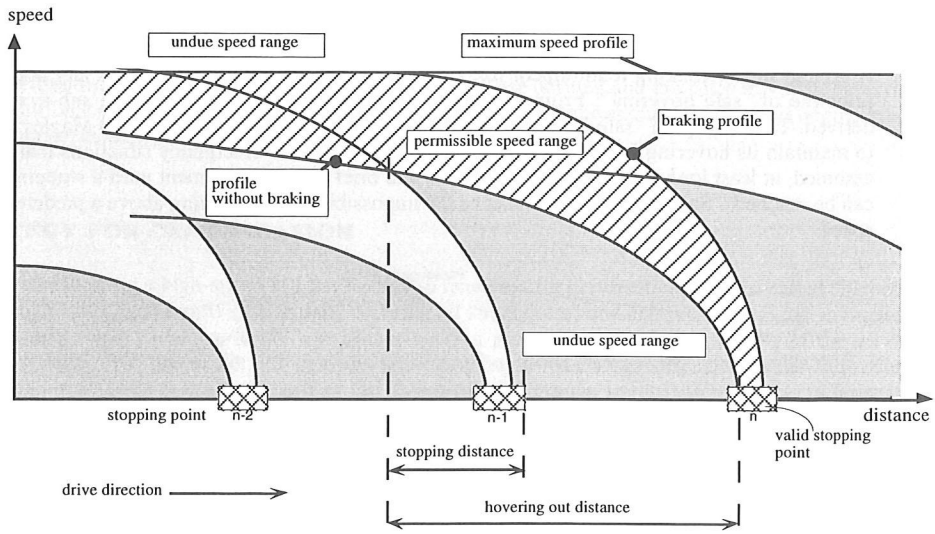

Figure 6 Permissible speed range

After Folio 0 which contains general explanations, and definitions in Part 1 (RW MSB-1) and explains the general procedure in Part 2 (RW MSB-2), and Folio 1, which deals with the higher-ranking requirements (RW MSB-1) and its applicable safety cases (RW MSB-2), the subsequent folios are concerned with sub-systems. These folios are also segregated into a document for requirements (Part 1) and one for measures to prove safety (Part 2). Covered are the following topics:

Folio 2 Drive system
Folio 3 On-board energy supply
Folio 4 On-board control system
Folio 5 Load assumptions
Folio 6 Proofs of static safety
Folio 7 Mechanical structures
Folio 8 Movable guideway elements
Folio 9 Operational control engineering
Folio 10 EMC/lightning protection
Folio 11 Fire protection
Folio 12 Rescue concept
Folio 13 Stopping points
Folio 14 Operating concept
Folio 15 Maintenance

INCORPORATION OF THE SET OF RULES INTO LAW AND REGULATIONS

Work on the set of rules started at a time when no legal basis existed for the licensing and operation of high-speed Maglev systems. Since then—on 23.9.1994—the Magnetic Levitation System Planning Act (MBPlG) [6] has been passed by the Bundestag and Bundesrat. This Act

regulates the (simplified) planning procedure, appoints the Federal Department of Railways (Eisenbahn-Bundesamt) as the planning approval and construction supervision authority and authorises the Federal Minister of Transport to issue a Regulation on the construction and operation of a Maglev system (MbBO). At the end of 1994 a committee was set up in the Ministry of Transport to draft the MbBO. All the relevant parties are involved in this committee, which is coordinated by the Ministry of Transport. TÜV Rheinland is also participating in this work because of its many years of experience in certifying Maglev-Systems. The objective in drawing up the MbBO is to produce a legal regulation that is as uncomplicated and generic as possible and is intended to harmonise the construction and operation aspects of Maglev systems in a non technology-dependent way. From the safety engineering point of view the MbBO will be based completely on the set of rules for high-speed Maglev systems which is now in preparation. An initial draft of the MbBO is expected in mid-1995.

In the same way as for other passenger transport systems (see Figure 1), by the end of 1995

- the Magnetic Levitation System Planning Act (later in conjunction with the General Magnetic Levitation Trains Act, AMbG);
- the Maglev System Construction and Operation Order; and
- the Rules for High-speed Maglev Systems (second edition)

will provide a complete basis for the licensing of the TRANSRAPID link between Hamburg and Berlin, which was given the go-ahead by the German Government in September 1994 and is expected to come into service in 2005.

REFERENCES

[1] (1994) Grundgesetz für die Bundesrepublik Deutschland (Stand Nov. 1994), das Deutsche Bundesrecht, Baden Baden.

[2] Bundesbahngesetz (vom 13. Dez. 1951), widely superseded by [3] as from 1st January 1994.

[3] (1993) Gesetz zur Neuordnung des Eisenbahnwesens (ENeuOG) vom 27. Dez. 1993, incorporating as Section 5: Allgemeines Eisenbahngesetz (AEG).

[4] Personenbeförderungsgesetz (PBefG) vom 08. August 1990, Stand 27. Dez. 1993.

[5] (1976) Gesetz über den Bau und Betrieb von Versuchsanlagen zur Erprobung von Techniken für den spurgeführten Verkehr, vom 29. Jan. 1976.

[6] (1994) Gesetz zur Regelung des Planungsverfahrens für Magnetschwebebahnen (MBPlG) vom 23. Nov. 1994.

[7] High-Speed Maglev Trains; German Safety Requirements RW-MSB (Translation of German Regelwerk Magnetschnellbahnen—Sicherheitstechnische Anforderungen), DOT/FRA/ORD-92/01, series Safety of High Speed Magnetic Levitation Transportation Systems.

Jansen, H. (1977) "Entscheidungskriterien für die rechtliche Beurteilung des Baus und Betriebs einer Demonstrationsanlage für Magnetschwebetechnik zur Personenbeförderung in Hamburg" (Decision criteria for the legal evaluation of the construction and operation of a demonstration installation for magnetic levitation technology for the carriage of passengers in Hamburg), TÜV Rheinland, Cologne.