AN EXAMINATION AND COMPARISON OF PASSENGER TRANSPORT BUS OCCUPANT PROTECTION REGULATIONS ACROSS 5 CONTINENTS

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ABSTRACT

A research project was undertaken to understand, compare and contrast the government regulations for mid to large size (mostly greater than 16 passengers) transport busses. The continent countries examined included Australia, Europe, Canada, United States, South Africa, Brazil, Chile and Peru. The occupant protection regulations examined included the requirements for superstructure capabilities, seat and seat attachments, seat belts and seat belt anchorages.

INTRODUCTION

Motor Coach/Bus (MCB) Regulations vary significantly around the world. After investigating a recent transport bus crash that included several fatalities, the team at Safety Engineering embarked on a research project to outline the differences in Governmental MCB Regulations for eight countries on 5 continents. Our main focus was on the occupant protection regulations that govern structural components and internal safety features. The investigated countries are shown with red stars on the global map in Figure 1.

Figure 1. Stars indicate country researched.

Types of Regulations Investigated

The main focus of our research comparison was the MCB superstructure regulations as adopted by various countries from the original United Nations joint resolution called the UN–ECE/R66 rule. [1] This regulation governs the superstructure strength minimum pass/fail testing requirements and has roof and side structure intrusion and deformation limits to protect occupants. The specific manufacturing and testing requirements for superstructures in the regulations are compared.

This research also investigated the associated regulations for internal occupant protection safety systems including seat belts, seats and the anchorage systems for both. It should be noted that there are both requirements for “having” seat belts on the MCB as well as requirements for “wearing” seat belts while riding in the MCB.

Application of Regulations

The research indicates that there are two main areas that classify the applicability of the regulations to any given MCB. First, some countries differentiate by MCB Service Type, i.e.: Public vs. Private Transport vehicles, and/or Paid vs. Free Transport vehicles, where some regulations apply to one and not the other. The second type of differentiation is the classification for the size of the MCB. There is some correlation of a global standard for MCB size classification, the “Category M” class which is almost universally used, but most countries had extensions, modifications and/or sub-classes for specialized vehicles such as the Double Decker MCBs found predominantly in Europe.

REGULATIONS RESEARCH

MCB Regulations vary significantly worldwide, from none at all to strict and seemingly affective standards. Some of the countries examined either didn't have regulations, didn't have regulations related to the superstructure or didn't have regulations for busses in the private sector. As a baseline understanding for these comparisons, the superstructure, seat belts and seat requirements are outlined in the next section.

Superstructure Regulations

Superstructure regulations for MCBs worldwide vary considerably. The Superstructure is defined as the *uppermost structural components* that form the outline of the imaginary envelope around the occupants, sometimes called the "Occupant Survival Space" or "Residual Space". These regulations are in place to govern MCB manufactures and the testing requirements that must be passed to limit intrusion and subsequent occupant injury from intrusion. A listing of these regulations by researched country is shown in Table 1. Three of the eight have adopted some form of United Nations Economic Commission for Europe (UNECE) Regulation No. 66 (R66), ECE/R66 the European Superstructure Standard.

Table 1.
MCB Superstructure Regulations by Country

Superstructure Regulations/Standards	
United States	N/A
Europe (ECE)	R-66
Australia (ADR)	59
South Africa (SANS)	1563
Canada	N/A
Peru	N/A
Brazil	N/A
Chile	N/A

History of ECE/R66 Superstructure Standard

The standard for MCB's Superstructure in Europe is ECE/R66. The regulation originated at the United Nations (UN) in Geneva in 1958 and entered into force in 1986 by the UN where 40 countries adopted the regulation shown in Table 2.

In 2002, at the UN 82nd Working Party on General Safety Provisions (GRSG) conference, the regulation was reviewed by informal expert groups who made recommendations to improve the regulation. ECE/R66 has been revised and amended several times over the last ten years with the most recent revision being in 2010, where they changed the language to define a "double-decker bus" and renumber the regulation.

Table 2.
Countries that Adopted ECE-R66 at the Original United Nations Inception: 1986

Countries That Have Adopted ECE-R66*		
Europe		
Germany	Turkey	Finland
Ireland	Latvia	France
Spain	Denmark	Croatia
Bulgaria	Switzerland	Malta
Romania	Slovenia	Lithuania
Netherlands	Austria	Poland
Slovakia	Hungary	Sweden
Luxembourg	Portugal	Belarus
Norway	Belgium	Italy
Czech Republic	Estonia	Greece
United Kingdom	Russian Federation	
Serbia/Montenegro	Bosnia/Herzegovina	
Asia		
Azerbaijan	Cyprus	Ukraine
Japan	Korea	
The former Yugoslav Republic of Macedonia		
Australia		
Australia	New Zealand	
Africa		
South Africa		
*Not all requirements of ECE-R66 were adopted by all countries.		

Application of Superstructure Regulations by Country Researched

A comparison of this standard with the other requirements we found, and how they are applied, reveals that the most advanced standard in terms of

crashworthiness is the ECE/R66. It requires MCBs to pass a superstructure strength test for compliance. This strength test includes the mass of the occupants in the MCB and to comply, the Superstructure must NOT intrude in to the "Residual Space" that surrounds the passenger seating locations. Both Australia and South Africa were among the countries that adopted ECE/R66 via the UN in 1986. However, both the Australian and South African standards have omitted the requirement to include the passenger mass as part of the test requirement. The United States and Canada do not have a MCB superstructure standard. In 2015, they will be instituting FMVSS 216 and CMVSS 216, a static roof strength test that requires a roof strength to vehicle weight ratio of one and a half for compliance and applies to vehicles with gross vehicle weight between 6000 and 10000 lbs, which may apply to some smaller MCBs.

The South American countries of Brazil, Chile and Peru also do not have a superstructure standard. Our study shows that these countries have the most risk of injuries due to rollovers for several reasons including poor road conditions, the lack of seat belt use, availability of black market driver's licenses, poor traffic regulations and a relatively older fleet of vehicles that most likely don't have ESC or other passive safety systems seen in newer vehicles.

Seat Belt "Wearing" Regulations

The general consensus from a global point of view is that seat belts should be worn on MCBs. Over the last ten years a number of countries have instituted regulations that make seat belt wearing on MCBs mandatory. The countries that have mandatory MCB seat belt wearing standards are Europe and Australia *if* there are belts in the bus. In 2015, Australia will have visual and auditory belt minders that will alert the driver. South Africa has a mandatory requirement for the driver of the bus and the driver/passenger relief person. Although the US currently has no standard, NHTSA recently proposed an amendment to FMVSS 208, the occupant protection standard, to include seat belts on MCBs of greater than 26000 lbs. A breakdown of mandatory belt use by country is in Table 3.

Table 3.
MCB Seat Belt "Wearing" Regulations

Countries **with** Mandatory **Wearing**	Countries **without** Mandatory **Wearing**
Europe (if equipped)	United States
Australia (if equipped)	Canada
South Africa (driver + relief driver only)	Brazil
Chile* (+ 2008 MY for public transport only)	Peru

Seat Belt and Anchorage Regulations

Most countries researched had some sort of seat belt and/or anchorage requirement for MCBs. Australia has the most stringent regulations including mandatory belts in MCBs as well as the mandatory wearing of belts. Table 4 shows the regulations.

Table 4.
MCB Seat Belts & Anchorages Regulations

Seat Belts & Anchorages	
United States	209, 210**
Europe	R14
Australia	4-05, 5-05
South Africa	1080, 1563, 1564, 20014
Canada	210, 209, 210.1-.2
Peru	Annex III
Brazil	N/A
Chile	Decree 122
** Driver's seat only (NPRM 208 – All Passengers, 2015)	

Seat Anchorage Regulations

It should be noted here that a significant finding from accidents investigated in Australia shows that in both rollover and frontal crashes, injuries in MCBs can occur from poor seat and seat belt anchorages allowing the seats and belts to come loose. Australia has increased the load requirements for both to prevent the seats and seat belt anchorages from dislodging under a 25g load. Table 5 shows the countries that have regulations for seat anchorages.

Table 5.
MCB Seat Anchorage Regulations by Country

	Seat Strength	Seat and Seat Anchorage
United States	207	207
Europe	R17	R80
Australia	66	3-03
South Africa	1429, 1430, 20017	1564
Canada	207	207
Peru	Annex III	
Brazil	N/A	N/A
Chile	N/A	N/A

Both seat and seat belt anchorages can have a significant effect on the injury potential for the passengers inside the MCB. The photo in Figure 2 shows how the seat anchorage comes loose and the seat rows pile up on each other.

Figure 2. Seat Attachment Failure in MCB Rollover

REGULATION RESEARCH BY COUNTRY

The following sections contain the information gathered for the various counties in this study. Included in each section are the regulatory requirements for MCBs and specifically how they compare to the ECE-R66 requirement.

Regulations in Europe

The specific ECE/R66 regulation has been adopted by the European countries listed in Table 6. However, as each country adopted the regulation they may or may not have added or deleted from the specific section of the original regulation.

Table 6.
17 European Union Countries with ECE/R66

17 EU Countries with ECE/R66		
Austria	Greece	Netherlands
Belgium	Hungary	Portugal
Denmark	Ireland	Spain
Estonia	Italy	Sweden
Finland	Luxembourg	
France	Malta	United Kingdom

The scope of the R66 regulation as it is today applies to: single-deck rigid or articulated vehicles designed and constructed for the carriage of more than 22

passengers, whether seated or standing, in addition to the driver and crew.

It is clear that ECE/R66 is by far the most advanced regulation for MCBs with regard to the superstructure. The main reason is the additional mass added for the occupants which increases the amount of load the superstructure must withstand when being tested for certification.

After the mandatory seat belt regulations were enacted in 1997 and 2006, the UNECE recognized that the occupant mass becomes coupled to the structure increasing its overall mass and centre of gravity height. This results in an increased rollover energy absorption requirement before intrusion of the superstructure into the residual space. [2]

The United Nations website has Addendum 65 to Regulation No. 66, Revision 1 - Corrigendum 2, from December 2006 which added the "Restrained Occupant Mass" as part of the compliance calculation as follows:

"Paragraph 3.2.2.1., correct to read: " ….
$M_t = M_k + k \cdot M_m$, where k = 0.5 and M_m is the total mass of the restrained occupants (see paragraph 2.15.). [3]

Sections 2.14 to 2.18 define the parts of the calculation and in addition, define the specific weights to be used for the Driver and Individual Occupant Mass as follows:

- 2.14. "Unladen kerb mass" (Mk) means the mass of the vehicle in running order, unoccupied and unladen but with the addition of **75 kg** (165lbs) for the mass of the driver, the mass of fuel corresponding to 90 per cent of the capacity of the fuel tank specified by the manufacturer, and the masses of coolant, lubricant, tools and spare wheel, if any.
- 2.15. "Total occupant mass" (Mm) means the combined mass of any passengers, crew who occupy seats fitted with occupant restraints.
- 2.16. "Total effective vehicle mass" (Mt) means the unladen kerb mass of the vehicle (Mk) combined with the portion (k = 0.5), of the total occupant mass (Mm), considered to be rigidly attached to the vehicle.
- 2.17. "Individual occupant mass" (Mmi) means the mass of an individual occupant. The value of this mass is **68 kg**. (150lbs)
- 2.18. "Reference energy" (ER) means the potential energy of the vehicle type to be approved, measured in relation to the horizontal lower level of the ditch, at the starting, unstable position of the rollover process.

These definitions come into play when the calculation for the Reference Energy that the structure must withstand is performed. It is stated in section 3.2.2.1 and reads as follows:
The value of reference energy (ER) which is the product of the vehicle mass (M), the gravity constant (g) and the height (h1) of centre of gravity with the vehicle in its unstable equilibrium position when starting the rollover test (see figure 3)…

$$E_R = M.g.h_1 = M.g\left[0.8 + \sqrt{h_0^2 + (B \pm t)^2}\right]$$

where:
***M = Mk**, the unladen kerb mass of the vehicle type if there are no occupant restraints, or, Mt, total effective vehicle mass when occupant restraints are fitted, and*
Mt = Mk + k • Mm**, where k = 0.5 and **Mm is the total mass of the restrained occupants
t = perpendicular distance (in metres) of the vehicle centre of gravity from its longitudinal vertical central plane.
B = perpendicular distance (in metres) of the vehicle's longitudinal vertical central plane to the axis of rotation in the rollover test.
g = gravitational constant
h1 = the height (in metres) of the vehicle centre of gravity in its starting, unstable position related to the horizontal lower plane of the ditch.

Section 5 of R66 explains the performance requirements for the superstructure of each vehicle that falls under the regulation. The requirements specify that no part of the superstructure shall intrude into the "Residual Space" during and after the rollover test on complete vehicle as defined in the regulation in section 5.2 and shown by the shaded

outline in Figures 3 and 4. The test configuration is shown in Figure 5.

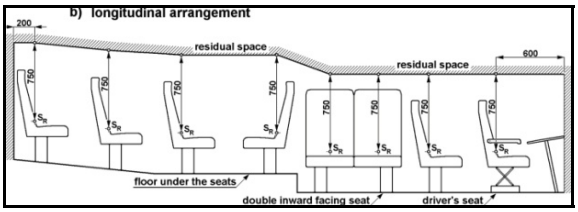


Figure 3. Side view showing step-up of Residual Space as the floor rises toward the rear.

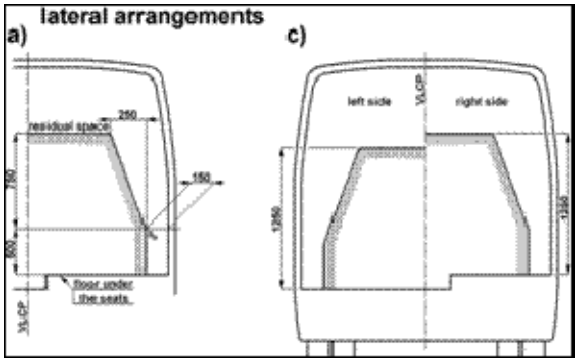


Figure 4. Lateral arrangements of the Residual Space for occupants. a) Cut out view from rear and c) Rear view showing both sides.

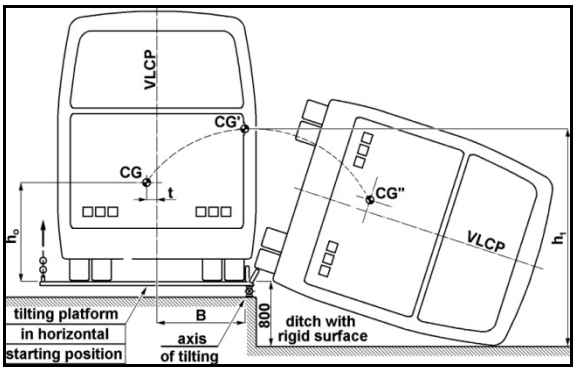


Figure 5. Image of 3.2.2.1, figure 3. Specification of the rollover test on a complete vehicle showing the path of the centre of gravity through the starting, unstable equilibrium, and at the end position.

The regulation specifies the following details further defining the requirements in sections 5.1.1, 5.1.2 and 5.3.2, which are given below:
5.1.1. No part of the vehicle which is outside the residual space at the start of the test (e.g. pillars, safety rings, luggage racks) shall intrude into the residual space during the test.
Any structural parts, which are originally in the residual space (e.g. vertical handholds, partitions, kitchenettes, toilets) shall be ignored when evaluating the intrusion into the residual space.
5.1.2. No part of the residual space shall project outside the contour of the deformed structure.
The contour of the deformed structure shall be determined sequentially, between every adjacent window and/or door pillar. Between two deformed pillars the contour shall be a theoretical surface, determined by straight lines, connecting the inside contour points of the pillars which were the same height above the floor level before the rollover test (see Figure 5).
5.3.2. The rollover test starts in this unstable vehicle position with zero angular velocity and the axis of rotation runs through the wheel-ground contact points. At this moment the vehicle is characterized by the reference energy ER.

These ECE-R66 superstructure requirements are the most robust of all the countries that were part of this research. Additionally, R66 has the requirement for a physical MCB test vehicle to perform the compliance test making it a costly endeavor for Manufacturers but at the same time keeping substandard MCBs off the market. The regulation drove down MCB fatality rates in the countries that adopted it. In the last few years, with new modeling tools, some companies have successfully presented their testing compliance via modeling. [3]

Regulations in Australia

The Department of Infrastructure and Transport governs the regulations for MCB's in Australia. R66 has been adopted in Australia throughout the 6 states that make up Australia including New South Wales, Victoria, Queensland, South Australia, Western Australia and Tasmania and 2 territories; the Australian Capital Territory and the Northern Territory as shown in Figure 6. However, the final adopted version of the R66 regulation, called Australian Design Rule (ADR) 59/00, does not require the occupant mass be included in the testing pass/fail requirement. [4]

Figure 6. Australia States and Territories

Australian Rule (ADR) 59/00

The Australian Design Rule for MCBs (Omnibuses) is ADR 59/00 which specifies requirements for bus superstructures to ensure that they withstand forces encountered in rollover crashes and maintain a survival space for each passenger. This regulation applies to vehicle in the MD and ME classes. MD is a Light omnibus with the subclasses of MD1-4 with GVM of between 3.5 and 5 tonnes and for MD2-4, more than 12 seats. ME is the class for a Heavy omnibus, over 5 tonnes.

ADR 59/00 technical content is based on ECE/R66 and includes design and construction of single-deck, rigid or articulated vehicles, constructed for the carriage of more than 16 passengers, whether seated or standing, in addition to the driver and crew.

The scope of the ADR.59 covers the following:
1. All the single deck buses having a passenger capacity more than 12.
2. Class B buses - (those **not** designed to carry standing passenger)*
3. Busses carrying 16 passengers *
4. Double Deck Busses are optional.*

**Amended in August 2010 which came from the R 66/02 as an alternative standard. The industry will continue to have the option of complying with UNECE R 66/00 and UNECE R 66/01 as well as the Australian requirements at Appendix B of the ADR. Appendix B is a modified extract of the technical provisions of UNECE R66/00 standard.*

Certain low floor height MCBs will continue to be exempted. Omnibuses are not required to comply with this rule if the following percentages of the area of the upper surface of the floor measured between its 'Axles', is not more than 550 mm (22 in.) above the ground. The floor height of 550 mm (22 in.) is measured at the 'Suspension Height' corresponding to the 'Unladen Mass' of the vehicle.
For a wheel base: 6.5 metres and over 75% , less than 6.5 metres 70%, less than 6.0 metres 65%, less than 5.5 metres 60%, less than 5.0 metres 55%, less than 4.5 metres 50%
What this means is that for a MCB that's wheel base (between the axles) is 6.5 meters (21 ft), 75% of that distance must be 550 mm (22 in) from the ground. This ensures that the center of gravity is low and thus keeps the MCB safer from a high propensity to rollover.

The "CALCULATION OF TOTAL ENERGY (E*)" under the ADR 59/00 Appendix B [5] states the same equation for E* as the R66 but has stricken the word "kerb" again and left it as "unladen mass of the vehicle".
For testing the calculation method of the fall of the centre of gravity (h) is determined by graphical method E may be taken to be given by the formula:*

Alternatively, E may be calculated by the formula:*
Where
M = the unladen ~~kerb~~ mass of the vehicle (kg)
g = 9.8 m/s2
W = the overall width of the vehicle (m)
Hs = the height of the centre of gravity of the unladen vehicle (m)
H = the height of the vehicle (m)

The wording in the 2007 version of the ADR 59/00 regulation at clause 8.1.3 is now "written" without the word "kerb" present.

There are additionally twenty regulations that are required by busses of this size. For example, Australia's regulation requires "lap/shoulder belts" at "all" passenger positions, even though they don't account for the occupant mass in the testing requirement. The more recent updates to the ADR Standards includes more robust requirement for both seat anchorages and seat belt anchorages. This was in

response to two frontal MCB crash investigations where the seat anchorages failed and the occupants were crush or injured between the seats.

A comparison between ECE R-66 and ADR 59/00 shows that the Australian's have stricken several regulations including many that speak to the interpretation or examination of the testing results. Not included in the 2007 version, which repealed the 2006 version) were: No application of approval (3.0), No approval (4.0), Modifications of the vehicle type and extension (9), Conformity of production (10), Penalties for non-conformity of production(11), Names and Addresses of Technical Services Responsible for Conduction approval tests and of administrative departments (13). Annex 2 of the regulation ECE R-66 required the arrangement of the approval mark which was also "stricken" in the ADR. With the exception of the occupant weight being excluded, the Australian rules do seem to be working as the fatality rates for injuries occurring inside the MCBs are dropping.

Regulations in the United States of America

The regulatory body for vehicle crashworthiness in the United States is the National Highway Traffic Safety Administration (NHTSA). This agency oversees the governing of safety regulations in the US. The regulations fall under two departments, the Federal Motor Vehicle Safety Standards (FMVSS) and the Federal Motor Carrier Safety Administration (FMCSA).

FMVSS regulations generally apply to consumer and some commercial vehicles at less than 10000 lbs. FMCSA regulations generally apply to Public and Private Transport in vehicles over 10,000 lbs. Both sets of requirements are enforced across all 50 states.

Some regulations, or "Standards" as they are called in the US, have different requirements based on vehicle weight. Federal Motor Vehicle Safety Standards (FMVSS) 216, the statically tested roof strength requirement calls for a 3-times strength to weight ratio for vehicles under 6000lbs, but only 1.5-times ratio for vehicles from 6000 to 10000 lbs. Most 8 to 12 passenger transport vehicles fall under the jurisdiction of FMVSS Standards. [5]

The standards for a vehicle of less than 10,000 lbs but greater that 8,550lbs (empty at 5,000) are limited and those in place mainly apply to vehicles that fall under the regulations for "vehicles for hire" such as mass transportation and school buses. Both the FMVSS and FMCSA versions of regulation # 217 contain some regulations pertaining to Transport MCBs such as windows, windshield and markings and emergency exits. [6] The purpose of FMCSA No. 217 is to minimize the likelihood of occupants being thrown from an MCB in a crash and to provide a means of readily accessible emergency egress. In addition to FMCSA/FMVSS No. 217, MCBs must comply with the following crashworthiness standards:
FMCSA/FMVSS No. 208, "Occupant crash protection"
FMCSA/FMVSS No. 209, "Seat belt assemblies"
FMCSA/FMVSS No. 210, "Seat belt assembly anchorages"
FMCSA/FMVSS No. 302, "Flammability of interior materials"
* FMCSA/FMVSS *Nos. 208, 209, and 210 presently apply to the Driver's seat only.* [7]

The Federal Motor Vehicle Safety Standards (FMVSS) define a MCB as a motor vehicle with motive power, except a trailer, designed for carrying more than 10 passengers. Per FMVSS, a bus can be either a school bus or "other type of bus". Because of the lack of specific crashworthiness standards, Para transit MCBs of Gross Vehicle Weight Rating (GVWR) often exceeding 10,000 lb are not subjected to any design restrictions unless a specific bidding process requires so.

The regulatory body for Heavy Vehicle crashworthiness is the Federal Motor Carrier Safety Administration (FMCSA). This agency is concerned with vehicles over 10000 lbs and regulate the trucking and heavy transport industry. FMCSA does not have a regulation for superstructure or design construction of an MCB and MCBs are not regulated by any national crashworthiness standard under the FMCSA.

The United States regulations, as compared to Europe and Australia, historically have been followers rather than leaders on the subject of MCB safety. However, in 2012, under the newly enacted Motorcoach Safety Provisions, NHTSA (DOT) is directed to require seatbelts on motocoaches within one year as well as regulations for roof strength and anti-ejection safety countermeasures and rollover crash avoidance regulations within two years. [8]

Regulations in South Africa

The regulatory body for vehicle crashworthiness in South Africa is the South African Bureau of Standards (SABS). [8] This statutory body was established as the national institution for the promotion and maintenance of standardization and quality. SABS is responsible for maintaining South Africa's database of more than 6,500 national standards, as well as developing new standards and revising, amending or withdrawing existing standards as required. SABS issues the South African National Standards called "SANS" which apply across all 9 Provinces shown in Table 7.

Table 7.
South African Provinces

South African Provinces	
EC = Eastern Cape	MP = Mpumalanga
FS = Free State	NC = Northern Cape
GA = Gauteng	NW = North West
KZ = KwaZulu-Natal	WC = Western Cape
LI = Limpopo	

The SANS 1563 standard applies to single-decked vehicles (M2<11,000 lbs, M3>11,000 lbs) constructed for the carriage of more than 16 passengers (not M1), whether seated or standing (Class I-III).

It is accepted as the text of E/ECE/324 Addendum 66, Regulation 66 (Uniform provisions concerning the approval of large passenger vehicles with regard to the strength of their superstructure) as suitable as the South African standard.

In SANS 1563, "Unladen kerb mass" is defined as the mass of the vehicle in running order, unoccupied and unladen, but complete with fuel, coolant, lubricant, tools and spare wheel, if any. The mass of the occupants has not been included in any calculations for testing, energy or mass.
M2 and M3 vehicles are subjected to one of the following below to ensure sufficient superstructure strength:

- Rollover Test on a complete vehicle
- Rollover Test on a body section or sections representative of a complete vehicle
- Pendulum test on a body section or sections
- Verification of strength of superstructure by calculation

After completing one of the testing methods or calculations, the superstructure shall be strong enough to ensure that during and after test methods or calculations that:

- No displaced part of the vehicle intrudes into the residual space
- No part of the residual space projects outside the deformed space

If the test methods prescribed in 2-4 cannot take account of a significant variation between one section of the vehicle and another, the vehicle must undergo the Rollover Test on a complete vehicle.

Additionally, South Africa has M2 & M3 Compulsory Specifications for Seat Belts and Anchorages which are:

3.6.3 Restraining devices (safety belts)
Subject to the proviso that no restraining devices (safety belts), excluding those given in (c) below, are required to be fitted to any vehicle of GVM exceeding 3.5 t , the following requirements shall apply:

a) the restraining devices (safety belts) that are fitted to a vehicle shall comply with the relevant requirements given in SABS 1080: 1983, (Seat belts and anchorages) Restraining devices (safety belts) for occupants of adult build in motor vehicles.

b) the type and location of the restraining devices (safety belts) required to be fitted to a vehicle and the method of installation thereof shall comply with the relevant requirements given in SABS 01 683 983.

*c) **in the case of class III vehicles**, non-protected seats (see 4.3.3 of the said SABS 1430), the details of which are specified in 3.6.2 (Excluding seating positions that have seats of the folding tip-up (jockey), rearward-facing or sideways-facing type, and seating positions in the rear rows of seats on simple single-box type construction), shall be fitted with at least a restraining device of the lap belt type.*

The South African Bureau of Standards "deleted" several of the ECE sections from which the regulations were originally adopted. The comparison is similar to the Australian changes of ADR 59/00 between the ECE R-66 and SAN 1563 from South Africa, which shows they have stricken several regulations including many that speak to the interpretation of the testing results.

Regulations in Canada

The Canadian Motor Vehicle Safety Regulations (MVSR) C.R.C., c. 1038 comes primarily from the safety standards in the United States (FMVSS). [10] A Canadian Technical Standard Documents (TSD) is a document that reproduces an enactment of a foreign government (e.g. a Federal Motor Vehicle Safety Standard issued by the United States National Highway Traffic Safety Administration). Canada has adopted many of the US standards and they are enforced across all of Canada including the Prairie and Northern Region, Yukon Territory, Northwest Territory, Pacific Region, Ontario Region, Quebec Region, and the Atlantic Region.

The most important rule for MCBs in Canada is that it has "admissible" vendors and approved MCBs that are allowed to be imported without modifications. [11] If the manufacturer and/or MCB type are not on the list, they cannot be imported for service.

The document or MVSR is known as the 1038 and is currently the accumulation of all the TSDs that the Canadian Government follows. The TSD for No. 216, Revision 1[12] is the document that speaks to the Roof Crush Resistance that pertains to MCBs; with a GVWR of 4 536 kg or less; that is built in two or more stages not using a chassis-cab and with a GVWR of 4 536 kg or less; bus with a GVWR greater than 2 722 kg but not greater than 4 536 kg and with an altered roof shall conform to the requirements of TSD 216 or TSD 220 (Rollover Protection) [13], which is referred to in section 220

of that schedule. The requirements of both TSD 216 and TSD 220 expire pertaining on January 1, 2014.

Schedule III of the MVSR shows a listing of all regulations that are associated with MCBs. All admissible vehicles must be labeled with the sticker shown in Figure 6, validating that it's authorized by the MVSR for use.

Figure 6. MVSR Official Compliance Stamp

Transport Canada defect investigators identify safety defects and take steps with manufacturers to correct defects through the Motor Vehicle Safety Act Notice of Defect provisions. MCB operator associations participate in regular National Public Safety Organizations consultation meetings with Transport Canada. Officials represent Canada on the ECE committee on occupant restraints, which developed the referenced European MCB passenger safety regulations. International standards are adopted where possible, when they meet safety needs and are consistent with Canadian regulatory policy.

Explanation of Mandatory Compliance Canada has a list of importation into the country of manufacturers of vehicles, specifically MCBs and passenger transport vehicles that are admissible. If the vehicle is not on the list you will not be able use them in Canada.

Canada has taken a different approach in that vehicles must meet standards in order to be allowed to operate or to be imported into the country. That leaves the responsibility of the safety compliance with the manufacturer or buyer of the MCB to be used in country. The 100 series crash avoidance standards and most of the Motor Vehicle Safety Regulations 200 and 300 series crashworthiness standards are now applicable to MCBs and all vehicles of a given weight category. Their revised standards, similar to the United States FMVSS 220 that now encompasses MCBs (not just school buses) require additional standards and testing for the manufacturers' compliance and this should continue to keep their fatal crashes to a minimum.

Regulations in Brazil

Brazil does not have a superstructure standard. In fact, there was no information as to Governmental Regulations for MCBs at all. Brazil has the 3rd largest overall fatality rate in Latin and South America at 25.6 deaths per 100,000 population. Recently, the Bloomberg Foundation donated several million dollars to create a better infrastructure for 10 emerging countries and Brazil is one of the countries that will receive funding from the foundation. [14]

Brazil is broken into five regions: North, Northeast, Southeast, South and Centerwest. The largest numbers of fatalities are in the Southeast, Northeast and South regions where concentrations of vehicles, urban population, and roads are the highest.

Regulations in Peru

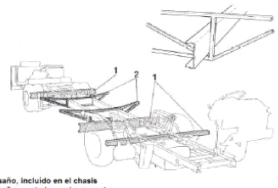
Approved National Vehicle Regulation Supreme Decree No. 058-2003-MTC is the standard that is regulated by the Ministry of Peru for MCBs. The 2003 adopted National Vehicle Regulation consists

of one hundred forty-three articles, and twenty additional provisions. The regulations are made up of Articles that describe the standards and Annex's that further explain information relating to specific requirements. Article 17 includes the "Additional Technical Requirements for vehicles of categories M2, M3, N2, N3 OR 2O3ad O4". The vehicles of category M2 & M3 are defined below and are obligated to follow a set of regulations and must have the approval documentation of the General Directorate for Land Traffic for both imports and vehicle manufactured in Peru. [15]

Category M: Motor vehicles of four or more wheels designed and constructed for the passenger transport.
M1: Vehicles of eight seats or less, excluding the driver's seat.
M2: Vehicles of more than eight seats excluding the driver's seat and gross vehicle weight of 5 tons or less.
M3: Vehicles of more than eight seats excluding the driver's seat and gross vehicle weight of over 5 tons.
Vehicles of category M2 and M3 transport of passengers are classified as:
Class I: Vehicles constructed with areas for standing allowing passengers frequent displacement
Class II : Vehicles constructed primarily for the transportation of passengers, sitting designed to allow the transport of passengers standing in the passage and / or an area which does not exceed space provided for two double seats.
Class III: Vehicles constructed exclusively for the carriage of passengers seated.
For M3:
1**. Bus standard** . - Vehicle body attached directly to the chassis frame, frame that does not undergo any alteration or modification structural or dimensional change in the distance between axes during the process of bodywork. Vehicles of this type can have the engine located on the front or rear of the chassis.
2. **Bus integral. -** Vehicle with the self-supporting single body to which sets the directional set at the front and the entire power train in back. The distance between axes is determined by the manufacturer bodywork. Vehicles of this type must locate the engine rear of the vehicle.
3. **Bus articulated** . - Vehicle composed of two rigid sections connected together by an articulated joint allowing free passage between one section to another.
4. **Omnibus bi-articulated** . - Vehicle composed of three rigid sections joined other by two articulated joints allowing free passage between the sections.

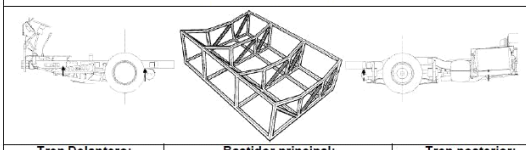
There are no "super structure" testing requirements but in the definitions of Annex II as stated above shows the way that the framework must be attached to the structure. Figure 7 describes the MCB framework and chassis connection for type M3.

Figura II.1 : Ómnibus Convencional



Ómnibus carrozado sobre chasis con bastidor completo

Figura II.2 : Ómnibus Integral



Tren Delantero:	Bastidor principal:	Tren posterior:
Eje delantero y sistema de dirección (suministrado por el fabricante del vehículo)	Elemento estructural intermedio que completa el chasis (suministrado por el carrocero con autorización del fabricante)	Eje posterior, sistema motriz (suministrado por el fabricante del vehículo)

Figure 7. Framework and chassis description for M_3 vehicle category

There is an approval/checklist of about 100 characteristic for safety features, weights, lengths, and axels types and locations, in order for a MCB to be approved and operating on the road systems.

Regulations in Chile

The body that regulates MCBs in Chile is the Ministry of Transport and Telecommunications. The division responsible for vehicle regulations is the Undersecretary of Transportation. A search of their website for MCB superstructure regulations and/or rollover regulations in general returned "no results".

However, Chile does have other requirements for MCBs that "perform services of paid transport of passengers" and defines the vehicle as "minibuses, with 12 or more seats, including the driver." There are a number of regulations that govern MCBs and some come from the Traffic Act. Decree-Law No. 1 dated October 29, 2009. [16] The regulations listed below come from Decree No. 122 out of Santiago on June 18, 1991 for fixed dimensional and functional requirements for vehicles of public transport serving urban and rural areas. There is also Decree No. 212 on November 21, 1992 for the regulation of national public passenger transport and Decree No. 80 dated September 13, 2004 that regulates private transport of passengers for reward. [17]

We found no information that shows that MCBs being manufactured or sold in Chile for any purpose other than public transportation are under any performance regulations.

The public transportation regulations apply to vehicles not older than 18 years and the regulation does include the passenger's weight at 65kg as a calculation of the vehicle passenger capacity. Additionally, in 2008 it became mandatory that MCBs of the model year 2008 and newer be equipped with seat belts and gave power to the MCB Driver/Company to enforce the rule.

In Article 2 and 3 of these documents are a few of the more important findings during our translation.

Article 2 °. - Buses that are made urban public transportation services, serving transportation capacity, fall within the following types:
a) Bus light (or **L** type): bus with no more than 26 seats including the driver, and with a gross weight less than 10 ton vehicle.
b) Medium Bus (Type **M)** bus with 26 seats, including the driver, and gross vehicle weight equal 10 tons or more but less than 14 tons.
c) Heavy Bus (Type **P**): bus with 26 seats, including the driver, and gross vehicle weight equal or greater than 14 tons.

Article 3. - Buses M and P type referred article 2 above, shall comply with the following requirements:

1. Overall dimensions: The outside width of the vehicle shall not exceed 2.60 m., In any case, the ratio between the width the vehicle and the distance between the outer faces of the rear axle wheels shall not exceed 115%. The length must be greater than 9.00 m for buses Type M and greater than 11.00 m.

for buses type P. The long rear overhang may not exceed 65% of the wheelbase.
2. Technical requirements relating to capacity passengers: Total number of passengers: The total number of passengers (N), both sitting and standing, should not exceed the numbers Nc and Ns, which are calculated as as follows:
Nc = (PBV - POM) / q, and Ns = A + IF / s in which:
GVW: Gross weight of the vehicle indicated by the manufacturer.
POM: Weight in running order, including the tare vehicle fuelling, spare wheel and normal tools, plus 75 kg to the weight of the driver.
q: a passenger's weight equal to 65 kg.
s: area required for a standing passenger equal to 0.167 m2.
Due to the length of this requirement and all the subsections that go along with it, we have abbreviated the listing in Table 8 with just the section headings.

Table 8.
MCB Regulation Section Headings for Chile

Types of Regulations in Chile	
Bumper	Handholds/handrails
Corridor	Internal lighting
Dividing panels	Levels of Noise
Driver's seat	Passenger seats
Emergency Exits	Service Doors
Exterior lights	Travel indicator
Floor of vehicle	Vehicle Systems
Glass windows/rear windshield	Warning system shutdown

The Chilean Regulations for the paid transport of passengers has some good rules in it that should be used as a baseline for more regulations. There are no regulations for the MCBs manufacturer to pass if the MCB will not be used for paid public transport.

METHODS AND DATA SOURCES

Research was conducted on the main governmental transportation websites governing MCB transport for each country. The United Nations website was used for the original UN resolution language and the adoption by nations. Many published papers were reviewed as well as articles and websites with verifiable information are referenced.

LIMITATIONS

This research was potentially limited by the language barrier in being able to identify and clearly understand the regulations in other than English speaking countries. It should be noted that the application of these regulations in some countries is limited by the generation of vehicles they have in service. Countries with little funding for new vehicles may have fleet vehicles that are older than the regulations and would not pass today or need to be retrofitted to pass.

CONCLUSIONS

MCB regulations vary significantly across these continents and countries. The more underdeveloped countries have a few occupant protection regulations for MCB passenger transport. The more developed countries have specific occupant protection regulations for both the public and private sectors which are strictly enforced.

Europe's ECE/R66 is the most comprehensive for superstructure testing and Australia's ADR 59/00 for seats, belts and anchorages. Australia and South Africa's SANS 1038 are good, but could use an upgrade to include occupant mass in the superstructure compliance calculation. The US and Canada seem to be starting to recognize the value of seat belts and rollover structural regulations and we are hopeful that the new Motor Coach Safety Provisions will help rectify the shortcomings in the regulations. Peru and Chile have some basic regulations for occupant protection, but would do well to adopt more. Brazil will hopefully benefit from the Foundational support they should be recieving.

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