AUSTROADS

HEAVY VEHICLE MASS

- *MEASUREMENT ALLOWANCES AND BREAKPOINTS*

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EXECUTIVE SUMMARY

As part of a national review of vehicle mass limits it is proposed that overloads be categorised into *minor*, *substantial* and *severe* offences. The sanctions applying to each of these categories are being dealt with as part of another project. Minor risk corresponds with “minor, accelerated road wear...[with] no appreciable risk to safety”. There is a need to establish an appropriate breakpoint, beyond which a minor risk becomes a substantial risk.

For many decades the mass enforcement agencies have made allowances for inaccuracies and variations in weighing devices and methods. Normally breach action only proceeds when the detected overload exceeds these *measurement allowances*. Measurement allowances ensure that variations due to the weighing methods do not result in a vehicle being treated as overloaded when it is in fact correctly loaded to the statutory limit.

Unfortunately the magnitude and application of measurement allowances vary across Australia. There are also concerns about the likelihood that some operators load up to the level of the allowance, in the false belief that they will not be prosecuted. (A vehicle that is loaded to exactly the statutory limit plus the measurement allowance has a 50% chance of being *measured in excess of the allowance* due to the variation inherent in the weighing process.) Such overloading results in accelerated road wear and unfair competition.

Austroads, the association of Australian and New Zealand road transport authorities, therefore commissioned a study to look at the setting of minor risk breakpoints and the measurement allowances that should apply to the enforcement of mass limits. This report summarises the results of that study. The study considered Australian and overseas practices and analysed Australian vehicle axle mass statistical data in order to estimate the effects of changes to measurement allowances and breakpoints.

Measurement allowances

In the mid-1980s a considerable amount of research was conducted by NAASRA (similar to Austroads at the time) into the sources of variation in the weighing of vehicles. The main sources of variation were found to be:

- the accuracy of scales,
- grade effects (i.e. the slope of the inspection site), and
- vehicle characteristics such as spring hysteresis and loadsharing within groups of axles.

Since that research was conducted, the accuracy of scales and the characteristics of inspection sites have changed little. Vehicle characteristics have improved considerably.

The most significant change in vehicle characteristics is that all axles in tandem and triaxle groups should now share loads effectively so that they cause less damage to the roads. Loadsharing regulations were introduced only in the late 1970s so the effect of loadsharing was not incorporated in the NAASRA research. In effect the measurement allowances introduced in the 1980s (the so-called *NAASRA tolerances*) were set on the basis that multiaxle groups were *not* loadsharing.

It is no longer appropriate to provide for poor loadsharing in the measurement allowances. The basis of the NAASRA tolerances was therefore re-evaluated as part of the present project.

The recommended measurement allowances, set out in the table below, include a reduced allowance for vehicle characteristics. It is estimated that approximately 10% of vehicles *currently operating in excess of statutory mass limits* would be within the recommended measurement allowances. This compares with about 20% for the NAASRA tolerances.

Minor risk breakpoint

Issues such as road damage, bridge damage and vehicle safety were investigated in order to determine appropriate breakpoints for minor risk breaches. There is general agreement that masses up to 5% above the statutory limit or manufacturer's limit (where less than the statutory limit) do not constitute a significant road damage or safety risk. It is estimated that about 21% of all overloaded axle groups are less than 5% overloaded.

If a vehicle is operating within the manufacturer's gross vehicle mass (GVM) or gross combination mass (GCM) then it is likely that all components of the vehicle will be operating within their capacity. Generally an overload of 5% beyond GVM/GCM should not cause problems. There is a concern about tyre capacity on steer axles because the sum of the rated capacities of commonly used tyres is often equal to the statutory limit for steer axles, but even in this case a 5% overload is considered acceptable.

In practice, enforcement of a minor breakpoint based on exactly 5% overload would be a nuisance. In order to simplify compliance and enforcement it is therefore proposed that the minor breakpoints be based on rounded values. The revised recommended breakpoints are set out in the summary table. They take into account concerns about tyres on steer axles.

The breakpoints between substantial and severe breaches are based on 20% overload. It is estimated that about 17% of all overloaded axle groups are in the severe risk category.

Summary of proposed breakpoints and measurement allowances

The proposed measurement allowances and breach breakpoints are shown in the table overleaf.

For example, for a tandem axle group weighed by enforcement staff:

- The statutory limit is 16.5t.
- The proposed measurement allowance is 0.5t, so loads *measured as* under 17t would not be penalised.
- The proposed minor/substantial breakpoint is 17.5t, so loads *measured* between 17t and 17.5t would be treated as a minor breach.
- The substantial/severe breakpoint at 20% overload is 19.8t, so loads *measured* between 17.5t and 19.8t would be treated as a substantial breach.
- Loads *measured* over 19.8t would be treated as a severe breach.

Summary table - All mass values in tonnes

Axle group	Axle group mass limit	Previous NAASRA tolerance	Proposed measurement allowances		5 percent overload	Proposed minor/ substantial breakpoint	Proposed substantial/ severe breakpoint
Single steer	6	0.25	0.3	6.3	6.3	6.3	7.2
Twin steer	11	1	0.3	11.3	11.55	11.5	13.2
Single, dual tyres	9	0.5	0.4	9.4	9.45	9.5	10.8
Tandem	16.5	1	0.5	17	17.33	17.5	19.8
Triaxle	20	1	0.5	20.5	21	21	24
Gross	-	1	0.5	-	-	5%	20%

Note that these proposals apply to conventional vehicles operating at or near the statutory mass limits. In the case of quad-axle groups (sometimes used for overmass vehicles) the proposed measurement allowance is 0.5t beyond the axle group mass prescribed on the permit. In the case of long combination vehicles such as B-doubles and road trains the proposed measurement allowance on gross mass is the greater of 0.5t or 1% of the permitted gross mass.

The gross mass proposals apply to vehicles weighed with portable scales where the scales are moved to each group being weighed, so that the vehicle stays in the same position on the inspection site. If it is necessary to move the vehicle to the scales then a larger measurement allowance is appropriate because there is a risk that measurement variations will accumulate. In the case where the vehicle moves to the scales the proposed measurement allowance for gross mass is the greater of 1.5t or 3% of the permitted gross mass.

There is far less variation in the outcomes when vehicle mass is measured at fixed weighbridges or checking stations so it is not necessary to apply the proposed measurement allowances when overloading is detected there. The allowances should nevertheless be applied to weighbridge measurements for the sake of simplicity and ease of enforcement.

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INTRODUCTION

Statutory limits apply to the mass of a vehicle for the protection of roads and bridges and to ensure that the vehicle operates safely within its design parameters. Several types of limit apply:

- *gross* (laden) mass - based on the maximum mass allowed for the particular configuration of vehicle or the vehicle manufacturer's limit, if it is less.
- *axle group* limits - based on the maximum mass allowed for the number of axles and tyres within the group or the vehicle manufacturer's or tyre manufacturer's limits (across an axle), if they are less
- *bridge formula* limits - based on the spacing of the outermost axles in combinations of axle groups. For example, if the distance between the foremost and rearmost axle on a vehicle is 4.2m then the mass must not exceed 25t. This formula can apply to any combination of axle groups on a vehicle.

As part of a national review of vehicle mass limits it is proposed that overloading cases be categorised into *minor*, *substantial* and *severe* offences. Minor risk corresponds with “minor, accelerated road wear...[with] no appreciable risk to safety” (NRTC 2000b). There is a need to establish an appropriate breakpoint, beyond which a minor risk breach becomes a substantial risk breach. The intention is that a minor risk breach is one where the measured mass exceeds the statutory mass limit but does not exceed the breakpoint between minor and substantial risks.

For many decades mass enforcement agencies have made allowances for inaccuracies and variations in weighing devices and methods (DMR 1986). Normally these *measurement allowances* must be exceeded before a breach action proceeds. The main purpose of measurement allowances is to ensure that variations in weighing methods do not result in vehicles being incorrectly treated as overloaded when they are in fact correctly loaded to the statutory limit.

Unfortunately the magnitude and application of measurement allowances vary from state to state. In 1985 the Road Vehicle Limits Group of the National Association of Australian State Road Authorities (NAASRA - now Austroads) prepared (but did not publish) the proceedings of a Weighing of Vehicles Conference (NAASRA 1985). This conference looked in detail at issues associated with the weighing of vehicles, including the “statistical basis for administrative tolerances” (discussed in more detail later under *Current Australian Practices*). The outcomes of this conference were incorporated in the NAASRA Guidelines for Weighing of Vehicles (NAASRA 1987). This document still forms the basis of weighing practices throughout Australia but there remain state to state variations in the application of administrative tolerances or measurement allowances.

In addition to concern about the state-to-state variations, there are concerns about the legislative uncertainties associated with tolerances and measurement allowances and the likelihood that some operators load up to the level of the measurement allowance in the mistaken belief that they will not be prosecuted. If it is assumed that the measured value is normally distributed about the actual axle load then it follows that an axle group that is loaded to exactly the statutory limit plus the measurement allowance will, due to the variation inherent in the weighing method, be measured as exceeding the allowance in 50% of the time.

CURRENT AUSTRALIAN PRACTICES

As part of the current project a survey form was circulated to Australian state and territory authorities seeking advice about current weighing practices. Not all responses had been received at the time of preparation of this report.

The *NAASRA tolerances* that were developed in the mid-1980s were intended to take into account the four major known sources of weighing variation:

- scale variation
- grade effect (i.e. slope of the inspection site)
- suspension hysterisis (a small force is required to overcome friction in springs and pivots of the vehicle suspension - this is strictly a vehicle construction issue)
- axle attitude effects (effects where some axles are at a different relative height to the others).

The paper by Sweatman, Tritt and Peters (NAASRA 1985) discusses each of these sources of variation. For example, scale accuracy is better than 1%. Hundreds of vehicle weighings were analysed (the sample size was not stated in the report). The standard deviations for scale accuracy were found to be 18kg for a single axle (two scales), 26kg for two axles (four scales) and 32kg for three axles (six scales). Similarly, an analysis of the grade effects at approximately 100 weighing sites throughout Australia revealed a standard deviation of 1.22% and a worst case standard deviation of 231kg. Repeated weighings of the same vehicles provided an indication of the suspension hysteresis effects, where the standard deviation ranged up to 100kg. For axle attitude effects the worst case vehicle (six axle articulated vehicle) was analysed.

The estimated variations were combined and, for the worst case vehicle (12^3), gave 99% percentile variations of: 256kg for the steer axle, 670kg for the tandem drive group, 700kg for the triaxle trailer group and 1000kg for the gross mass. Based on this analysis, the authors recommended as the tolerances adopted by NAASRA: 0.25t for the steer axle, 1t for a tandem group, 1t for a triaxle group and 1t for the gross mass. NAASRA also applied a 0.5t measurement allowances to a single dual-tyred axle (not covered in the statistical analysis).

Review of 1985 analysis

It is considered that, technically, little has changed with measurement methods since the NAASRA analysis was conducted: weighing equipment and site characteristics have not changed significantly. However, heavy vehicle suspensions should have less hysteresis and be less prone to variation from unfavourable axle attitudes (that is, effects from standing on uneven ground). For more than two decades multi-axle groups (other than twin steer groups) have been required to loadshare as a road-protection measure. In theory a vehicle with a perfect loadsharing suspension would not be vulnerable to axle attitude effects (Paine 1994).

The issue of variations from axle attitudes is closely related to the issue of *deductions* for unblocked axle groups. (*Blocking* is the practice of placing wooden blocks under the tyres of all unweighed axle groups so that they are the same relative height as the axle group being weighed–. It is tedious and time consuming and it adds extra hazards to the weighing process.) The draft Guidelines for Weighing Vehicles (NAASRA 1985) include a section on deductions for unblocked axles that states “all axles were analysed on the basis that the suspension system did not transfer load between axles within the group”. This is no longer a valid assumption.

The NAASRA Guidelines specify requirements for *conforming inspection sites* for the purpose of weighing vehicles. We recommend that the practice of deductions be discontinued for weighings on conforming sites when using scales 40mm thick or less. In such circumstances it can be shown that unblocked axle groups introduce the equivalent of a 10mm height variation between axles on the group being weighed - this is well within the 15mm limit on ground variations for conforming sites and should be well within the capability of effective loadsharing suspensions.

Similarly, it is considered that a suspension that does not loadshare effectively should not benefit from the tolerance system. Any variations in axle weighing due to the inability of an axle group to loadshare properly should not be taken into account when setting measurement allowances. The data provided in the 1985 NAASRA statistical analysis has therefore been reanalysed to disregard the effects of axle attitude (Appendix A). The analysis was confined to vehicle configurations that make up a significant proportion of the current fleet and took the worst case for each axle configuration. This resulted in the following proposed measurement allowances, rounded to the nearest 100kg:

Table 1. Reanalysed measurement allowances, ignoring axle attitude - tonnes

Axle group	Axle group mass limit	NAASRA tolerance	Proposed measuremen t allowance	Difference
Single steer	6	0.25	0.3#	0.05
Twin steer	11	1	0.3	-0.7
Single, dual tyres	9	0.5	0.4	-0.1
Tandem	16.5	1	0.5	-0.5
Triaxle	20	1	0.5*	-0.5
Gross	-	1	0.5*	-0.5

Notes:

The NAASRA analysis concluded that a 6-axle articulated vehicle was the worst case and based all axle group measurement allowances on that vehicle. However, rigid trucks exhibited a greater variation on the steer axle and this has been used in the above table.

* Triaxle groups actually performed better than tandem groups, with the worst case being 420kg. For consistency, however, the measurement allowance for tandem groups has been used for triaxles. Similarly, the effects of scale and site variations tend to cancel out when calculating gross mass (under the preferred weighing method of moving the scales to each axle group and keeping the vehicle in the same location) and a measurement allowance of 300kg could therefore be justified. Again, for consistency, the measurement allowance for tandem groups has been used for gross mass.

The effects of these proposed measurement allowances are discussed later.

Analysis of a sample of mass limit breach reports

A sample of 104 breach reports issued by RTA inspectors working in metropolitan Sydney was analysed. While these should not be taken to be representative of the Australian heavy vehicle fleet they do provide an indication of the characteristics of the overloading problem. Most cases involve substantial or severe overloads because those in the minor category that were intercepted were generally not breached. However, the inspectors recorded information about all axle groups on breached vehicles and this enabled analysis of some overloaded axle groups in the minor category.

Details of the survey are provided in Appendix B. In summary:

- There was a high proportion (81%) where the manufacturer's GVM was exceeded. In 40% of the 79 cases where GVM was exceeded (32% of all cases) the overload was more than 20%, placing the vehicle in the severe breach category. Many of these vehicles were small two-axle tipper trucks. 14% exceeded the limit by 5% or less (possible minor breakpoint).
- In 21% of cases the bridge formula was exceeded but only 10% of these (2% of all cases) were in the severe category (20% overload). 27% exceeded the limit by 5% or less.
- In 57% of cases axle load limits were exceeded. Of the 17 steer axles overloaded, 29% were in the severe category of 20% overloaded and 24% exceeded the limit by 5% or less. Of the 52 drive groups overloaded, 19% were in the severe category (20% overload) and 19% exceeded the limit by 5% or less. Of the 19 trailer groups overloaded, 26% were in the severe category (20% overload) and 11% exceeded the limit by 5% or less.

Many vehicles breached more than one category so the above percentages are not exclusive.

OVERSEAS PRACTICE

A review of the Proceedings of the 5th and 6th International Symposiums on Heavy Vehicle Weights and Dimensions (1998 and 2000 respectively) did not provide useful information about measurement allowances applied by overseas enforcement authorities. Similarly an internet search revealed very little information about this subject. Therefore a request for information about overseas weighing practices was circulated via the Road Transport Technology email forum (operated by David Cebon at Cambridge University, UK). The following summarises the responses.

- Mr Steve Mueller from Colorado, USA advised that while liaising with the Colorado Police on mass enforcement issues he was told that nearly always when they observed overweight vehicles they found numerous safety (roadworthiness) violations. This issue is discussed later in the report. Mr Mueller also commented that the Colorado Motor Carriers Association had the view that lawbreakers represent unfair competition for its members and represent a greater risk to the entire industry.
- Mr Hans van Loo from the Ministry of Transport, The Netherlands, advised that enforcement officers always deduct 200kg from every measurement to allow for scale inaccuracy. If the adjusted axle load is more than 10% higher than the limit then a fine is issued. If the adjusted gross mass is more than 5% higher than the permitted gross mass then a fine is issued. If the adjusted gross mass is more than 10% higher than the permitted mass then the vehicle is required to unload.
- Mr Fred Nix from Canada cautioned that he was not directly involved with mass limit enforcement but he understood that some Canadian provinces had a tolerance of 500kg per axle prescribed in the legislation. In others there was no tolerance prescribed but it was known that enforcement officers allowed some leeway before issuing fines (he estimated around 250kg per axle).
- Mr Anders Lundqvist from the Swedish National Road Administration provided a schedule of fines for overloading in Sweden. Strictly there is no tolerance in the legislation but there is a provision for excessive loads. Where a single axle is more than 1000kg beyond the limit or a group or the gross is more than (500kg times the number of axles) beyond the limit then a sliding scale of fines applies:

Overload per axle	Fine
100-2000kg	SEK400 for every 100kg (SEK8000 for 2000kg)
2100-4000kg	SEK600 for every 100kg (SEK12000 for 4000kg)
4100-6000kg	SEK800 for every 100kg (SEK16000 for 6000kg)
6100kg or more	SEK1000 for every 100kg

These amounts are added to a base fine of SEK2000. Hence an 8000kg overload on a single axle would be fined 2000 + 8000 + 12000 + 16000 + 10000 = SEK48000.

- Mr Gary Cull advised that he understands the UK Vehicle Inspectorate applies a 150kg tolerance to low speed weigh-in-motion measurements. No information was forthcoming directly from the Vehicle Inspectorate.

- Mr Tom Klimek from the Office of Freight Management and Operations, Federal Highway Administration, USA advised in general that the federal regulations include the phrase “includes all tolerances” with every reference to mass limit so legally there is no tolerance or administrative allowance applied to federal highway enforcement. However, it is acknowledged that “officer discretion” is applied in the field. Although there are no written guidelines on this it is based, in part, on experience with success in court.
  Section 658.17 of the *US Code of Federal Regulations - Highways, 1996* contains the clause “The weights... of this section shall be inclusive of all tolerances, enforcement or otherwise, with the exception of a scale allowance factor when using portable scales.... The current accuracy of such scales is generally within 2 or 3 percent of actual weight but in no case shall an allowance in excess of 5% be applied. Penalty or fine schedules which impose no fine up to a specified threshold, ie 1000 pounds, will be considered as tolerance provisions not authorised by 23 U.S.C. 127.”

PROPOSED CHANGES TO AUSTRALIAN PRACTICES

The approved national policy on *Compliance and enforcement: Mass, dimensions and load restraint* (NRTC 2000b) proposes that the NAASRA tolerances be replaced by a *minor breach* category so that exceeding the mass limits within the minor risk range is considered a breach, not merely a tolerance.

The policy also states that “*The proposal will not affect any allowances made purely for weighing and measuring methods. By and large, the allowances needed for weighing and measuring device accuracy are dealt with in each jurisdiction’s weights and measures legislation and in the manufacturer's standards applying to each individual [weighing] device. Current allowances for methods of weighing are currently being reviewed by Austroads to ensure they are still appropriate*” (now part of the present project).

It appears the above statement is an oversimplification of the situation. The weights and measures legislation does set limits on machine accuracy under ideal conditions and the scale manufacturers also make claims about device accuracy under site conditions that are not generally attainable in Australia. These are useful for selecting and calibrating suitable weighing equipment but they do not take in to account variations with weighing in the field. This is likely to be one of the reasons that NAASRA (1985) prepared a specification for “conforming sites” and conducted a statistical analysis of hundreds of weighings at these sites in order to establish the real-world variations.

Apart from changes to the ability of suspensions to cope with axle attitude differences, the data from the 1985 study is still considered to be valid since weighing site characteristics and scale accuracy have not changed. The reanalysis presented earlier is therefore considered to be valid, since it ignores the effects of axle attitude.

This outcome raises doubts about the concept of replacing the old "NAASRA tolerances" with a minor breach category. In effect, the statistical analysis looked at the likelihood that variations inherent in the weighing methods would result in a legally loaded vehicle being treated as overloaded. For example, assuming a normal distribution about the statutory limit, half of the vehicles loaded to *exactly* the legal limit could be expected to be found to be overloaded (albeit only by a small amount) *due to the method of measurement* and therefore fall into the proposed minor breach category.

A valid argument would be that the axle mass limits have been set to take into account normal variation due to weighing methods and that, like the situation in the USA, the statutory limits "include all tolerances". However, the *Mass Limits Review* (NRTC 1996a) recommended that the NAASRA tolerances be reduced for higher mass limits proposed for "road friendly" suspensions and the Review of Road Vehicle Limits Study (RoRVL) refers to "tolerances". It is therefore apparent that the current mass limits have been set on the basis that they do not include a measurement tolerance.

It is therefore considered necessary to retain the concept of tolerances or measurement allowances when dealing with possible overloads. In other words, there should be a measurement allowance above the statutory mass limit before an overload is regarded as a minor breach. The proposed measurement allowances are set out in Table 1.

MINOR BREACH BREAKPOINTS

The *Compliance and enforcement: Mass, dimensions and load restraint* policy (NRTC 2000b) briefly examines options for setting the minor breach breakpoint, beyond which a breach becomes *substantial*.

A breakpoint 5% over the statutory mass limit was put forward in an earlier discussion paper published during the development of the policy. In that paper it was argued that the driver would not necessarily know about the overload under this value and that the 5% was "convenient and easily recalled". However, the discussion paper noted that "whilst there was some lukewarm support for the 5% breakpoint, there was considerable criticism of the use of a single percentage-based figure as the minor risk breakpoint for breaches involving all heavy vehicles, vehicle configurations and axle groups". A focus group subsequently rejected the 5% proposal and "solidly endorsed an approach of aligning the minor risk category with [existing NAASRA] tolerances for axle mass and [gross] mass, except for the [gross mass] tolerance for [B-doubles and road trains]".

The report went on, however, to express concerns about the NAASRA tolerances, with the inference that they should be reviewed. We support those concerns, as described earlier, and consider it inappropriate to base the minor breach breakpoints on the NAASRA tolerances because they are derived from measurement variations and are not necessarily related to safety and road protection, which are the prime issues for a minor breach breakpoint.

A criticism of the 5% overload proposal was that the resulting masses were fractions of a tonne and would be difficult to remember in the field. It was therefore suggested that these values be rounded. Generally the minor breach breakpoints can be rounded to the nearest 0.5t.

For example, a 5% overload on a tandem axle group is 17.33t, which could be rounded to give a minor breakpoint of 17.5t. (By coincidence, this is the same as the statutory limit of 16.5t plus the NAASRA tolerance of 1t.)

However, there are concerns about tyre capacity on steer axles (discussed in more detail later) and therefore it is proposed that the 5% value of 6.3t be used. In this case the minor breakpoint is the same as the statutory limit of 6t plus the proposed measurement allowance of 0.3t. In this case no axles would fall into the minor breach category. Any that exceed the measurement allowance would be regarded as a substantial breach or severe breach. Note that NAASRA tolerance was 0.25t but we are recommending it be increased to 0.3t. It is this increase that causes the odd situation with the minor breach category.

Table 2. Summary of proposed changes (all mass values in tonnes)

Axle group	Axle group mass limit	Previous NAASRA tolerance	Proposed measurement allowances		5 percent overload	Proposed minor/ substantial breakpoint	Proposed substantial/ severe breakpoint
Single steer	6	0.25	0.3	6.3	6.3	6.3	7.2
Twin steer	11	1	0.3	11.3	11.55	11.5	13.2
Single, dual tyres	9	0.5	0.4	9.4	9.45	9.5	10.8
Tandem	16.5	1	0.5	17	17.33	17.5	19.8
Triaxle	20	1	0.5	20.5	21	21	24
Gross	-	1	0.5	-	-	5%	20%

Note that these proposals apply to conventional vehicles operating at or near the statutory mass limits. In the case of quad-axle groups (sometimes used for overmass vehicles) the proposed measurement allowance is 0.5t beyond the axle group mass prescribed on the permit. In the case of long combination vehicles such as B-doubles and road trains the proposed measurement allowance on gross mass is the greater of 0.5t or 1% of the permitted gross mass.

The gross mass proposals apply to vehicles weighed with portable scales where the scales are moved to each group being weighed, so that the vehicle stays in the same position on the inspection site. If it is necessary to move the vehicle to the scales then a larger measurement allowance is appropriate because there is a risk that measurement variations will accumulate. In the case where the vehicle moves to the scales the proposed measurement allowance for gross mass is the greater of 1.5t or 3% of the permitted gross mass.

There is far less variation in the outcomes when vehicle mass is measured at fixed weighbridges or checking stations so it is not necessary to apply the proposed measurement allowances when overloading is detected there. The allowances should nevertheless be applied to weighbridge measurements for the sake of simplicity and ease of enforcement.

Analysis of potential effects of changes to the breakpoints

In April 2001 the NRTC released a report titled *Dimension and Mass Characteristics of the Australian Heavy Vehicle Fleet* (NRTC 2001a). This provided a comprehensive analysis of the configuration, axle spacing and axle loads of the Australian heavy vehicle fleet, as monitored by weigh-in-motion systems such as Culway. For each vehicle configuration the report provides graphs of axle mass distribution for each axle group. Subject to caution about possible misclassifications with the system, dynamic load effects and the possibility that some "overloads" were in fact vehicles operating at higher axle loads under permit, the report provides the best available data for analysis of the possible effects of alternative minor breach breakpoints.

The graphs for the popular vehicles provided in NRTC 2001a were analysed to determine the distribution of overloaded axles. In addition, an estimate of relative road damage from various scenarios was determined by applying the "fourth power law" to the magnitude of over-loading. For example, an axle group loaded 10% higher than the statutory limit was assumed to cause $(1.1)^4$=1.46 times the road damage of an axle loaded at the statutory limit. The fourth power law was used in the1996 *Mass Limits Review* (e.g. NRTC 1996d) and later evaluations (e.g. NRTC 2000a). There are criticisms of its use (Cebon 1989) but the formula is generally accepted and is convenient for relative comparisons such as this (comparing the relative effects of varying the breakpoints rather than trying to estimate absolute road damage).

Based on our reanalysis of the data provided in NTRC 2001a, it is estimated that, overall, 10% of *axle groups* were overloaded. This is less than the 14% of *vehicles* that Koniditsiotis previously estimated to be overloaded, (NRTC 2000a, Koniditsiotis 1998). Koniditsiotis's analysis was based on 1996 Culway data. Reasons for the difference (which would be even greater if Koniditsiotis had also provided data on axle groups) are not clear but the later data from NRTC 2001a is considered to be more reliable. Note that the Koniditsiotis project was targeted at gross overloading that was a concern for bridge damage.

From our reanalysis, B-double axle groups had a higher proportion of overloaded axle groups than the overall average (however, see cautions above about data quality and interpretation). Twin steer rigid trucks also had a higher than average proportion of overloads.

The general shape of the distribution curve is for a sharp drop just beyond the statutory limit and then a long tail with a few cases of gross overloads. The steep curve in the minor breach range makes analysis very sensitive to the chosen breakpoints. The following analysis should therefore be regarded as indicative only.

We have analysed the proposed measurement allowances and breakpoints (Table 2) against the base case where the current NAASRA tolerances are used for breach action. Detailed results of the analysis are summarised in Table 5, overleaf. Points to note are:

- The selected vehicle configurations represent just under 90% of the total heavy vehicle fleet (based on NRTC 2001a, Appendix E).
- Two-axle rigid trucks and six-axle articulated trucks make up the majority of the vehicles surveyed.

Using the current NAASRA tolerances as the minor/substantial breakpoint and 20% overload as the substantial/severe breakpoint, the following estimates have been derived.

Table 3. Possible effects of NAASRA tolerances

	within tolerance	substantial breach	severe breach
% of all overloaded axle groups	21%	62%	17%
% of all damage from overloaded axle groups	16%	59%	25%

The effects of applying the fourth power law to the damage estimates are evident from this table, with severe breaches representing a disproportionate share of the total damage from overloading.

The outcomes for the proposed measurement allowance and breakpoints are set out in Table 4.

Table 4. Possible effects of proposed measurement allowances and breakpoints

	Proposed measurement allowance	Minor breach	Substantial breach	Severe breach > 20% overload
% of all overloaded axle groups	11%	13%	60%	17%
% of all damage from overloaded axle groups	7%	10%	58%	25%

Overall the proportion of vehicles falling into the substantial and severe breach categories is very similar to the "base case" because the proposed minor breach breakpoints are the same as, or close to, the NAASRA tolerances. However, there are some types of vehicles where a large proportion of the overloads would move from the minor breach category to the substantial breach category. In particular, about one quarter of the overloaded twin steer axle groups (or about 4% of all twin steer groups surveyed) would become a substantial breach with a breakpoint of 11.5t.

Table 6 and Figure 1 show the effects for the main vehicle classifications. Note that, in effect, there would be no minor breaches for single steer axles since the proposed measurement allowance is the same as the proposed minor breach breakpoint. In these cases, once the measurement allowance is exceeded, the breach is a substantial risk.

Table 5. Estimated effects of changes to the minor breakpoints

						Previous NAASRA tolerance		5% breakpoint			Proposed measurement allowance			
Vehicle type	**Vehicle config'n**	**Proportion of fleet**	**Axle group**	**Mass limit (t)**	**% over-loaded**	**Minor breakpoint**	**Minor as %**	**Mass diff (t)**	**% of all overloads**	**% of o'load damage**	**Proposed allow'ce (t)**	**Mass diff (t)**	**% of all overloads**	**% of o'load damage**
RIGID	11	26.3%	STR	6.0	2.39%	6.25	4.2%	0.05	5.6%	3.8%	0.30	0.05	5.6%	3.8%
RIGID	11	26.3%	DRV	9.0	0.10%	9.50	5.6%	-0.05	-2.6%	-1.9%	0.50	0.00	0.0%	0.0%
RIGID	12	7.6%	STR	6.0	13.62%	6.25	4.2%	0.05	5.9%	4.0%	0.30	0.05	5.9%	4.0%
RIGID	12	7.6%	DRV	16.5	4.70%	17.50	6.1%	-0.18	-7.6%	-6.0%	0.50	-0.50	-21.7%	-16.8%
RIGID	22	0.9%	STR	11.0	16.56%	12.00	9.1%	-0.45	-25.5%	-20.3%	0.30	-0.70	-38.7%	-29.8%
RIGID	22	0.9%	DRV	16.5	15.65%	17.50	6.1%	-0.18	-5.5%	-3.8%	0.50	-0.50	-14.6%	-9.9%
T&T	12-1^2	2.4%	DRV	16.5	12.06%	17.50	6.1%	-0.18	-10.1%	-9.8%	0.50	-0.50	-28.6%	-27.0%
T&T	12-1^2	2.4%	DOL	9.0	5.31%	9.50	5.6%	-0.05	-2.8%	-2.1%	0.40	-0.10	-5.5%	-4.1%
T&T	12-1^2	2.4%	TRL	16.5	0.64%	17.50	6.1%	-0.18	-8.3%	-12.6%	0.50	-0.50	-33.8%	-49.2%
SEMI*	12^2	4.7%	DRV	16.5	4.58%	17.50	6.1%	-0.18	-7.7%	-6.1%	0.05	-0.18	-21.5%	-16.6%
SEMI*	12^2	4.7%	TRL	16.5	5.78%	17.50	6.1%	-0.18	-7.6%	-6.0%	0.50	-0.50	-21.0%	-16.1%
SEMI*	12^3	38.7%	STR	6.0	9.09%	6.25	4.2%	0.05	8.6%	6.5%	0.30	0.05	8.6%	6.5%
SEMI*	12^3	38.7%	DRV	16.5	12.84%	17.50	6.1%	-0.18	-8.8%	-6.9%	0.50	-0.50	-24.0%	-18.5%
SEMI*	12^3	38.7%	TRL	20.0	15.62%	21.00	5.0%	0.00	0.0%	0.0%	0.50	-0.50	-18.5%	-13.8%
B-DOUB	1233	9.0%	STR	6.0	17.31%	6.25	4.2%	0.05	8.0%	6.2%	0.30	0.05	8.0%	6.2%
B-DOUB	1233	9.0%	DRV	16.5	13.17%	17.50	6.1%	-0.18	-10.3%	-8.6%	0.50	-0.50	-28.4%	-23.2%
B-DOUB	1233	9.0%	TRL1	20.0	18.76%	21.00	5.0%	0.00	0.0%	0.0%	0.50	-0.50	-21.9%	-17.2%
B-DOUB	1233	9.0%	TRL2	20.0	18.82%	21.00	5.0%	0.00	0.0%	0.0%	0.50	-0.50	-22.2%	-17.4%
		89.6%	**of fleet**		**10%**	**weighted av. for all groups**			**-0.5%**	**-0.6%**			**-9.6%**	**-7.7%**

* SEMI = semi-trailer or truck and trailer (Culway unable to distinguish)

Notes: NAASRA TOL is the estimated proportion within the current NAASRA tolerance.

% of all overloads is the proportion of all overloaded axle groups

% of damage is the estimated proportion of all road damage arising from overloaded axle groups, based on 4th power analysis

Table 6. Details of possible combination of tolerances and 5% breakpoint

				Proposed measurement allowance			Minor risk breach			Substantial risk breach			Severe risk breach	
Vehicle config'n	Proportion of fleet	Axle group	Mass limit (t)	% of overloads	% of damage	Mass (t)	% of overloads	% of damage	Minor breakpoint	% of overloads	% of damage	Substant'l breakpoint	% of overloads	% of damage
11	26.3%	STR	6	13.2%	8.7%	6.30	0.0%	0.0%	6.30	60.8%	54.7%	7.20	26.0%	36.7%
11	26.3%	DRV	9	15.0%	10.1%	9.40	5.2%	3.7%	9.50	58.0%	53.9%	10.80	21.8%	32.4%
12	7.6%	STR	6	11.9%	7.9%	6.30	0.0%	0.0%	6.30	63.5%	54.9%	7.20	24.5%	37.2%
12	7.6%	DRV	16.5	9.1%	5.4%	17.00	21.7%	16.8%	17.50	53.0%	53.9%	19.80	16.2%	23.9%
22	0.9%	STR	11	3.2%	2.2%	11.30	9.8%	6.9%	11.50	63.3%	57.8%	13.20	23.7%	33.0%
22	0.9%	DRV	16.5	4.2%	2.7%	17.00	14.6%	9.9%	17.50	47.3%	43.1%	19.80	34.0%	44.3%
12-1^2	2.4%	DRV	16.5	19.6%	8.3%	17.00	28.6%	27.0%	17.50	49.2%	59.8%	19.80	2.7%	4.9%
12-1^2	2.4%	DOL	9	16.0%	11.2%	9.40	5.5%	4.1%	9.50	62.6%	60.5%	10.80	15.9%	24.1%
12-1^2	2.4%	TRL	16.5	51.3%	26.3%	17.00	33.8%	49.2%	17.50	14.9%	24.5%	19.80	0.0%	0.0%
12^2	4.7%	DRV	16.5	9.2%	5.1%	17.00	21.5%	16.6%	17.50	52.1%	53.0%	19.80	17.2%	25.3%
12^2	4.7%	TRL	16.5	8.8%	4.8%	17.00	21.0%	16.1%	17.50	52.9%	53.7%	19.80	17.3%	25.4%
12^3	38.7%	STR	6	17.2%	12.7%	6.30	0.0%	0.0%	6.30	67.8%	62.3%	7.20	15.0%	25.0%
12^3	38.7%	DRV	16.5	7.3%	5.3%	17.00	24.0%	18.5%	17.50	51.7%	51.2%	19.80	16.9%	24.9%
12^3	38.7%	TRL	20	3.7%	2.7%	20.50	18.5%	13.8%	21.00	63.0%	61.7%	24.00	14.9%	21.8%
1233	9.0%	STR	6	11.6%	8.8%	6.30	0.0%	0.0%	6.30	78.4%	74.9%	7.20	10.1%	16.3%
1233	9.0%	DRV	16.5	8.7%	6.7%	17.00	28.4%	23.2%	17.50	54.1%	56.4%	19.80	8.8%	13.7%
1233	9.0%	TRL1	20	4.6%	3.5%	20.50	21.9%	17.2%	21.00	63.8%	64.5%	24.00	9.7%	14.8%
1233	9.0%	TRL2	20	4.7%	3.6%	20.50	22.2%	17.4%	21.00	63.6%	64.3%	24.00	9.6%	14.7%
	89.6%	**of fleet**		**10.7%**	**7.4%**		**12.5%**	**9.9%**		**60.0%**	**57.7%**		**16.7%**	**25.0%**

Notes:
% of overloads is the proportion of all overloaded axle groups
% of damage is the estimated proportion of all road damage arising from overloaded axle groups, based on 4th power analysis

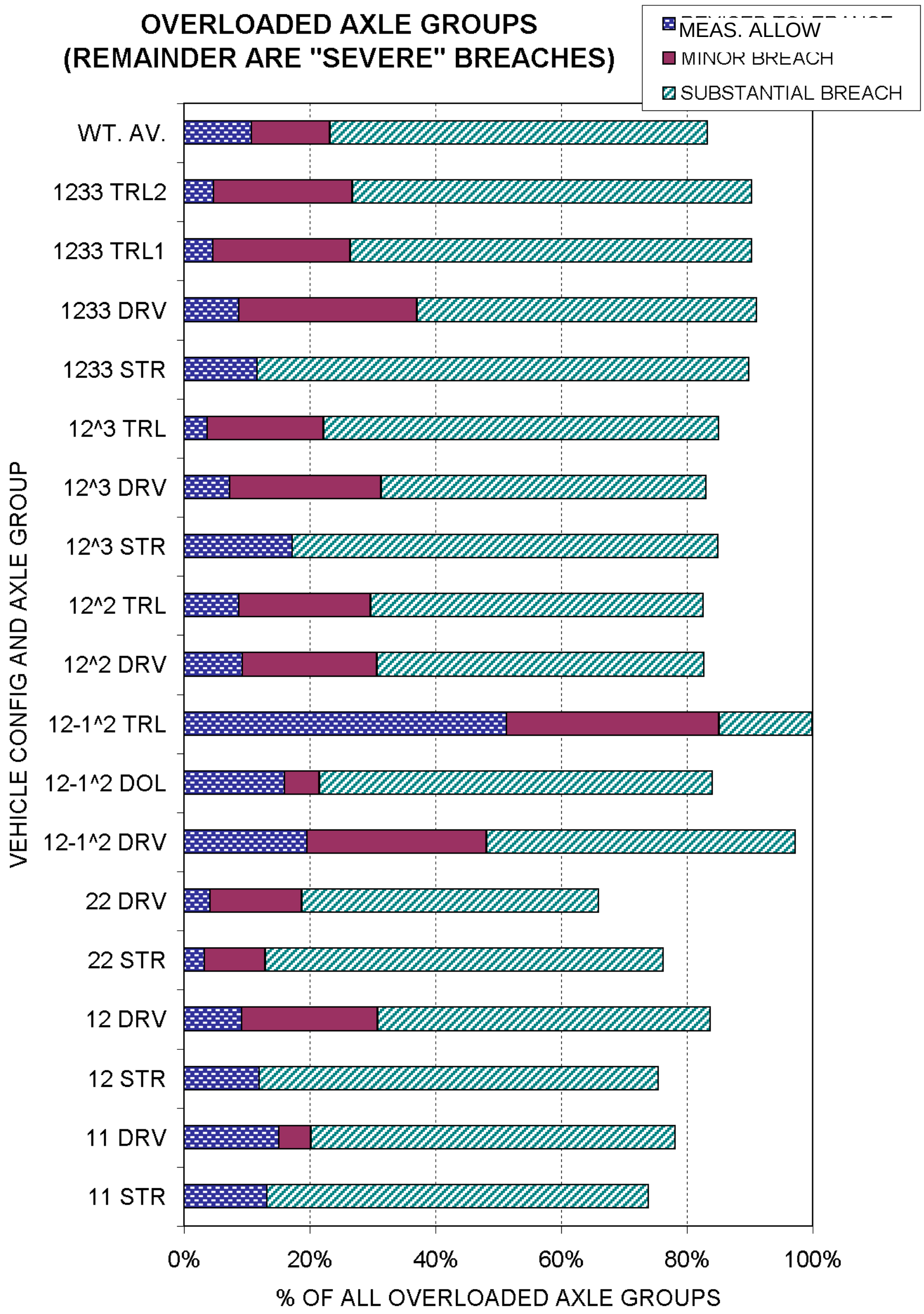

Figure 1. Summary of possible effects on analysed vehicles (based on Table 6)

Road damage

Road damage has been taken into account in the previous analysis by assessing the estimated changes to total road damage caused by overloaded axle groups.

The adoption of a risk-based enforcement and penalty system should result in an overall reduction in the incidence of overloading, particularly in the substantial and severe risk categories. It is likely, however, that the current NAASRA tolerances are well known in the industry and that some operators are loading up to these tolerances. Our proposal to generally reduce these tolerances to measurement allowances should therefore result in fewer vehicles being intentionally operated at more than the statutory limit. Approximately 10% of current overloads (and 8% of all damage due to overloading) would be in this category.

It is important that operators realise that if they load beyond the statutory limit but within the measurement allowance then they risk being found to be in excess of the allowance due to variations inherent in the measurement process. Also it should be noted that the recommended breakpoints for substantial and severe breaches take these variations into account. It is recommended that legislation describing the breakpoints should take the US approach and include words such as “these breakpoints include all variations arising from weighing methods”.

Bridge damage

Koniditsiotis (1998) and NRTC (1996c) both indicate that gross overloading is the main concern with bridges. Vehicle overloading at the level proposed for the minor breach breakpoint should not be a concern with bridges.

Safety issues

Safety issues associated with the setting of minor risk breakpoints are similar to those associated with proposed increased mass limits for road friendly suspensions. Part A of NRTC 1996b, *Road Safety and Environmental Effects*, reviewed these issues. In brief, stability and handling, crash exposure and crash severity were analysed. Overall no significant safety issues were found within the level of mass increases proposed. The 1996 study did not, however, look closely at the issue of manufacturers’ limits on vehicles and vehicle components. This may have been because the study was considering vehicles of a particular design that were assumed to be suitable for the proposed increased mass limits.

Table 7. Vehicle factors associated with overloading

Component	Concern with overloading
Tyres	Tyres loaded beyond their rated capacity might fail, possibly causing immediate loss of control of the vehicle. Tyre failures on steer axles are likely to be more serious than other axles. Overloaded tyres may shed their tread, causing a hazard to other road users.
Axles	Although very unusual, overloaded axles may fail, causing loss of vehicle control. Overloaded steering axles may result in deteriorated steering response, including deteriorated or failed power steering.
Suspensions	Although very unusual, overloaded suspensions may fail, causing loss of control. Overloaded bushes and other components may wear excessively, leading to deterioration in the control of the vehicle. This may not be important until an emergency arises and the vehicle does not have the response needed to avoid a collision.

Brakes	Overloaded brakes may exceed their capacity and be unable to stop the vehicle at prescribed minimum levels. This may not be important until an emergency arises and the vehicle does not have the response needed to avoid a collision. Overloaded brakes are more susceptible to brake fade (the brakes become inoperative after sustained application, particularly on long descents).
Gross mass	Various performance tests, such as braking, are carried out by the manufacturer in order to demonstrate compliance with several Australian Design Rules (ADRs). Many of these tests are performed at the manufacturer's nominated gross vehicle mass (GVM). There is no assurance that a vehicle operated at beyond the GVM will continue to comply with the ADRs and therefore continue to provide the accident avoidance and road user protection levels intended with the ADRs.

The approved *Compliance and enforcement: Mass, dimensions and load restraint* national policy (NRTC 2000b) refers to manufacturers' limits, but mainly in regard to the setting of breakpoints for severe risk breaches. In discussing options, the document refers to Northern Territory policy where loads up to 5% beyond manufacturer's ratings are, in effect, treated as a minor breach. However, the document then indicates that the preferred option is to enforce the manufacturer's limits when they are below the statutory limit.

In reviewing the safety effects of minor risk breakpoints it considered that the Northern Territory approach is conservative – that is, an overload that is within 5% of the manufacturer's limit should not present a safety problem. This is because all vehicle designs should have a reasonable factor of safety and operation at slightly more than the design load should not result in catastrophic failure. There may be increased wear, or accelerated fatigue failure, but in both cases a reasonable maintenance program should pick up the deterioration before it becomes a safety risk.

Where the vehicle manufacturer's gross vehicle mass rating is equal to, or greater than, the statutory mass limit it is highly likely that individual vehicle components will also be within their design ratings when the vehicle is operating at the statutory limit. It is therefore a reasonable assumption that any such vehicle operating at 5% above the statutory limit (or the proposed rounded values) would be no more than 5% above the manufacturer's ratings for all other critical vehicle components. Such an overload should not cause any safety concerns. Therefore, in general, the breakpoints for axle group mass and revised measurement allowances discussed in the previous section are not a safety concern.

A rare exception might be where an unfavourable load distribution results in one axle group (or one side of the vehicle) being overloaded and the other groups (or side) being unloaded. Axle group mass limits should come into play for uneven load distribution between axle groups. It is understood that side-to-side load differences are not usually enforced but such loads are unusual and a vehicle is unlikely to be consistently loaded in such a way.

Manufacturer's ratings

For the reasons outlined in the previous section, it is recommended that the breakpoint for minor breaches of a vehicle manufacturer's rating be set at 5% above those ratings. This situation will only occur where the manufacturer's gross vehicle mass is less than the statutory mass (the lesser of *the bridge formula gross mass* and *the sum of the allowable axle group masses*).

With the exception, perhaps, of tyres (covered in the next section), it is unusual for the ratings of individual vehicle components to be exceeded if the vehicle is operating within its manufacturer's gross vehicle mass. If overloading of individual components does come to attention then the 5% breakpoint for a minor breach should apply.

Tyre ratings

Tyre capacities are specified by the Tyre and Rim Association of Australia and are usually embossed on the tyre sidewall. From the Culway data (NTRC 2001) it is not possible to determine the size of tyres fitted to various vehicles but it is known that 10.00R20 and 11.00R22.5 tyres are commonly used on highway vehicles. 16 ply tyres provide the highest load ratings and the capacities of the 16 ply versions are the same for the two popular tyre sizes. These capacities are 3.0t for a single tyre and 2.725t for a tyre that is part of a dual tyre combination. The total tyre capacity for various types of axle groups are set out in Table 8.

Table 8. Effective tyre capacity for each type of axle group

Axle group	Sum of tyre capacity	Statutory mass limit
Single-tyred single axle	6.0t	6.0t
Twin steer group (single tyres)	12t	11t
Dual-tyred single axle	10.9t	9.0t
Dual-tyred tandem axle group	21.8t	16.5t
Dual-tyred triaxle group	32.7t	20t

For a single-tyred single axle, such as a steer axle, total tyre capacity is therefore the same as the statutory mass limit. Therefore any steer axle that is over the statutory limit will also exceed the tyre capacity, assuming that the popular tyres are fitted. Table 9 shows the estimated proportion of vehicles that exceed the tyre capacities.

Table 9. Analysis of tyre capacities

					% of all vehicles (not just overloads)			
Vehicle type	**Vehicle config'tn**	**Group**	**Tyre capacity**	**Tyre capacity @ 5% o'load***	**Over tyre cap**	**5% over tyre cap**	**10% over tyre cap**	**20% over tyre cap**
RIGID	11	STR	6.0t	5.0%	2.4%	2.1%	1.6%	0.6%
RIGID	11	DRV	10.9t	-13.3%	0.7%	0.3%	0.1%	0.0%
RIGID	12	STR	6.0t	5.0%	13.6%	12.0%	7.8%	3.3%
RIGID	12	DRV	21.8t	-20.5%	0.1%	0.0%	0.0%	0.0%
RIGID	22	STR	12.0t	-3.7%	9.5%	5.9%	3.9%	0.0%
RIGID	22	DRV	21.8t	-20.5%	2.5%	1.6%	0.8%	2.5%
SEMI	12^3	STR	6.0t	5.0%	9.1%	7.5%	3.8%	1.4%
SEMI	12^3	DRV	21.8t	-20.5%	0.8%	0.5%	0.2%	0.0%
SEMI	12^3	TRL	32.7t	-35.8%	0.0%	0.0%	0.0%	0.0%

* (Tyre Capacity - (Statutory+5%))/Tyre capacity - the amount of tyre overloading if the minor breach breakpoint for axle group mass is set at 5% above the statutory limit.

At an axle group mass that is 5% over the statutory limit, all groups except the single steer axle are under the total tyre capacity for the group. In the case of single steer axles the tyres are 5% over their rated capacity. Although this is a concern for the purpose of setting a minor risk breakpoint, there are some mitigating circumstances. Firstly, some highway vehicles are fitted with higher capacity tyres on the steer axles and these would be operating within the combined tyre capacity at 5% over the statutory limit. Secondly, for many of the remaining vehicles it is common practice to place new tyres on the steer axle. Once these wear out the casing is used for retreading and the tyre is then usually fitted to a drive or trailer axle. New tyres can be expected to withstand slight overloading better than retreaded tyres.

On the other hand, the failure of a steer axle tyre can be expected to have graver consequences than the failure of a drive axle or trailer tyre. This is mainly because of the importance of the steering axle for directional control of the vehicle. The estimate (Table 8) that more than 3% of three-axle rigid trucks have tyres on steer axles loaded to more than 20% beyond their rated capacity is therefore an enforcement concern (albeit, not a concern for the purpose of setting minor risk breakpoints).

Twin steer vehicles are also a concern. Although a negligible proportion exceeded 20% of tyre capacity, some 4% exceeded 10% of the tyre capacity. The mass limits encourage the use of loadsharing, twin-steer axle groups by allowing 11t compared with 10t for a non-loadsharing twin steer group. This was probably justified as a road-protection measure but the presence of a loadsharing mechanism can make the consequences of an individual tyre failure more severe. This is because the tyre will deflate until the rim contacts the roadway but the loadsharing mechanism will, as it is designed to do, ensure that the wheel with the deflated tyre carries an equal share of the group load. This could make directional control of the vehicle difficult. With a non-loadsharing group the intact tyres carry a greater share of the total load and the wheel with the deflated tyre carries less load so steering response is close to normal.

Risk taking

Several correspondents have commented on the issue of risk taking. It is speculated that an operator who frequently overloads is also more likely to take other risks. These other risks may increase the chances of being involved in an accident. For example, speeding, excessive driving hours and poor vehicle maintenance may be more likely with an operator who overloads. There appears to be only anecdotal evidence to support this idea at this stage.

Failure to maintain brakes properly could make the consequences of overloading more serious. If the brakes on some axles are inoperative or ineffective then the overall braking performance of the vehicle is reduced and the remaining brakes have to do more work - with consequent increased risk of brake fade. In these circumstances overloads could have a much greater effect on braking performance than in a well maintained vehicle, where the braking system has some spare capacity.

CONCLUSION

The approved *Compliance and enforcement: Mass, dimensions and load restraint* national policy, in effect, proposes that the practice of applying measurement allowances to axle and gross mass measurements cease and that a minor risk breach category be introduced to cover slight overloads. The policy suggested that the minor breach breakpoint be based on the current NAASRA tolerances and measurement allowances, subject to review of these tolerances and allowances.

Our review of the issues suggests that it would be inappropriate to dispense with measurement allowances. These allowances take into account a range of sources of variation (such as scale accuracy, site characteristics and some vehicle characteristics) that may result in a legally laden vehicle being measured and found to be overloaded. It is therefore not appropriate to regard all vehicles within the tolerance band as minor risk overloads.

One approach would be to adopt the US policy of stating in the legislation that the statutory limits "include all tolerances". This may be difficult to justify in Australia since the last two national reviews of mass limits appear to acknowledge the need for tolerances beyond the statutory limits. Legal opinion could be sought on this option, in the unlikely event that it receives widespread support. It would, however, be appropriate to consider the US approach in the wording that describes the breach breakpoints.

Statistical data from weigh-in-motion measurements taken throughout Australia and presented in a 2001 NRTC report have been analysed to estimate the effects of various options for setting minor breakpoints. These align reasonably well with an analysis of NSW breach reports for overloading. The latter analysis also provided information about vehicles loaded beyond the manufacturer's gross vehicle mass and "bridge formula" overloads.

The analysis looked at the road damage and road safety implications of various options for setting the minor breach breakpoints. Road damage was assessed using fourth power analysis and comparing the outcome of scenarios with the base case of the current NAASRA tolerances. Road safety was not found to be an issue with overloads of around 5%, as proposed for the minor risk breakpoints.

The values of the "NAASRA tolerances" are in need of review. We have looked at the basis of those allowances as they described in a 1985 conference paper. One factor that was included in the 1985 analysis was the sensitivity of vehicles at the time to slight variations in axle heights. Since then more effective loadsharing suspensions have reduced the problem. Loadsharing was introduced as a road-protection measure and only suspensions that do not loadshare effectively will be susceptible to variations in axle height. In the circumstances it is considered that "axle attitude" should no longer be a factor in the measurement allowances. The statistical information reported in 1985 has therefore been re-analysed.

The proposed measurement allowances are generally less than the upper breakpoint of 5% above the statutory limit for the minor risk category (the exception is a single steer axle where the proposed tolerance is equal to a 5% overload). Therefore a viable option is to derive the upper breakpoint for the minor risk category from a 5% overload but to round the result to a convenient fraction of a tonne. For example, for a tandem axle group:

- The statutory limit is 16.5t.
- The proposed tolerance is 0.5t so loads *measured* as under 17t would not be penalised.
- The proposed minor breakpoint is17.5t (i.e. a 5% overload of 17.33t rounded to the nearest 0.5t), so loads *measured* between 17t and 17.5t would be treated as a minor breach.
- The substantial breakpoint at 20% overload is 19.8t, so loads *measured* between 17.5t and 19.8t would be treated as a substantial breach.
- Loads *measured* over 19.8t would be treated as a severe breach.

Under this proposal it is estimated that some 24% of overloaded vehicles would fall below the minor risk breakpoint and, of these, about half would be covered by the proposed measurement allowances. By coincidence, the remaining half are mostly covered under the current NAASRA tolerances and therefore currently operate without penalty.

It is recommended that this option be considered for national policy.

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APPENDIX A. REANALYSIS OF NAASRA BREAKPOINTS

Table A1 - Derivation of revised measurement allowances

		95% Confidence (from NAASRA Table VI)				99% Confidence (derived)			
Vehicle	**% of fleet**	**STR**	**DRV**	**TRL**	**GR**	**STR**	**DRV**	**TRL**	**GR**
11	26.3%	170	280		40	238	392		56
12	7.6%	210	350		80	294	490		112
22	9.0%	200	330		80	280#	462*		112
12^2	3.5%	150	370	360	170	210	518*	504*	238
12^3	38.7%	180	320	300	220	252	448*	420@	308

Notes:

Twin steer - worst case 280kg, rounded to nearest 100kg = 300kg
* Tandem group - worst case 518kg, rounded to nearest 100kg = 500kg
@ Triaxle group - worst case 420kg but 500kg measurement allowance recommended for consistency with tandem group
Worst case single steer 294kg, rounded to nearest 100kg = 300kg
Worst case dual tyred single axle 392kg, rounded to nearest 100kg = 400kg
Worst case gross mass 308kg but 500kg measurement allowance recommended for consistency with tandem group.

The 95% confidence levels are from the 1985 NAASRA report and are based on analysis of hundreds of vehicle weighings at many sites throughout Australia. This table takes into account scale variation, suspension hysteresis and grade effects *but not axle attitude.*

99% confidence levels are based in the assumption that the masses are normally distributed. Therefore the 99% value is 1.4 times the 95% value.

The 1985 paper recommended tolerances based on the 99% values for the worse case vehicle. However, this was not the worst case for steer axles, therefore the recommended measurement allowance is greater than the current NAASRA tolerance of 250kg.

The 1985 analysis did not consider quad-axle groups (four axles within a group). These are normally only encountered in the case of overmass vehicles. The technical characteristics of typical modern quad-axle groups are very similar to those of triaxle groups. It is therefore proposed that a measurement allowance of 500kg also apply to quad-axle groups.

APPENDIX B - RESULTS OF BREACH REPORT SURVEY

This Appendix sets out the results of an analysis of 104 mass-limit breach reports issued by Roads & Traffic Authority officers in metropolitan Sydney. The breach reports cover a variety of vehicle types and intercept locations. While they cannot be assumed to be representative of nationwide mass limit breaches they do give an indication of the types and magnitudes of overloads that can be expected.

Note that in many cases the vehicle exceeded more than one mass limit. The breach action may have proceeded on the basis of the most serious breaches but the analysis was performed for all axles on the vehicle so it also covers less serious breaches (that, by themselves, might not have resulted in breach action).

Vehicle types

Vehicle type	Count
Garbage truck	1
Mobile crane	3
Rigid	9
Rigid table top	10
Rigid tipper	52
Rigid van	6
Semi	2
Semi table top	1
Semi tipper	9
Truck & dog	5
Truck & pig	6

Offence

Type of offence	Count*
Exceed GVM or Agg Weight	84
Exceed GCM (with trailer)	5
Exceed axle load limits	61
Exceed bridge formula	22
Exceed GVM/Agg but not axle or bridge limits	43

* Not exclusive. Many vehicles breached more than one category.

GVM breaches

% beyond GVM	Count	Cumulative %
5%	11	13.9%
10%	12	29.1%
15%	11	43.0%
20%	14	60.8%
25%	7	69.6%
30%	6	77.2%
35%	9	88.6%
40%	1	89.9%
45%	2	92.4%
50%	0	92.4%

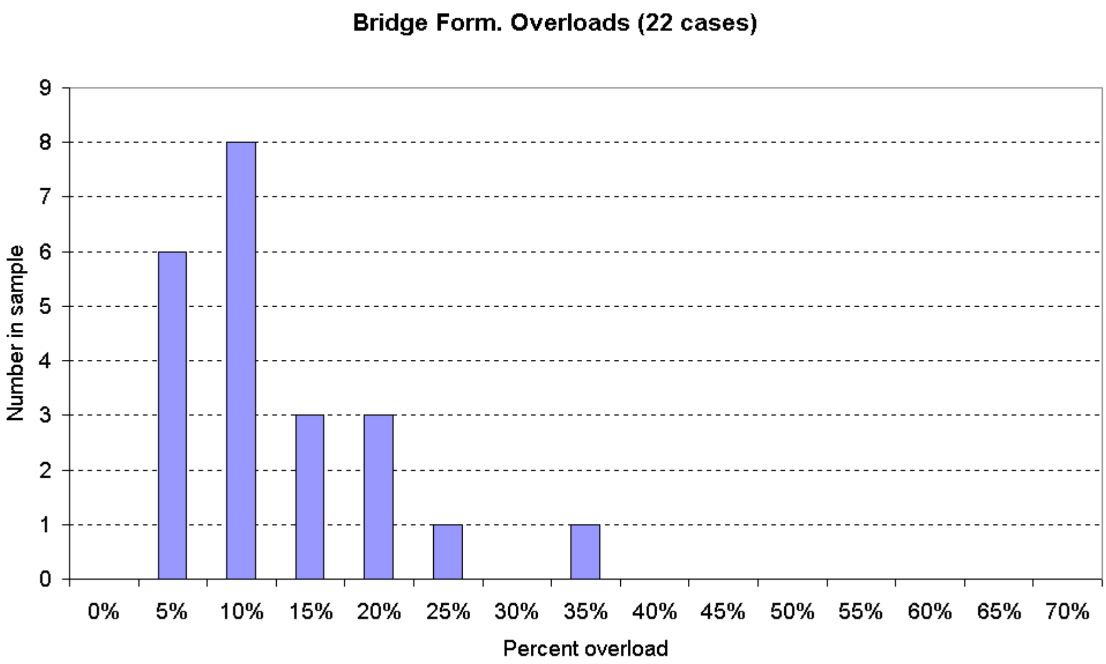
% beyond GVM	Count	Cumulative %
55%	1	93.7%
60%	1	94.9%
65%	1	96.2%
70%	0	96.2%
75%	0	96.2%
80%	1	97.5%
85%	1	98.7%
90%	1	100.0%
TOTAL	**79**	

Mean: 0.21, Standard deviation: 0.18

Bridge formula

% beyond bridge formula	Count	Cumulative %
0%	0	0.0%
5%	6	27.3%
10%	8	63.6%
15%	3	77.3%
20%	3	90.9%
25%	1	95.5%
30%	0	95.5%
35%	1	100.0%
40%	0	100.0%
45%	0	100.0%
50%	0	100.0%
TOTAL	**22**	

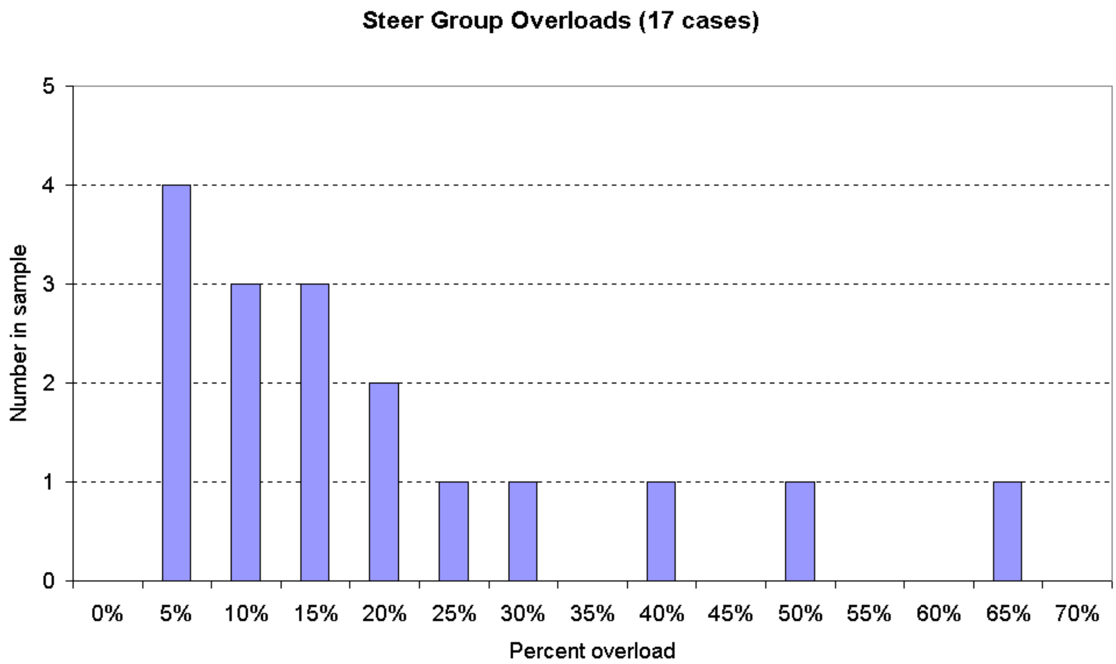
Mean: 0.10, Standard deviation: 0.07



Steer axle group

% beyond axle load	Count	Cumulative %
0%	0	0.0%
5%	4	23.5%
10%	3	41.2%
15%	3	58.8%
20%	2	70.6%
25%	1	76.5%
30%	1	82.4%
35%	0	82.4%
40%	1	88.2%
45%	0	88.2%
50%	1	94.1%
55%	0	94.1%
60%	0	94.1%
65%	1	100.0%
70%	0	100.0%
TOTAL	17	

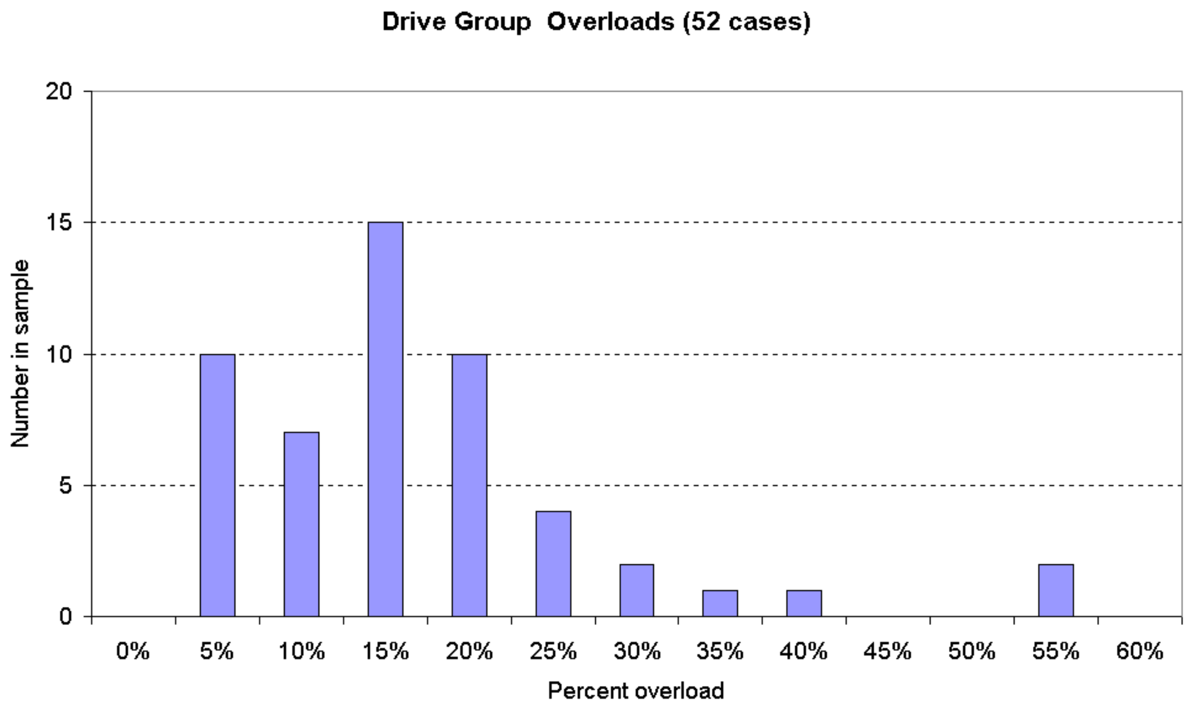
Mean: 0.18, Standard deviation: 0.168209



Drive group

% beyond axle load	Count	Cumulative %
0%	0	0.0%
5%	10	19.2%
10%	7	32.7%
15%	15	61.5%
20%	10	80.8%
25%	4	88.5%
30%	2	92.3%
35%	1	94.2%
40%	1	96.2%
45%	0	96.2%
50%	0	96.2%
55%	2	100.0%
60%	0	100.0%
TOTAL	52	

Mean: 0.15, Standard deviation: 0.11



Trailer group

% beyond axle load	Count	Cumulative %
0%	0	0.0%
5%	2	10.5%
10%	4	31.6%
15%	3	47.4%
20%	5	73.7%
25%	2	84.2%
30%	2	94.7%
35%	0	94.7%
40%	0	94.7%
45%	1	100.0%
50%	0	100.0%
TOTAL	19	

Mean: 0.17, Standard deviation: 0.10148