SINCLAIR KNIGHT MERZ

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Australian Government

Department of Defence

Defence Support Group

Heavy Roller Operating Manual

- Final
- 06 May 2009

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1. Introduction

1.1 General

The Department of Defence - Defence Services Group – Infrastructure Asset Development Branch – Directorate of Estate Engineering Policy – Civil Engineering Section manages a number of heavy rollers specifically for use for compaction and proof rolling of aircraft pavements and subgrades during their construction or strength evaluation of existing pavements. These rollers are usually hired by construction companies contracted to construct aircraft pavements on Defence airfields. Construction companies contracted to construct aircraft pavements on non-Defence airfields and consultants are also permitted to hire the rollers.

Defence currently maintains a fleet of nine heavy rollers. These include eight pneumatic tyred rollers (previously called Marco and Macro Rollers) of which three have been refurbished as pneumatic tyred types, two have been refurbished with solidified pneumatic type tyres, and one (ninth) has been fitted with solid urethane rubber coated wheels designed to provide an average contact pressure of 1,700 kPa. The pneumatic tyred rollers are currently limited to a tyre inflation pressure of 1,000 kPa.

1.2 Aim of Document

This document is an update of the Heavy Roller Operating Manual prepared for Defence by Airplan (Pavement Specialist Services) in January 2003. The primary aim of this document is to detail the number, configuration, operation and use of the rollers for the compaction and proof rolling of aircraft pavements during construction. However, these heavy rollers are also suitable for strength evaluation of some existing aircraft pavements, if required, when other methodologies are inappropriate. Transport, maintenance, storage and operating requirements are also included.

1.3 Background

Compaction and proof rolling is the act of inducing a stress in a pavement layer that exceeds its expected in-service stress. By inducing a number of repetitions of stress that exceed the service stress, any deficiency in the quality of the materials or state of compaction in the layer can be identified prior to the acceptance of the layer being proven and its covering by the subsequent pavement layers. The proof rolling process applies additional construction compaction as the materials are proof rolled whilst at their optimum moisture content.

The current method for aircraft pavement thickness design is based on the full scale testing and design procedure developed by the US Army Corps of Engineers in the 1940s to 1970s. The development of this thickness design method was based on a number of assumptions regarding materials and construction processes. One of those assumptions was that all subgrade and granular pavement materials would be proof rolled during construction. Australia has retained proof rolling as a routine part of aircraft pavement construction. Other countries have not. The USA has largely discontinued proof rolling but has adopted cemented base course and thick asphalt surfacings instead[2)].

Proof rolling is considered an integral part of aircraft pavement construction in Australia, without which the basis of the pavement thickness design is voided. With the trend for aircraft manufacturers to produce heavier aircraft with increasing wheel loads (now up to 30 t for the A340-600 aircraft) and tyre pressures (1,570 kPa for the A340-600), proof rolling pavements is becoming increasingly critical.

Defence imported two rollers from the USA in the 1950s. These rollers, known as Macro rollers, were capable of applying up to 50 t on four wheels with a tyre pressure of up to 1,400 kPa. The Commonwealth then constructed, a number of additional Macro rollers, based on the US roller design. In additional, a roller was modified to replicate the stress with depth induced by a B727 aircraft and was known as the Test Rig. As the B727 is no longer an active aircraft type, this roller has not been maintained. Two 200t rollers known as the Porter Supercompactors were also developed for proving deep layers of hydraulically placed sand fill. One of these was sold to Hong Kong Airport in the 1990s and the other is located at RAAF Pearce. Due to the lack of demand for a Supercompactor, Defence have not maintained the remaining roller.

In 2004 a number of projects, including those at Sydney Airport and Cairns Airport, were underway. During the preparation for the proof rolling of the granular layers, the Macro Roller tyre suppliers (Michelin tyres at the time) revoked the previous certification (of which no record can be found) to inflate the tyres to very high pressures. The tyres are rated to 1000 kPa whereas a previous agreement had been reached to allow 1400 kPa to be utilised with restrictions on the operation of the rollers (such as maximum travel speeds). Further discussion with Michelin and other tyre manufacturers (Bridgestone) revealed that due to increasing OHS issues and the increasingly litigious society, no earthmoving tyre would be rated or certified for inflation above 1000 kPa. The existing tyres were also deemed to be unserviceable due to their age and replacement tyres of the same type were not available, the line of tyres being virtually discontinued.

The limitation of the pneumatic tyred rollers to 1,000 kPa inflation pressure left a gap between the stresses induced by modern aircraft and the capacity of the rollers. This

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meant that pavement layers could not be proven for adequacy under design aircraft loads during construction. The ‘gap’ existed only for the proving of the upper base course layers of flexible pavements with thin asphalt surfacings (ie the top 200 mm of base course under a 50-60 mm asphalt surface) as shown in Figure 1.

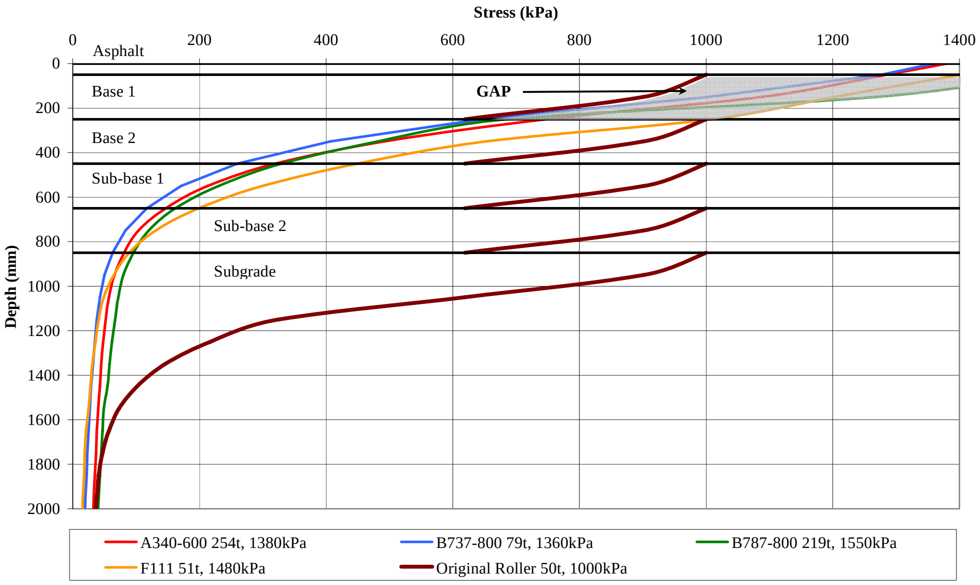

Figure 1. Proof Rolling Gap with 1,000 kPa pressure limit.

Following a number of investigations, one roller was upgraded to include solid steel wheels with a urethane rubber outer liner or solid tyre. The urethane was intended to have an average effective contact pressure of 1,700 kPa. This roller successfully filled the gap left by the 1,000 kPa tyre pressure restriction. A preliminary trial of the solid tyred roller was held at RAAF Base Amberley in June 2007. Following further trials, additional solid tyred rollers are expected to be developed through upgrading of the existing roller fleet.

Two rollers have also been equipped with ‘solidified pneumatic tyres’ and were intended to be able to create surface pressure of 1,000 kPa and 1,400 kPa. Recent trials have shown that at maximum weight (50t on the standard 4 wheel Marco roller, i.e. a 12.5t wheel load) only 1,020 kPa and 1,040 kPa have been achieved by these rollers.

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1.4 Current Roller Fleet

As of May 2009, the Defence heavy roller fleet is detailed in **Table 1**.

Table 1. Heavy Roller Fleet.

Roller	Type	Location	Condition
R50-1	Pneumatic	RAAF Edinburgh	Sound except tyres
R50-2	Pneumatic	RAAF Edinburgh	Tow hitch removed
R50-3	Solidified Pneumatic 10,040 kPa*	RAAF Amberley	Modified to solidified pneumatic tyres
R50-4	Pneumatic	RAAF Learmonth	Unknown
R50-5	Pneumatic	Canberra Airport	Unknown
R50-6	Pneumatic 1,000 kPa	RAAF Williamtown	Refurbished
R50-7	Pneumatic 1,000 kPa	Gold Coast	Refurbished
R50-8	Solidified Pneumatic 1,020 kPa*	Sydney Airport	Modified to solidified pneumatic tyres
R50-9	Solid 1,700 kPa	RAAF Amberley	Upgraded and refurbished

**These 'Solidified Pneumatic' tyred rollers achieve this pressure at a load of 12.5T per wheel / 50T all up weight, on a standard 4 wheel Marco Roller.*

The rollers detailed in Table 2 also remain in Australia but are not being maintained or hired out by Defence.

Table 2. Disused Rollers.

Roller	Type	Location	Condition
R200-1	Supercompactor	RAAF Pearce	Unknown
R50-TR	Test Rig	Sydney Airport	Unknown

2. Roller Types and Description

2.1 General

There are three (3) types of heavy compaction/proof rolling rollers available from Defence for hire. Basically the body/frame & ballast are common to all, however the wheels and tyres differ depending on application. The different wheel types are described below.

a) Pneumatic Tyred Rollers

Four wheeled pneumatic tyred rollers fitted with wheels for use with high pressure Radial 16–R24 or similar tyres which are designed to carry a maximum tyre pressure of 800kPa (old type, generally Michelin tyres) and 1,000 kPa (refurbished type). It is noted that the old tyres limited to 800kPa have a weight limitation of 7.5 tonnes per wheel or 30 tonnes AUM due to the tyre pressure limitation.

Two rollers have also been fitted with solidified pneumatic tyres. These rollers are fitted with Indian made ‘CEAT’ brand tyres and have been shown to acheive 1040kPa surface pressure under 12.5 t wheel loads.

b) Solid Tyred Roller

A single four wheeled solid tyred roller fitted with solid steel wheels with a urethane coating, designed for operation at an effective contact pressure of 1,700 kPa at 40 t total roller mass is available. The roller is designed to operate at a maximum mass of 50 t.

The solid tyred roller is only suitable for operation on smooth, compacted, base course layers of high quality crushed rock. Its use on subgrade, fills of any type, sub-base and cement treated materials is not recommended and may result in bogging of and/or damage to the roller or wheel coatings

2.2 Physical Description of Rollers

The following physical description applies to both types of pneumatic tyred roller & the solid tyred roller.

The complete roller consists of two articulated units each 4,500 mm long, 2,000 mm wide and 1,400 mm high. The overall dimensions of the roller are 8,120 mm long (including drawbar), 4,180 mm wide and 1,400 mm high.

The frame is fabricated from 304 RSC 42 section. There are eight ballast boxes per roller, which each measure 1,050 mm long, 800 mm wide and 700 mm high. The two units are joined by three 65 mm pins through hinge plates which allow the units to articulate.

The four wheel assemblies are mounted in the frame on horizontally split mounting blocks and retained by caps using 32 mm (1.25 inch) Grade 5 bolts, nuts and structural grade washers. The bolts and nuts should be torqued to 1,400 Nm (which is a force of 70 kg on a two metre bar). Grade 5 bolts are identified by radial marks as illustrated in Figure 2.

Figure 2. Pneumatic tyred roller wheel nut, note radial marks denoting Grade 5 Bolt.

2.3 Transportation

The pneumatic tyred roller is typically transported in an un-ballasted condition on a standard semi-trailer or by rail.

Loading of the un-ballasted roller onto the semi-trailer is either by crane lifting the roller onto the trailer or through the use of a front end loader (eg Caterpillar 950 or similar) pushing the roller onto the trailer either through the use of earth loading ramps or trailers fitted with loading ramps. Transport operators are to make enquires of the individual airports and Defence installations as to whether loading ramps are available.

Weights are loaded either through cranage or lifting with a front end loader or similar.

Transport operators are to make their own assessment of cranage requirements for lifting of unballasted rollers and weights.

2.4 Ballasting

The empty roller should be placed approximately level with the rear blocked up. The jacks on the front corners of the boxes should be extended 250 mm to 300 mm after taking load. This will make the front of the box higher than the rear and make it easier to stack the weights.

The ballasting should be done with pig iron or steel ingots, which should be blocked or wedged as necessary to prevent them shifting when the roller moves.

To avoid injury during the ballast loading of the rollers, staff must never stand in areas over which the weights are lifted and must never enter the ballast boxes containing weights. Optional ballast arrangements for different types of weights are shown in **Figures 3** and **Figure 4**.

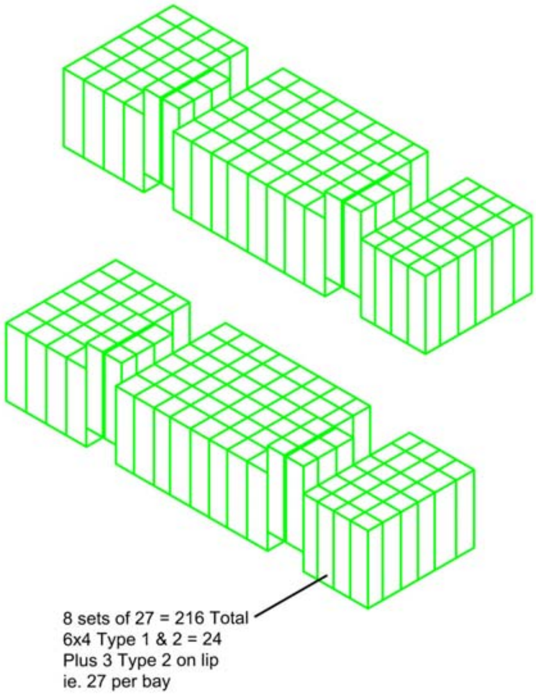

Figure 3. Ballast Arrangement for Red Weights.

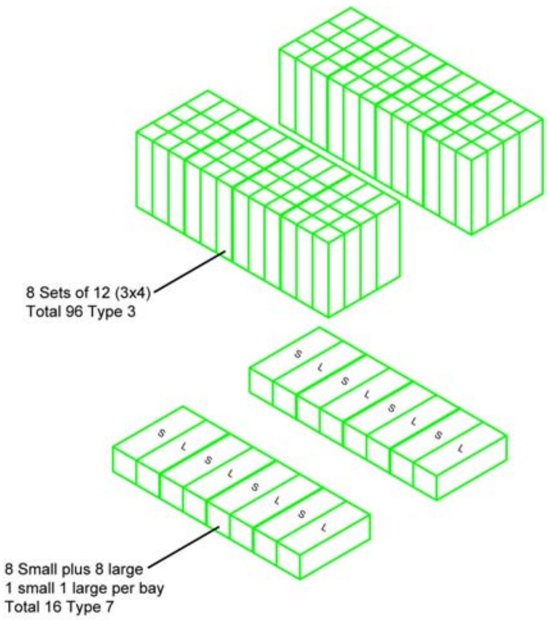

Figure 4. Ballast Arrangement for Yellow, White and Grey Weights.

The ballast for the solid tyred roller has been 'boxed' as shown in **Figure 5** to make loading and unloading more efficient and to minimise the OHS risks associated with handling the ballast.

Figure 5. Boxed ballast.

2.5 Weight and Tyre Pressure Restriction for Pneumatic Tyred Rollers Old Marco with 800kPa Tyre Pressures

a) When fully loaded with 21,800 kg of ballast, a tyre pressure of 800 kPa should be maintained at all times. Allowable tyre pressures for intermediate loadings are shown in Table 3 and graphically at Figure 6. Tyres can not be inflated beyond 800 kPa inflation pressure due to the withdrawal of previous relaxations allowed by the tyre manufacturers.

Ballast (kg)	Total Load (kg)	Minimum (kPa)	Maximum (kPa)
21,800	30,000	800	800
16,800	25,000	675	800
11,800	20,000	540	800
6,800	15,000	400	800
1,800	10,000	270	800

Table 3 *Allowable Tyre Pressures*

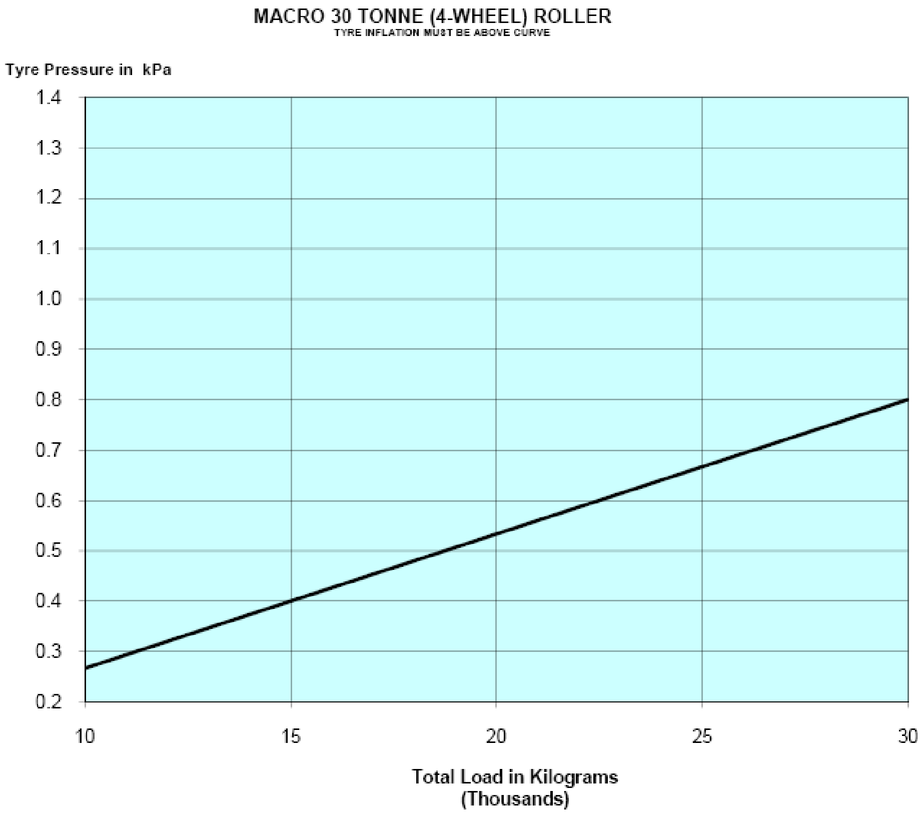

***Figure 6**. Minimum Allowable Tyre Pressure*

b) Refurbished Roller with 1,000kPa tyres and solidified pneumatic tyres

These instruction refer to the operation of rollers with refurbished tyres such as the Bridgestone Industrial Service 16.00-25 32 Ply YS2 or the CEAT 16.00-25 Tubeless, Slick 431L-47 tyre modified to solidified tyres by Bearcat.

Brisgeston Tyres can not be inflated beyond 1,000 kPa inflation pressure due to the withdrawal of previous relaxations allowed by the tyre manufacturers.

Solidified pneumatic tyres (rollers fitted with CEAT brand tyres) have been shown to achieve up to 1,040kPa surface pressure under 12.5t wheel loads.

Allowable tyre pressures for intermediate loadings are shown in **Table 4** and **Figure 7** for the Bridgestone Industrial Service 16.00-25 32 Ply YS2 tyre limited to 10 km/hr. The manufacturer must be consulted to determine the allowable tyre pressure-mass relationship for other tyres.

Table 4. Intermediate Tyre Pressure and Masses
(Bridgestone Industrial Service 16.00-25 32 Ply YS2 tyre limited to 10 km/hr).

Ballast (kg)	Total Load (kg)	Minimum (kPa)	Maximum (kPa)
41,800	50,000	600	1,000
36,800	45,000	500	1,000
31,800	40,000	410	1,000
26,800	35,000	320	1,000
21,800	30,000	250	1,000
16,800	25,000	190	1,000
11,800	20,000	120	1,000
6,800	15,000	80	1,000
1,800	10,000	40	1,000

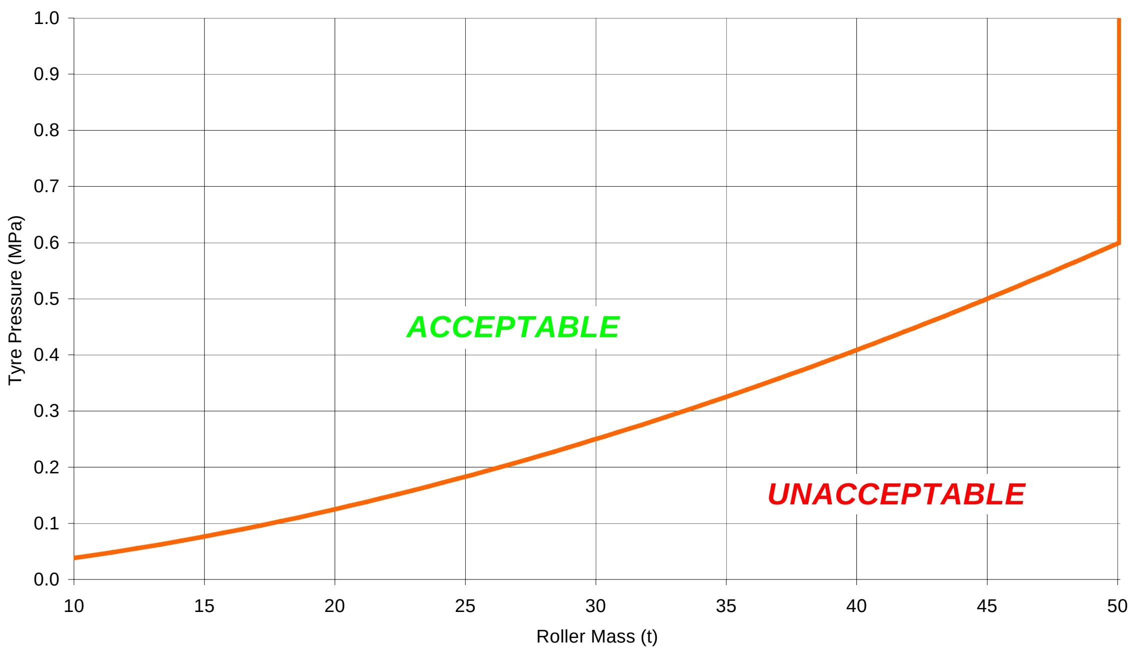

Figure 7. Allowable Tyre Pressure and Mass Combinations
(for Bridgestone Industrial Service 16.00-25 32 Ply YS2 tyre limited to 10 km/hr).

2.6 Weight and Wheel Contact Pressure for Solid Tyred Roller

These Specification, Operating and Maintenance Instructions refer to four wheeled solid tyred roller fitted with solid steel wheels with a urethane coating, designed for operation at an effective contact pressure of 1,700 kPa at 40 t total roller mass. The roller is designed to operate at a maximum mass of 50 t.

The roller is fitted with solid steel wheels with urethane coating or tyre as shown in **Figure 8**.

Figure 8. Solid steel wheels with urethane tyre.

Due to the nature of solid tyres, the tyre pressure can not be selected for this roller. The tyre pressure is a direct function of the mass adopted. The relationship between roller mass and average effective contact pressure is detailed in **Figure 9**, based on load/contact area calculations of the actual wheels.

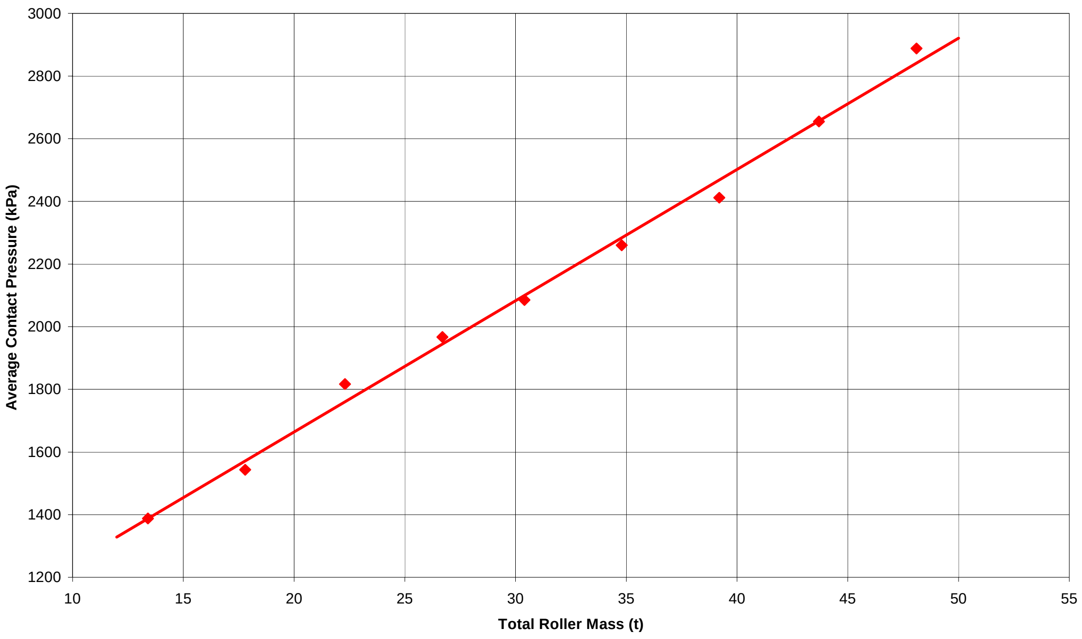

Figure 9. Mass and Effective Contact Pressure Relationship

2.7 Operating Speed Limits

One of the major causes of structural damage to tyres is excessive tyre deflection, which can cause cracking in the tyre wall.

Operation of the solid tyred rollers is limited to 6km/hr under all conditions.

In addition to the pressure-load relationship detailed above, deflection is affected by the speed at which the roller operates and the under-foot conditions. Therefore the following speed limits must be observed at all times for pneumatic tyred rollers:

- First passes over uncompacted fill or in transit over uneven terrain. 6km/hr.
- Subsequent passes over fill and in transit over smooth terrain. 10km/hr. The operation of the ballasted roller is restricted to 6 km/hr.

2.8 Tyre Data

Tyres must be a Bridgestone Industrial Service 16.00-25 32 Ply YS2 or equivalent earthmoving tyre rated for inflation to 1,000 kPa at maximum wheel load of 8,750 kg, as shown in **Figure 10**.

Figure 10. Bridgestone 16.00-25 32 Ply YS2 tyres fitted to roller.

Rollers with solidified pneumatic tyres have used Indian made CEAT 16.00-25 Tubeless, Slick 431L-47 Nylon industrial tyres.

2.9 Tyre Inflation Information

Because of the high energy stored in tyres when inflated with air only, operators and service people should be aware of the potential danger of a blowout.

As a safety precaution, all tyres should be ballasted first with water to 75% of their volume so as to reduce the stored energy.

The internal volume is approximately 390 litres

- 75% is approximately 290 litres
- mass of water ballast 290 kg

Rust prevention additive should be added to the water in accordance with the tyre manufacturer's recommendations.

Notwithstanding the recommendations and requirements of the tyre manufacturer the following procedures should be adopted as good practice:

- When inflating tyres, use an inflation device with at least three (3) metres of hose between the valve on the rim and the in line inflation control valve. This allows the tyre service person to inflate the tyre and check inflation pressure without standing in front of the tyre and rim assembly.

- Always check that the components of the assembled tyre are correctly positioned and the tyre is safe to inflate.
- Inflate the tyre to 30% of the recommended cold working pressure and check that the tyre has seated correctly on the rim assembly. If the tyre has not seated correctly, deflate and recommence the inflation procedure. Refit the valve core and cap once the required inflation pressure has been reached.
- Leakage of air from the valve stems of these tyres is generally caused through over-tightening the valve stem cores. This may be corrected by replacement with new valve cores and avoidance of over-tightening.

The following safety guidelines should be observed during tyre inflation:

- Never under any circumstances leave an inflating tyre unattended.
- If there is any doubt about the seating of a tyre onto a rim base during inflation, turn the air supply off and deflate the tyre for inspection.
- Never stand in front of a vertical tyre during deflation.
- Never stand over or sit on a horizontal tyre during inflation.
- Never put yourself between the tyre and an immovable object.
- Rollers must be un-ballasted when undertaking tyre changes.

2.10 Roller Maintenance

2.10.1 Operating Roller Maintenance

The following procedures should be undertaken when the roller is in use:

- Grease all pivot points (daily).
- Check tyre pressure (daily).
- Check tyre wear (daily).
- Block roller at the end of each day to take load off the tyres (daily).
- Check tow bar coupling and drawbar pin for wear, damage and cracks (weekly).
- Check frame for cracks and signs of fatigue (weekly).
- Check all studs, bolts and nuts for tightness (weekly).

- Check welds on axle mounting blocks and gussets to ensure there are no cracks (weekly).
- Maintain all painted surfaces to ensure the roller remains free of corrosion (as required).

2.10.2 Periodic Roller Maintenance

Defence may require the following maintenance to be performed at no cost to the hiring contractor:

- Wheel and Tyre Maintenance:
  - Replace any damaged tyres (as required).
  - Repack wheel bearings with a NLGI 3 grease (12 monthly).
  - Replace wheel bearings (as required).
  - Replace hub seals (as required).
  - Apply rust preventive paint to the inner faces of the wheel rims and the cylindrical faces of the wheels (as required).
  - Apply anti-freeze compound to the axle clamp bolts (as required).
- Paintwork Maintenance:
  - Treat any rust and ensure that paintwork is in good condition (as required).
  - Repaint as required following maintenance (as required).
  - Particular attention should be given to welded joints, ballast boxes, carriage frame, underside of gusset plates and wheel rims.
- Crack and Weld Maintenance:
  - Undertake weld and crack repairs in equipment carriage frame, gusset plates, axle mounting blocks and gussets (as required).
  - Particular attention should be given to the tow frame, hinge plates and ballast boxes.

2.10.3 Periodic Roller Inspections

During long term hires or as directed by the Fleet Manager, the following inspections must be carried out:

- Wheel and Tyre Inspection:
  - Inspect tyres for visible cracks and edge fretting (on return from hire and prior to hire).
  - Inspect wheel rims for damage, rust or damaged paint (on return from hire and prior to hire).

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  - Check inflation pressure and maintain at not less than 300 kPa (3 monthly)- Pneumatic only.
  - Rotate wheels to prevent etching of bearings (3 monthly).
  - When rotating wheels listen for bearing noise (3 monthly).
  - Inspect hub seals for leaks (3 monthly).
  - Check wheel bearing adjustment. Bearing should have zero end-float (6 monthly).
  - Apply anti-freeze compound to the axle clamp bolts (6 monthly).
- Paintwork Inspection:
  - Inspect paint for damage (6 monthly).
  - Identify paint scratches, paint peeling and signs of corrosion (6 monthly).
  - Treat any rust and ensure that paintwork is in good condition (as required).
  - Particular attention should be given to welded joints, ballast boxes, carriage frame, underside of gusset plates and wheel rims.
- Crack and Weld Inspection:
  - Inspect roller frame for cracks and tears (6 monthly).
  - Identify signs of corrosion, visible cracks at all welded joints (6 monthly).
  - Identify tears in equipment carriage frame, gusset plates, axle mounting blocks and gussets (6 monthly).
  - Particular attention should be given to the tow frame, hinge plates and ballast boxes.

2.11 Roller Storage

When not in use for a period exceeding 24 hours but not exceeding 7 days, the roller must be blocked to take the weight off the wheels. When not in use for a period of more than seven days, the roller must be stored as if being placed into long term storage.

Long terms storage requirements are:

- Undercover storage:
  - Unballast the roller.
  - Block machine and take weight off wheels.
  - Ensure the sufficient blocks are used to distribute weight to protect pavement.
- Open-air storage:
  - As for undercover storage

- Remove the wheels and store wheels in a covered area or cover with tarps. Note protection of wheels both tyred and solid urethane against UV degradation is important.

3. Design of Proof Rolling Regimes

3.1 General

The aim of proof rolling these heavy duty pavements is to expose the various layers to a level of 'damage' (indicated by calculated stress, strain or deflection) that is slightly greater than the maximum expected service 'damage', prior to constructing the next layer of the pavement structure. By proving pavements in this manner, the variability of the structural strength of the pavement is significantly reduced, allowing thinner pavements to be constructed with equal reliability.

The design of proof rolling regimes therefore comprises two steps:

- Calculating the values of the chosen indicator of damage at various depths through the pavement layers.
- Selection of a proof rolling regime (mass and tyre pressure combination) to be applied to the various layers of the pavement structure such that the calculated maximum service damage indicator value is just exceeded.

3.2 Damage Indicator Calculation

In 1996, MINCAD Systems first released the aircraft pavement specific version of CIRCLY, titled Aircraft Pavement Structural Design System (APSDS) (MINCAD, 2000). The layered elastic component of the design tool is used for the calculation of the damage (stress, strain or deflection at the critical points) induced by a single load application. Many other mechanistic aircraft pavement design tools are also available for the generation of these pavement damage indicators.

During each design scenario, the layered elastic design tool algorithms calculate the stresses, strains and deflections of the pavement at a range of depths, as well as at user defined lateral and longitudinal coordinates. The ability to view all damage indicators calculated at all pavement locations is not available in all layered elastic tools and is one advantage of APSDS. This provides for the ability to easily generate plots of stress, strain and deflection against depth under the aircraft wheels or between aircraft wheels.

An investigation performed by Greg White in 2007 determined that the most appropriate method of determining proof rolling regimes was by comparing stress with depth. Stress was selected as it provided the following advantages:

- Easy to visualise and understand compared to strain.
- Equal to tyre pressure at the pavement surface.
- Related to load per landing gear at depth.

- Essentially equal for all modeled subgrade strengths and granular pavement materials.
- Essentially equal, at depth, under the tyre and in the centre of a multiple wheel landing gear.
- Decreases smoothly with increased depth from a maximum value at the surface.

This investigation also determined that for practical purposes, a standard pavement of 1000 mm of crushed rock base course on CBR 6 subgrade could be used for stress with depth calculations for proof rolling regime design. This selection is based justified by:

- All materials having an essentially negligible differential effect.
- The relative or comparative (aircraft to roller) stress being more important than the accuracy of any absolute stress values.
- Base material having a modulus approximately equal to the mean of the moduli of asphalt and subgrade.
- CBR 6 being typical of many pavement subgrades at airports in Australia.

When absolute stresses or far from typical pavement structures are required, a customised pavement for the determination of stress with depth may be justified. However, as the roller and the aircraft stress with depth would be similarly affected by the non-standard pavement, it would be inconsequential to use a single layer pavement in most practical circumstances. Where required, customised stress with depth plots can readily be generated for any pavement structure, for both the design aircraft and the proposed proof rollers, using APSDS or other layered elastic tool.

3.3 Roller Stress with Depth

Roller stresses with depth are generated based on the level of the pavement layer being rolled. This is because the roller is applied directly to this pavement layer at the time that it is constructed and not to the finished surface level.

Example stress with depth plots are shown in **Figure 11** for the pneumatic tyred roller at varying mass and tyre pressure combinations as permitted for generic tyre types (maximum allowable mass adopted for each tyre pressure considered).

Figure 12 shows an equivalent stress with depth plot for the 1,700 kPa solid tyred roller. It is noted that the 1000 kPa/36 t pneumatic tyred roller is included for reference. The stress with depth induced in base course material (assuming a 50 mm thick surface layer) by the A340-600 and F111 aircraft are also included. Only 300 mm of pavement thickness is shown as the solid tyred roller is only for proving base course layers and these are generally limited to 200 mm thickness to enable adequate compaction to be achieved. From **Figure 12** it can be seen that even at 30 t total mass, the solid tyred roller's 1,700 kPa effective contact pressure is more than adequate to prove the top 250-300 mm of base course for the A340-600 and F111 aircraft.

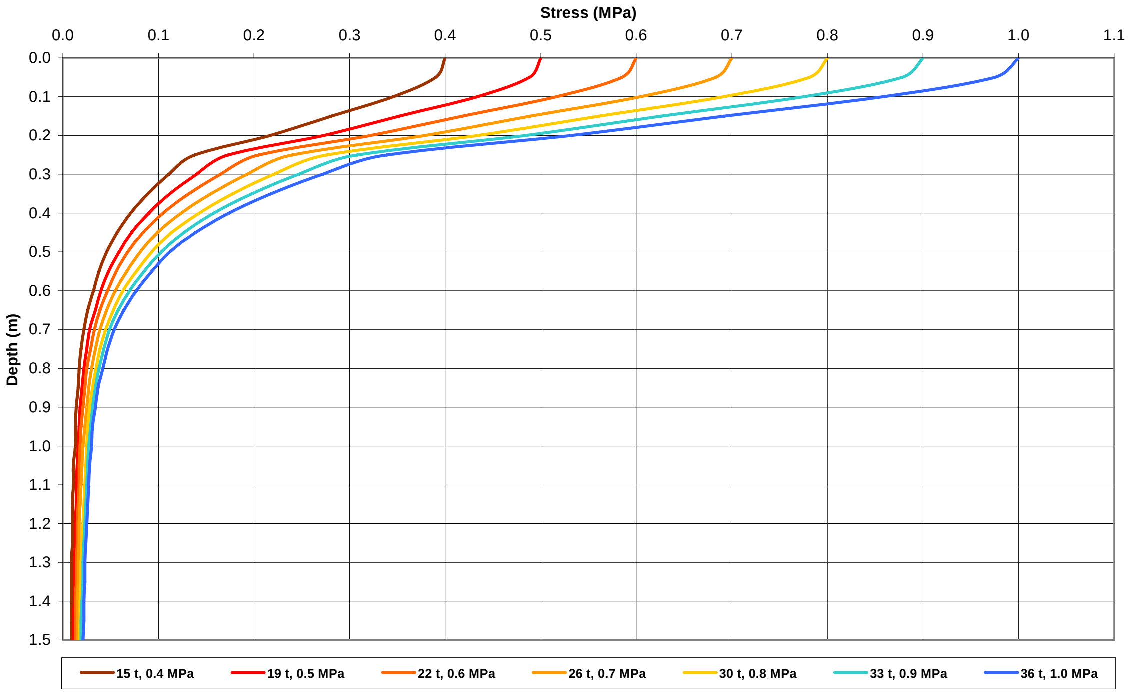

Figure 11. Example Pneumatic Tyre roller stress with depth plots.

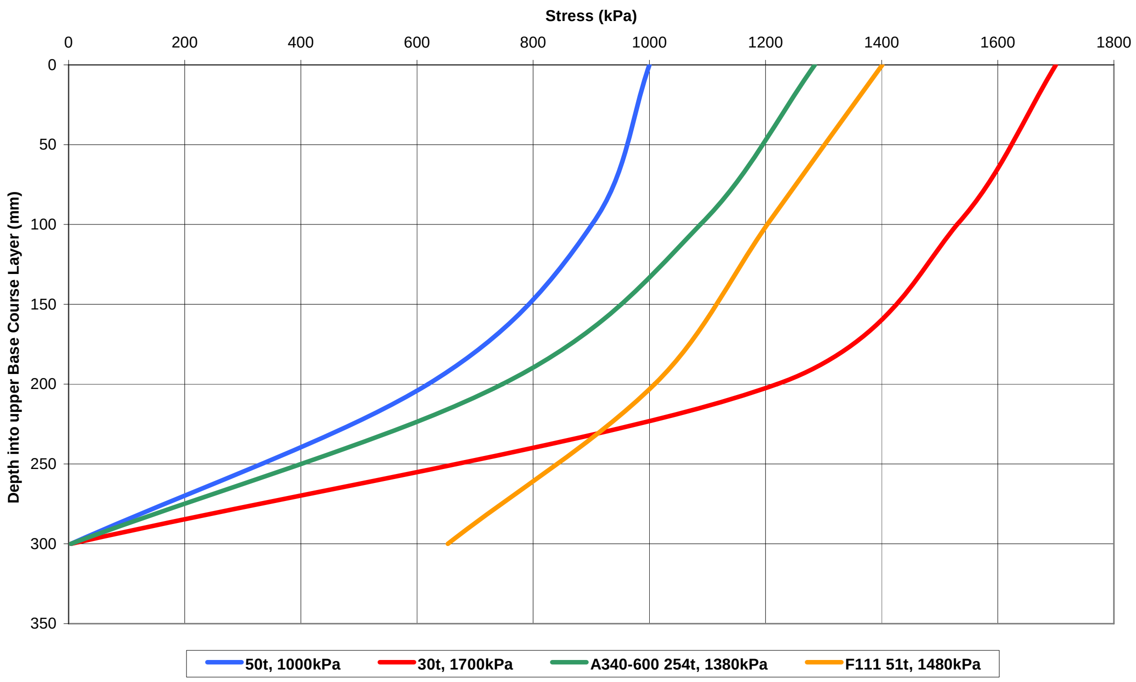

Figure 12. Example Solid Tyre roller stress with depth plots.

3.4 Aircraft Stress with Depth

Aircraft stresses with depth are generated from the theoretical finished surface level of the pavement as this is where the aircraft loads will be applied. Example stress with depth plots for a number of common aircraft are shown in **Figure 13**.

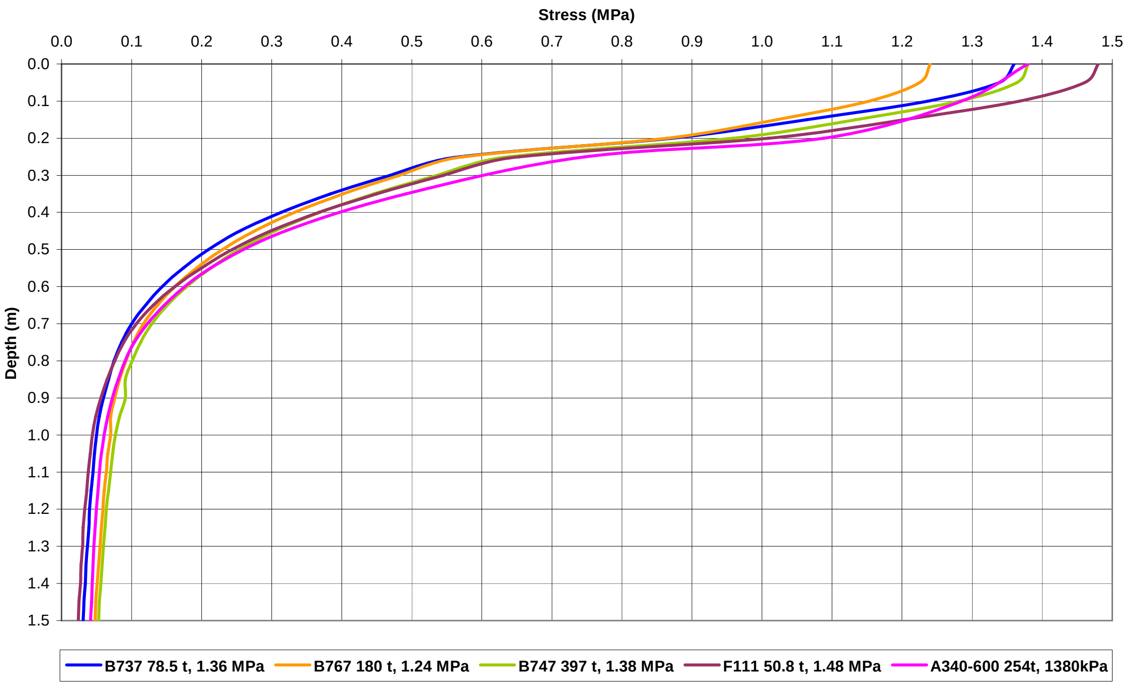

Figure 13. Common aircraft stress with depth examples.

3.5 Proof Rolling Regimes Design

The proof rolling regime is then generated on a layer-by-layer basis, with the combination of mass and tyre pressure for the pneumatic tyred roller selected so that the stresses at depth just exceed those induced by the aircraft when applied at the finished pavement surface. For the upper base course layers, the solid tyred roller will be required for pavements designed for high tyre pressure aircraft. To allow the depths in the pavement that the rollers are to be applied to be determined, the pavement composition must be known. Stresses with depth can remain generated for simplified pavement structures (eg 1000 mm base on CBR 6%) for convenience as long as the same simplified pavement structure is adopted for aircraft and roller stress with depth calculations.

An example (fictitious) proof rolling regime resulting from this process is detailed in **Figure 14**. The aircraft (F111 in this case) stress with depth is shown in blue. The roller stresses with depth (applied at each pavement layer shown) are detailed as follows:

- Red. Solid tyred roller applied to top of upper base course layer at 30t and 1,700 kPa.
- Purple. Solid tyred roller applied to top of lower base course layer at 30t and 1,700 kPa.
- Green. Pneumatic tyred roller applied to top of sub-base at 30 t and 0.8 MPa.

- Orange. Pneumatic tyred roller applied to top of subgrade or fill at 19 t and 0.5 MPa. Typically 8-12 coverages of all areas of the pavement layer surface are specified.

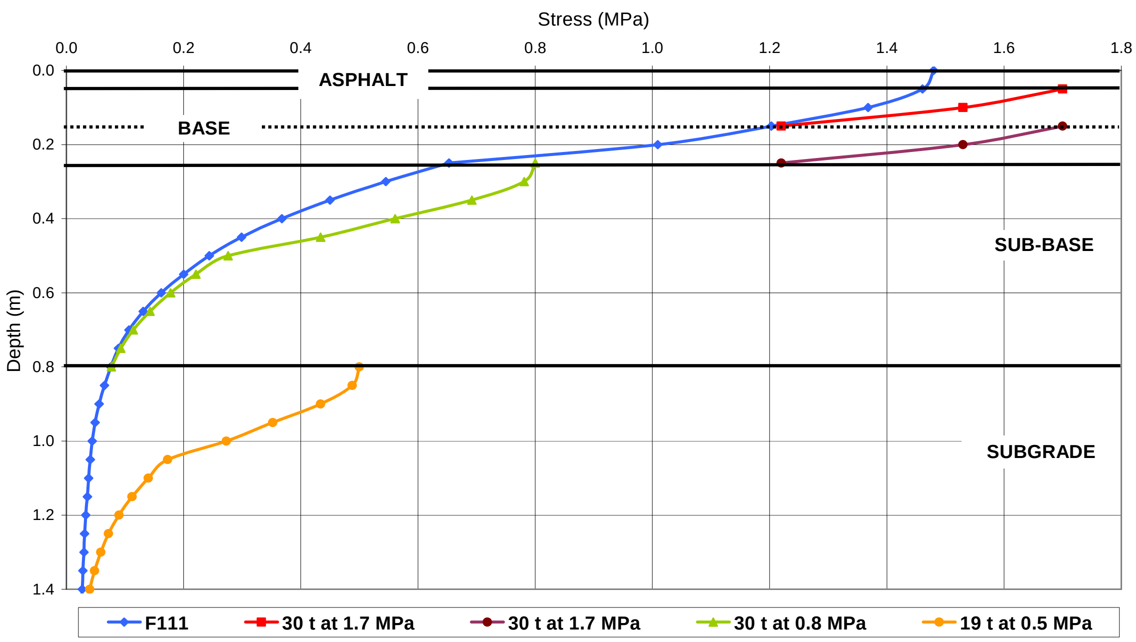

Figure 14. Example proof rolling regime.

Appendix A Roller Details

A.1 R1 – Pneumatic Tyred Roller

A.2 R2 – Pneumatic Tyred Roller

A.3 R3 – Pneumatic Tyred Roller

A.4 R4 – Pneumatic Tyred Roller

A.5 R5 – Pneumatic Tyred Roller

A.6 R6 – Pneumatic Tyred Roller

A.7 R7 – Pneumatic Tyred Roller

A.8 R8 – Pneumatic Tyred Roller

A.9 R9 – Solid Tyred Roller

Appendix B Supply and Service Details

Organisation	Location	Website	Phone number	Service

Appendix C Hire Agreement – Pneumatic and Solid Tyred Rollers