Ground Level Riding Cars.

MANUAL

Please feel free to use this manual and its contents for non-commercial purposes. We accept no responsibility or liability arising from the use of this manual.

While we do not require any payment for the use of this manual, we would be grateful for any donation to our new clubhouse building fund.

Please contact the secretary @ cardiffmes.com
Ground Level Riding Cars.

Introduction.

The ground level riding cars are designed and constructed as a folded steel main body with wooden end blocks. Two bogies per car are used with full compensation and a rubber based suspension to ensure clean riding without derailment. The leading bogie is braked by an automatic vacuum braking system; this braking system is automatic fail safe.

There are two standards of ground level car; seven built in the 1980’s and six built in the late 1990’s.

The earlier cars are hand painted in Burgundy and lined and labelled in a different manner, they are numbered 19 to 26. They have green seat squabs, currently the brake cylinders are being altered to the PNP cylinders which have been deemed as the standard for our cars, the bogie wheel base is shorter and therefore the bogies are further apart by a small amount.

The newer cars are finished by a professional car shop, and lined in gold with a printed vinyl badge centred on the sides, they are numbered 30 to 36 they have grey seat squabs, the wheel base of the bogie is extended approx 2” and the bogie centres are shorter by a small amount, the body of the cars is lower by about one inch and so have greater resistance to derailing during passenger loading and unloading.

The running boards are wooden stained mahogany.

A board is fitted at each end with hand holds these boards are again finished mahogany stain. The purpose of these boards is to prevent passengers being able to reach the coupling gear while not forming a hand trap when the train is cornering.

The seats are sponge on ply and covered in grey or green vinyl.

The cars are designed to seat between 5 and 6 passengers depending on their size; the limitation of passenger number is physical space not the weight of passengers.

The braking system is set to stop the train in a distance consistent with not throwing the passengers forward. Every car’s brakes are set to a standard that ensures that each car in a train is applying equal braking power. We expect a train of cars to stop within two or three car lengths consistent with the above criteria of not throwing passengers about from 5mph without the motive power pulling.

Coupling of cars within the train is by fixed length draw bars with high tensile steel screws acting as draw pins. Interconnection of the vacuum system through the train is by nylon tube and push in type connectors.

Wherever possible construction is from readily available commercial parts; thus ensuring speedy and effective repairs and maintenance.

This manual describes the construction, testing and maintenance of the ground level cars. It is the property of Cardiff Model Engineering Society and is protected by copyright.
Ground Level Riding Cars.

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1-off per car

1/4" 3/8"

6mm

MILD STEEL

DO NOT SCALE DRAWING

FINISH: DEBUR AND BREAK SHARP EDGES

NAME SIGNATURE DATE

DRAWN Styles 12/5/07

C/WRO

APPROVED

MFG

G.A

MATERIAL: MILD STEEL

DWG NO. adjustment clevis

WEIGHT:

SCALE 1:2

SHEET 1 OF 1
20mm push fit to bearing

Centre drill both ends for future wheel turning

For loctite reduce centre part of press fit by 0.004 on diameter

Paint black

Finish: Debur and break sharp edges

Material: MILD STEEL

4-off per car

J Styles 12/5/07

20mm push fit to bearing
Natural

2 3/4"

0.200

2.375 - 0.005

0.000

47mm press fit

0.550

1 5/8"

1/16"

7/8

A-A

A

B

C

D

NAME

J Styles

SIGNATURE

DATE

12/5/07

FINISH:

DO NOT SCALE DRAWING

REVISION

MATERIAL:

Aluminium

FINISH:

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REV

NAME

SIGNATURE

DATE

DRAWN

J Styles

12/5/07

C.W.O

APPROVED

MFG

Q.A

MATERIAL:

bearing housing

DRAWN

CHKS

APPROVED

MFG

Q.A

WEIGHT:

8 -off per car

DO NOT SCALE DRAWING

REV

DRAWN

CHKS

APPROVED

MFG

Q.A

WEIGHT:

bearing housing

DRAWN

CHKS

APPROVED

MFG

Q.A

WEIGHT:

bearing housing

DRAWN

CHKS

APPROVED

MFG

Q.A

WEIGHT:

bearing housing

DRAWN

CHKS

APPROVED

MFG

Q.A

WEIGHT:
centred in length

A (4 : 30)

2mm sheet

B (1 : 5)

12"

1" 11/4"

1 1/4"

4 3/4"

4 3/4"

8 5/8"

3/4"

72"

1 coat primer, 2 grey flat
2 Maroon top coat
Original cars in automotive finishes.
Vinyl gold stripes and printed vinyl badge

Finish:

Deburr and break sharp edges

Do not scale drawing

1-off per car

Revision:

Material: 1.5 mm MS sheet folded

Body
Black Paint

FINISH: DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISON

2-off per car

NAME 

SIGATURE 

DATE 

MATERIAL: Mild Steel

DRAWN: J Styles

12/05/07

APPROVED

MFG

Q.A

BODY END ANGLE

A4

sheet 1 of 1
Drill 9/32 dia
chamfer both sides
1/32 x 45

5/8 dia

11 33/64"

4 21/32"

body stretcher

J Styles

12/5/07

Square hollow section
50mmx50mmx4mm wall

Sheet 1 of 1

1:1.0

Material:

DO NOT SCALE DRAWING

2-off per car

DRAWN: J Styles

CHECKED: J Styles

APPROVED: J Styles

MFG:

Q.A.
DRAWN: J Styles  2/5/07
CHECKED: APPROVED: MFG: Q.A

NAME:  SIGNATURE:  DATE:

FINISH: DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING  REVISION

TITLE:  DWG NO:  SHEET 1 OF 1

MATERIAL:  WEIGHT:

BODY STRETCHER END A4

4 - off per car

MILD STEEL

0.236
Mild Steel

Bogie pivot

2-off per car

Finish: Deburr and break sharp edges. Paint exposed parts black.

M8 x 5/8 depth

M12

5 7/8"

1 3/8"

1 3/4"

1 15/16"

Name
Signature
Date

M A T E R I A L: Mild Steel

D W G N O.: A4

W E I G H T: SHEET 1 OF 1

S C A L E: 1:2

D O N O T S C A L E D R A W I N G R E V I S I O N:

S T Y L E S: 12/5/07

1 3/8"
SQUARE HOLLOW SECTION
40mm x 40mm x 3mm wall

12/5/07

J Styles

DRAWN

CHECKED

APPROVED

MANUFACTURED

Q.A

WEIGHT:

bogie stretcher

MATERIAL:

SQUARE HOLLOW SECTION
40mm x 40mm x 3mm wall

NAME

SIGNATURE

DATE

TITLE

SCALE: 1:5

-sheet 1 of 1

2 per car

DO NOT SCALE DRAWING

REVOLUTION

FINISH:

DEBUR AND BREAK SHARP EDGES

NAME SIGNATURE DATE
MILD STEEL

bogie stretcher ends

4 - off per car

WEIGHT:

MATERIAL:

DWG NO.

SCALE: 1:1

SHEET 1 OF 1

J Styles 12/5/07

Mild Steel

DRAWN:

CHECK'D:

APPROVED:

MFG:

Q.A

NAME

SIGNATURE

DATE

TITLE
M6 x 1/2 depth

cross drill 1/16 dia

brake pin

paint black

DO NOT SCALE DRAWING

8 - off per car

brake pin

Mild Steel

SCALE 2:1
3 holes 1/4 dia

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TO LERANCS:
LINEAR:
ANGULAR:

FINISH: Natural
DEBUR AND BREAK SHARP EDGES

MATERIAL: mild steel

DO NOT SCALE DRAWING
REVISION

4 - off per car

NAME: j-styles
SIGNATURE: 12/5/07
DATE: 

DWG NO.: brk lever 1
SCALE: 1:1
SHEET: 1 OF 1
MILD STEEL

brk lever 2

FINISH: Natural

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

4 - off per car

NAME: J Styles

SIGNATURE: 12/5/07

DRAWN: 12/5/07

CHK'D

APPROVED

MFG

Q.A

MATERIAL: Mild steel

WEIGHT:

SCALE: 1:1

SHEET 1 OF 1
BRAKE SHOE

pnp railways Standard Plastic shoes

8 - off per car

FINISH: DEBUR AND BREAK SHARP EDGES

MATERIAL: BRAKE SHOE

J Styles 12/5/07

DRAWN CHK'D APPV'D MFG Q.A

WEIGHT:

SCALE: 1:1 SHEET 1 OF 1
DRAWN: J Styles
CHECKED: 12/5/07
APPROVED: 
MANUFACTURED: 
TESTED: 
MATERIAL: Wood
WEIGHT: 
SCALE: 1:2

TITLE: buffer back

FINISH: finish with sadolin
TEAK

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REV:}

2-off per car

buffer back

MFG

Q.A
Finish: Sadliin teak

Deburr and break sharp edges

Material: Wood

Weight: buffer front

Drawing sheet: 1 of 1

Scale: 1:2
Finish: Debur and break sharp edges.

Material: Wood

Weight: 2 off per car
DRILL 2 HOLES 9/32 DIA COUNTERSINK 1/32 X 45 BOTH SIDES

DATE STAMP WHEN PUT INTO USE

12.5.2007

MATERIAL: MILD STEEL

1 - off per car

DRAWN: styles
CHECKED: 12/5/07
APPROVED: MFG

WEIGHT: drawbar

 SCALE 1:2 SHEET 1 OF 1
21" 15 1/2" R4" 2 1/4" 6 1/2" 6"

R1/2"

A

2 coats of teak Sadolin

0.748 3"

B

C

D

1"

R17/32"

12 4

A (2 : 5)

2.1/4"

6 1/2"

ALL EDGES ROUTERED WITH 1/8 RADIUS

FINISH IN TEAK SADOLIN

A (2 : 5)

ALL EDGES ROUTERED WITH 1/8 RADIUS

FINISH IN TEAK SADOLIN

J Styles

12/5/07

20mm Smooth face ply

endboard

A4
DRILL 1/4

DRILL 2 HOLES 1/16 DIA

FINISH: DEBUR AND BREAK SHARP EDGES

NAME SIGNATURE DATE

DRAWING

SKYLES 12/5/07

C/HO

APPROVED

MFG

Q.A

MATERIAL: Mild Steel

DO NOT SCALE DRAWING

REVISION

2 - off per car

TITLE:

DWG NO.

inner beam

A4

WEIGHT:

SCALE 1:5

SHEET 1 OF 1
DRILL 3 HOLES
1/4 DIA

lever

MATERIAL: Mild Steel

Q.A

MFG

DATE: 12/5/07

J Styles

DRAWN

CHECKED

APPROVED

SIGNATURE

NAME

DWG NO.

WEIGHT

SCALE 1:2

SHEET 1 OF 1
1 - off per car

FINISH: Paint Black

DEBUR AND BREAK SHARP EDGES

MATERIAL: Mild Steel

G.A

WEIGHT:

SCALE: 1:5

SHEET 1 OF 1

outer beam

15/16"

7 7/32"

15/16"

3"

5/8"

1/16 dia

1/4"

1/8"

drill 2 holes 1/16 dia

11/16"

1/16"

1/4 dia

1/8"

1/8"

drill 6 holes 1/4 dia
Paint Black

1 - per car

MILD STEEL

DEBUR AND BREAK SHARP EDGES

WEIGHT:

MATERIAL:
Mild Steel

SCALE 1:2

SHEET 1 OF 1

DRAWING

TITLE:
PUSH ROD

MFG

APPROVED

CHECKED

DRAWN

NAME
J Styles

SIGNATURE

DATE
12/5/07

REVISION

FINISH:

DO NOT SCALE DRAWING

Q.A

MATERIAL:

MILD STEEL

DO NOT SCALE DRAWING

1 - per car

231 4

1/2"

A4

1/4"

7/8"

5 7/64"

5 1/2"

7/8"
Drill 1/16 dia

FINISH: DEBUR AND BREAK SHARP EDGES

MATERIAL: Mild Steel

DO NOT SCALE DRAWING

TITLE: pivot pin

SCALE: 2:1

SHEET 1 OF 1
M6 standard threaded rod (see Material)

Natural

pull rod

1 - off per car

MATERIAL:
Mild steel Zinc plated or Stainless steel

WEIGHT: 12/5/07
1 - off per car
drill & tap M6 X 1/2 IN DEEP BOTH ENDS

mild steel or brass

pull rod coupling

J Styles 12/5/07

1 - off per car

Mild Steel
rubber block

DRAWN: J Styles 12/5/07
CHECKED:  
APPROVED:  
MFG:  

NAME:  
SIGNATURE:  
DATE:  

FINISH: Natural

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISON

WEIGHT:

MATERIAL: Rubber

SCALE: 1:1

SHEET 1 OF 1
DRAWN

CHECK'D

APPROVED

manufacturer

QUALITY ASSURANCE

FINISH: DEBUR AND BREAK SHARP EDGES

1 -off per car

MATERIAL: Aluminium

DO NOT SCALE DRAWING

REVISION

TITLE:

DWG NO.

SCALE 1:1

SHEET 1 OF 1

NAME SIGNATURE DATE

DRAWN: J Styles 12/5/07

MFG

G.A

WEIGHT:

vacuum plate A4
FINISH: DEBUR AND BREAK SHARP EDGES

DRAWN: J. Styles
DATE: 12/5/07

DO NOT SCALE DRAWING

1-off per car

MATERIAL: Aluminium

NAME SIGNATURE DATE

DRAWN: J. Styles
CHECKED: [Blank]
APPROVED: [Blank]
MFG: [Blank]
Q.A: [Blank]

Dwg No: vacuum plate rear

WEIGHT:

SCALE: 1:1 SHEET 1 OF 1
Press fit on axle

1" drill & ream

4 3/4 diameter over flanges

REF. Flange depth is 3/16"

Paint black on assembly

MATERIAL: Mild Steel

DO NOT SCALE DRAWING

8 - per car
The following procedure is to be carried out at least twice per running season.

- The first time should be before the running season starts and in any case as close to the first public open day as practicable.
- The second time should be in the middle of the summer running season.

1. Invert the car using the plywood supports provided
2. Inspect the whole car and bogies for loose parts
3. Lubricate all brake linkages and bogie pivot and bearing pads with the loco lubricating oil in the oil store (ensure oil does not contact the brake shoe faces or wheel treads).
4. Check wheels visually for excessive wear or flats.
5. Ensure the draw gear bolts and pins are intact and not worn
6. Check brake shoes for wear, replace according to specification elsewhere in this manual.
7. Ensure the draw bar at the back of the car is retained.
8. Apply vacuum of between 10 & 12 inches Hg
9. Isolate the vacuum source and check for leaks. (the system should loose no more than 2 inches of mercury in 30seconds
10. Fit the torque lever rig to the front axle and restrain the bogie sides parallel with the car sides,
11. Adjust the brakes using the prescribed test rig to 3 KgF with the spring balance in the longest hole of the torque lever rig.
12. Re invert the car remove the plywood supports
13. ensure the front draw pin is fitted into the draw bracket at front of car
14. If a hand braked car, check operation of the hand brake.
15. Release the vacuum from the car to allow the car to be moved.
16. Check running direction is correct.

The following procedure is to be carried out before any public running day (may be done earlier as long as the trains are not divided before the public day),

1. Assemble trains in sets A, B, C, etc or to the configuration needed as instructed by the track marshal in agreement with the locomotive owners/drivers. If possible do not separate the A B and C sets and in any case separate the C set first.
2. ensure all vacuum connections between cars are secure
3. ensure all draw bars are secure between cars
4. Ensure a guard’s seat and brake set is fitted at the back of the train.
5. Apply vacuum of between 10 & 12 inches Hg to the train.
6. Isolate the vacuum source and check for leaks. (the system should loose no more than 2 inches Hg in 30seconds
7. Operate the guard’s brake valve.
8. Check every car has the brakes applied by trying to move each car a small amount.
9. Release the vacuum in the train by operating the vacuum release valve on each car.
10. Ensure a draw pin and nut is fitted to the front of the first car so that the loco can be attached.
11. Fit a short plastic vacuum pipe to the vacuum connection at the front of the first car in the set.

Note:
The torque adjustment to the brake setting at 11 above is derived from the following:

with the car brakes fully applied with between 10 & 12inches Hg, attach a locomotive using a spring balance as the draw bar, adjust the brakes on each car so that the force required to draw the car with the wheels rotating is 16kgF. It may be necessary to load the car to prevent wheel locking.
CARDIFF MODEL ENGINEERING SOCIETY

Ground Level Riding Cars.

Data Sheets

Taken from PNP instruction sheet.

PNR-1H – vacuum Limiting Valve

Connection

The vacuum-limiting valve is designed to allow a set limit to the degree of vacuum applied to the system through the limit valve. A filter should be fitted.

If fitting a filter; screw onto the open end of the valve.

Slacken the brass lock nut at the other end of the valve. And unscrew brass screw to the limit, put the vacuum pipe onto a hose tail and attempt to generate vacuum.

Observe vacuum gauge, which should be reading a small number. Start to tighten brass screw mentioned above until desired vacuum level is reached. Finally lock up brass nut to keep the brass screw in position.

Mounting.

Mount the valve with a small saddle or something similar, leaving access to the brass adjusting screw.

Check the valve and settings at regular intervals.

This product must not be used for any other purpose than the one described. Its function and condition should be checked regularly. Issue 1- dec -2000

CMES NOTE

The above is the data and instruction sheet issued with the part bought from PNP. CMES checking and maintenance instructions have taken the information contained here into consideration and therefore this page is for information only and does not form part of, nor should be used as the maintenance and setting procedures.
PNR-1G – vacuum Release Valve

This vacuum release valve will allow atmospheric air pressure to destroy the vacuum on specific rolling stock or indeed the whole train to allow stock movements when uncoupled or when a train has to be moved and no vacuum is available.

**Connection**

It is suggested that the valve is connected to the spare tail on the vacuum reservoir; this can be achieved with flexible tube and fittings from the PNP range.

**Mounting.**

It is suggested that the valve is mounted under the rolling stock clear of the reach of passengers, unauthorised users or dirt. A ¼” B.S.P. hole or a clearance hole can be put into a thin bracket. The bracket can be trapped between the valve and the connection fittings.

**Operation**

The ring is pulled to release vacuum, a cord or chain can be attached to allow operation remote from the valve. The cord or chain should be well clear of potential catchments or misuse.

This product must not be used for any other purpose than the one described. Its function and condition should be checked regularly.

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CARDIFF MODEL ENGINEERING SOCIETY

Ground Level Riding Cars.

Spare parts list.

Supplied by PNP

Brake cylinder  PNPR-1A
- Insert/4035 spring 2056302s26 1 per cylinder
- Insert/4036 Silicone ‘o’ ring – 4mm x 1 1 per cylinder
- Insert/4037 Silicone ‘o’ ring – BS009 70 1 per cylinder
- Insert 4042 BZ Plated washer 3mm 8 per cylinder
- Insert/4043 BZ Plated full nut 3mm 8 per cylinder
- Insert/4124 Slotted pan head screw 8 per cylinder
- PNR013 Non return Valve 1 per cylinder

Vacuum Reservoir PNPR-1C
- Vacuum release valve PNP part no. PNR-1G 1776k-0-05
- Vacuum Limiting valve & filter PNP part no. PNR-1H
- PVC tube PNP part no. PNR-1I Clear PVC tube
- Bake Shoes  PNP 1/8 th scale
- Wheel bearings SKF6204 2Z double STEEL seals
BRAKE TESTS

30th June 2002

Purpose of trial:
to determine a benchmark for future testing of braking effectiveness on ground level cars.

Each car No. 31 to 37 was tested for vacuum leaks. When all leaks were corrected each car’s brakes were applied with 12.5 inches of mercury of vacuum and the pull required to move the car was measured.

It was noted that the best car required more than 25 Kg force & in fact could not be moved by one man (3 man Load).

When the car was moving the reading was taken. If the wheels were locked then weight was added until the wheels rotated, and a new steady reading taken.

The Results

<table>
<thead>
<tr>
<th>Car No.</th>
<th>Test 1</th>
<th>test 2</th>
<th>test 3</th>
<th>test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>13</td>
<td>18.5 lckd</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>12</td>
<td>22 locked</td>
<td>25+ lckd</td>
<td>24</td>
</tr>
<tr>
<td>36</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Car 33 was adjusted and retested

<table>
<thead>
<tr>
<th>Car No.</th>
<th>Test 1</th>
<th>test 2</th>
<th>test 3</th>
<th>test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>15</td>
<td>25+ lckd</td>
<td>25+ lckd</td>
<td>car failed to move</td>
</tr>
</tbody>
</table>

Detail of load for above tests

<table>
<thead>
<tr>
<th>Car No.</th>
<th>Test 1</th>
<th>test 2</th>
<th>test 3</th>
<th>test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>1 person</td>
<td>2 person</td>
<td>18.5 lckd</td>
<td>16.5</td>
</tr>
<tr>
<td>35</td>
<td>1 person</td>
<td>2 person</td>
<td>25+ lckd</td>
<td>24</td>
</tr>
<tr>
<td>37</td>
<td>1 person</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Car 33 was adjusted and retested

<table>
<thead>
<tr>
<th>Car No.</th>
<th>Test 1</th>
<th>test 2</th>
<th>test 3</th>
<th>test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>15</td>
<td>25+ lckd</td>
<td>25+ lckd</td>
<td>car failed to move</td>
</tr>
</tbody>
</table>

Car 33 could not be moved & therefore we cannot make a true assessment of it’s stopping time or distance, but I have assumed if one man can’t pull it then the force required is in excess of 100lbs.
Calculations: were made for

1. The lowest reading @10mph & 5mph
2. The highest loaded braking that met the rotating wheels criteria for both 10mph & 5mph

Formulae:
Imperial units were used so that distances were expressed in units that the majority can assimilate.

\[ 10 \text{ mph} = 14.67 \text{ ft/sec} \quad 5 \text{ mph} = 7.335 \text{ ft/sec} \]
\[ G = 32.2 \text{ ft/sec/sec} \]
\[ W = \text{weight of car (assumed to be 100 lbs) + weight of passengers (assumed to be 15 stone or 200lbs)} \]

Therefore equals worse case

Deceleration = \( A \)

Time to stop = \( t \)

\[ F = \text{force to decelerate car} = \text{force to keep car steadily rolling under same conditions} \]

1. \[ F = \frac{W \times A}{g} \quad \text{therefore} \quad A = \frac{F \times g}{W} \]

2. Average Velocity = Initial velocity + Final velocity \[ \frac{2}{2} \]

3. \[ \text{time to stop (t)} = \frac{\text{velocity}}{A} \]

4. Distance to stop = Average velocity \( \times \) \( t \)

______________________________

1. 10 kg force empty car \( W = 100\text{lb} \) similar to car 36.
\[ A = \frac{22 \times 32.2}{100} = 7.08 \text{ ft/sec}^2 \]
\[ \frac{14.67 \text{ ft/sec}}{7.08 \text{ ft/sec}^2} = 2.07 \text{ sec.} \]

\[ 7.335 \times 2.07 = 15.67 \text{ feet} \text{ (2.5 car lengths)} \]

Ditto for 5 mph
\[ 7.335 \text{ ft/sec} = 1.035 \text{ sec.} \]
\[ 7.08 \text{ ft/sec}^2 \]

\[ 3.667 \times 1.035 = 3.795 \text{ feet} \text{ (60\% car length)} \]

\[ i.e. \ 1/2 \text{ speed} = \frac{1}{2} \text{ time} & \frac{1}{2} \text{ distance}. \]

2. 6 kg force empty car \( W = 100\text{lb} \) Car 31
\[ A = \frac{13.236 \times 32.2}{100} = 4.262 \text{ ft/sec}^2 \]
\[ \frac{14.67 \text{ ft/sec}}{4.262 \text{ ft/sec}^2} = 3.44 \text{ sec.} \]

\[ 7.335 \times 3.44 = 25.23 \text{ feet} \text{ (4 car lengths)} \]

Ditto for 5 mph

1. 72 sec. 6.3 feet (1 car length)

3. 24 kg force 3 people + car \( W = 700\text{lb} \) Car 35
\[ A = \frac{52.9 \times 32.2}{700} = 2.4334 \text{ ft/sec}^2 \]
\[ \frac{14.67 \text{ ft/sec}}{2.4334 \text{ ft/sec}^2} = 6.03 \text{ sec.} \]

\[ 7.335 \times 6.03 = 44.22 \text{ feet} \text{ (7 car lengths)} \]
Ditto for 5 mph

3 sec. 11 feet (1.9 car length)

4. 16.5 kg force 2 people + car W = 500lb Car 333 1st test

\[
A = \frac{36.37 \times 32.2}{500} = 2.342 \text{ ft/sec}^2
\]

\[
\frac{14.67 \text{ ft/sec}}{2.342 \text{ ft/sec}^2} = 6.26 \text{ sec.}
\]

\[
7.335 \times 6.26 = 45.9 \text{ feet (7.7 car lengths)}
\]

Ditto for 5 mph

3 sec. 11.5 feet (2 car length)

5. 100lbs force 3 people + car W = 700lb Car 33 2nd test (Assumed stopping force)

\[
A = \frac{100 \times 32.2}{700} = 4.60 \text{ ft/sec}^2
\]

\[
\frac{14.67 \text{ ft/sec}}{4.6 \text{ ft/sec}^2} = 3.1894 \text{ sec.}
\]

\[
7.335 \times 3.189 = 23.39 \text{ feet (3.9 car lengths)}
\]

Ditto for 5 mph

1.599 sec. 5.9 feet (1 car length)

**Conclusions** (by JS)

Car 35 12 kg braking causes wheels to lock on empty car. 11kg (car36) does not.

Max breaking force on empty car should not be greater than this or skill by driver stopping empty train with routine of checking for flats.

Car 33 2 tests worst & best result for loaded car. This illustrates reduction in running speed is easiest way of reducing stopping distance.

½ speed reduces stopping distance to ¼

To have loaded cars stopped in reasonable distance the brakes need to be set better than for light car braking (better than car 35).

OR reduce running speed to 7 mph? This would give about a 4 sec. stopping time.

In this case bench mark would be 12 kg light 15kg loaded typical buy 2 adults.
The following basic calculation for sizing cylinder and levers for adequate braking power is borne out by the more accurate and longer calculation; Diameter in the first calc is the cylinder diameter.

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>3.1875</th>
<th>area = 7.980803</th>
</tr>
</thead>
<tbody>
<tr>
<td>vacuum</td>
<td>10&quot;</td>
<td>4.9 lbs/in</td>
</tr>
</tbody>
</table>

Therefore force available to operate brakes is 39.10593 lbs f

My brakes required approx 4kg to lock wheels.

The following shows the point at which the wheels will lock and therefore slide. (A bad condition) and the derated settings to ensure efficient stopping while ensuring passenger safety in not throwing them forward in an emergency application.

**Maximum brake force**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>3 &quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0762</td>
<td></td>
</tr>
<tr>
<td>0.00456</td>
<td>m²</td>
</tr>
</tbody>
</table>

Pressure

| 20265 | Pa |

Force

| 92.41584 | N  |

Strut load

| 336.8381 | N  |

Brake

| 673.6761 | N  |

Coeff

| 0.3 |

Slips at 202.1028 N at rim 404.2057 N Car

**Actual setting for Brakes**

<table>
<thead>
<tr>
<th>Car Brake Force</th>
<th>17 kgf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>166.77 N</td>
</tr>
<tr>
<td>per axle</td>
<td>83.385 N</td>
</tr>
<tr>
<td>diameter</td>
<td>0.1 m</td>
</tr>
<tr>
<td>radius</td>
<td>0.05 m</td>
</tr>
<tr>
<td>torque</td>
<td>4.16925 Nm</td>
</tr>
<tr>
<td>lever arm</td>
<td>0.15</td>
</tr>
<tr>
<td>Force</td>
<td>27.795 N</td>
</tr>
<tr>
<td></td>
<td>2.833333 kgf</td>
</tr>
</tbody>
</table>