RESTRICTED

INCIDENT REPORT NUMBER: ES/ME/11/15

Harpur Hill, Buxton
Derbyshire, SK17 9JN
T: +44 (0)1298 218000
F: +44 (0)1298 218590
W: www.hsl.gov.uk

Tagada ride: Inspection and analysis of downward acceleration

ES/ME/11/15/R2

Author(s): **Robert White BEng(Hons), MSc, AMIMechE**
Science Unit: **Engineering Safety Unit**

DISTRIBUTION

Janice Dale	HSE, Field Operations Division
Melvin Sandell	HSE, Operational Strategy Division
Cameron Adam	HSE, Operational Strategy Division
Andrew Curran	HSL, Science and Resources Director
Karen Russ	HSL, Project Delivery Director
Paul Bridges	HSL, Head of Engineering Safety Unit
Philip Heyes	HSL, Investigations Manager
Richard Isherwood	HSL, Mechanical Engineering Technical Lead
Paul McCann	HSL, Field Engineering Section
Robert White	HSL, Mechanical Engineering Section
Dianne Connell	HSL Information Centre

Revisions:

Section 2.4.1 - References to ‘hydraulic’ components have been replaced with references to ‘pneumatic’ components.

INCIDENT REPORT

PRIVACY MARKING:

Not to be communicated outside **HSE** without the approval of the Authorising Officer
Melvin Sandell

HSL report approval:	**Philip Heyes**
Date of issue:	**16 February 2012**
Job number:	**PH04169**
Registry file:	**031674**
Electronic file name:	**Engunit on ‘Kalki’ (K:)\mecheng\WORK\HSE\Reactive\Incidents\Inc2010\PH04169 Tagada Rides\PH04169Report2.doc**

CONTENTS

EXECUTIVE SUMMARY

In each version of a fairground ride named ‘the Tagada’, occupants sit on bench seats that wrap round the perimeter of a ‘bowl’. The seats have discontinuities so there are spaces through which to walk on and off the ride. The ride does not have occupant restraints, but there is a bar behind the seat that riders can hold onto.

The bowl is located on a plane that is inclined from horizontal, and rotated about an axis that is inclined from vertical. Whilst the ride is being rotated, the higher part of the ride can be raised and lowered by two independent rams. The axis of rotation is therefore variable.

Objectives

I was asked by Mr Melvin Sandell of HSE Operational Strategy Division to examine the Tagada ride following reports that the passengers on this type of ride had sustained injuries.

Mr Sandell asked me to investigate the movement of the ride when it was operated, and comment on ways to reduce the potential for injuries arising from vertical acceleration. Prior to this investigation, Mrs Melanie Dalby of HSL Ergonomics Team had highlighted a concern over the excessive downward acceleration of the ride.

Main Findings

The vertical motion of the Tagada ride is generated by a combination of two movements. As the ride spins on a non-vertical axis, riders are cyclically raised and lowered. The ride is also raised and lowered by the rams which change the angle of the bowl.

Based on data from one particular Tagada ride it appears possible for the downward acceleration of this ride to fall within a category that would require occupant restraints according to a relevant British Standard. However the rides are not generally equipped with occupant restraints.

Conclusions

The downward acceleration of the ride due to rotation could be reduced by reducing the rotating speed, or reducing the inclination from vertical of the axis of rotation.

The downward acceleration caused by lowering of the rams could be reduced by employing a flow control valve.

An alternative method of controlling the downward acceleration originating from the rams was employed on the Crazy Shake Tagada operated by Scott Gray that I examined on 20 April 2011. This ride vented the compressed air exhausted during downward travel into an air receiver held at above atmospheric pressure. This reduced the ride’s downward acceleration.

If downward acceleration was not restricted it may still be possible for the ride to conform to the British Standard if occupant restraints were fitted.

1 INTRODUCTION

I was asked by Mr Melvin Sandell of HSE Operational Strategy Division to examine the Tagada fairground ride following reports that passengers on this type of ride had sustained injuries.

Mr Sandell asked me to investigate the movement of the ride when it was operated, and comment on ways to reduce the potential for injuries arising from vertical acceleration.

I conducted this investigation and prepared this report myself. I took the photographs and prepared the diagrams within the report. I was accompanied on one site visit by Mrs Melanie Dalby of HSL Ergonomics Team. Mrs Dalby also provided some accelerometer data that she had acquired on an earlier visit. All measurements shown in this report were taken using uncalibrated equipment and are for indication only.

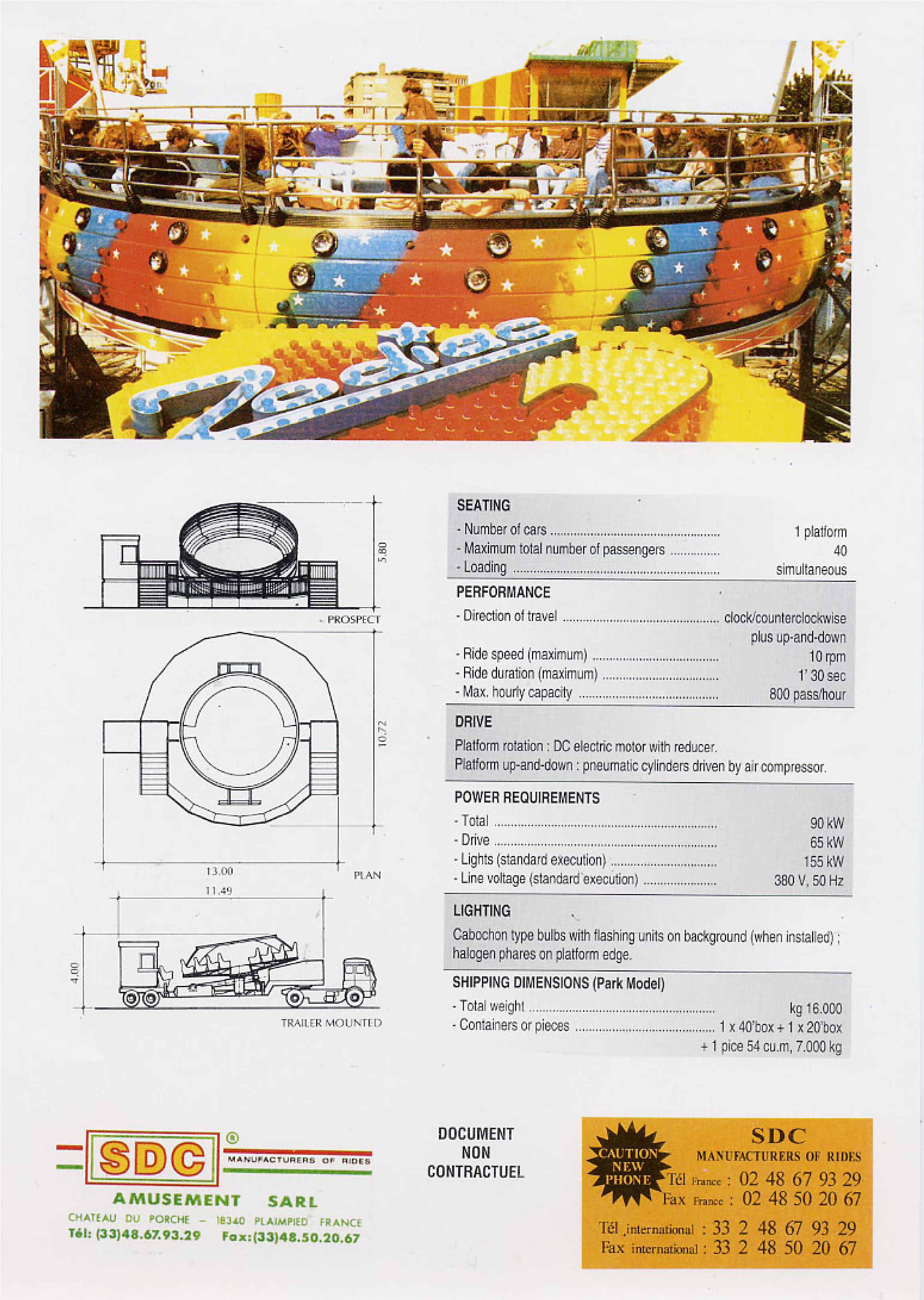
1.1 DESCRIPTION OF RIDE

There are versions of this ride produced by different manufacturers (see Appendix A). In each version, riders sit on bench seats that wrap round the perimeter of a ‘bowl’. The seats have discontinuities so there are spaces through which to walk on and off the ride. The ride does not generally have occupant restraints, but there is a bar behind the seat that riders can hold onto.

The bowl is located on a plane that is inclined from horizontal, and rotated about an axis that is inclined from vertical. Whilst the ride is being rotated, the higher part of the ride can be raised and lowered by two independent rams and the axis of rotation is therefore variable.

Figure 1 shows a data sheet from SDC, one of the Tagada manufacturers.

Photographs that show one of the rides I inspected are presented in Figures 7 and 8.



SEATING	
- Number of cars	1 platform
- Maximum total number of passengers	40
- Loading	simultaneous
PERFORMANCE	
- Direction of travel	clock/counterclockwise plus up-and-down
- Ride speed (maximum)	10 rpm
- Ride duration (maximum)	1' 30 sec
- Max. hourly capacity	800 pass/hour
DRIVE	
Platform rotation : DC electric motor with reducer.	
Platform up-and-down : pneumatic cylinders driven by air compressor.	
POWER REQUIREMENTS	
- Total	90 kW
- Drive	65 kW
- Lights (standard execution)	155 kW
- Line voltage (standard execution)	380 V, 50 Hz
LIGHTING	
Cabochon type bulbs with flashing units on background (when installed) ; halogen phares on platform edge.	
SHIPPING DIMENSIONS (Park Model)	
- Total weight	kg 16.000
- Containers or pieces	1 x 40'box + 1 x 20'box + 1 pice 54 cu.m, 7.000 kg

SDC® MANUFACTURERS OF RIDES
AMUSEMENT SARL
CHATEAU DU PORCHE – 18340 PLAIMPIED FRANCE
Tél: (33)48.67.93.29 Fax:(33)48.50.20.67

DOCUMENT NON CONTRACTUEL

CAUTION NEW PHONE
SDC
MANUFACTURERS OF RIDES
Tél France : 02 48 67 93 29
Fax France : 02 48 50 20 67
Tél international : 33 2 48 67 93 29
Fax international : 33 2 48 50 20 67

17815-9.jpg (Supplied by Ian Trowell, National Fairground Archive)

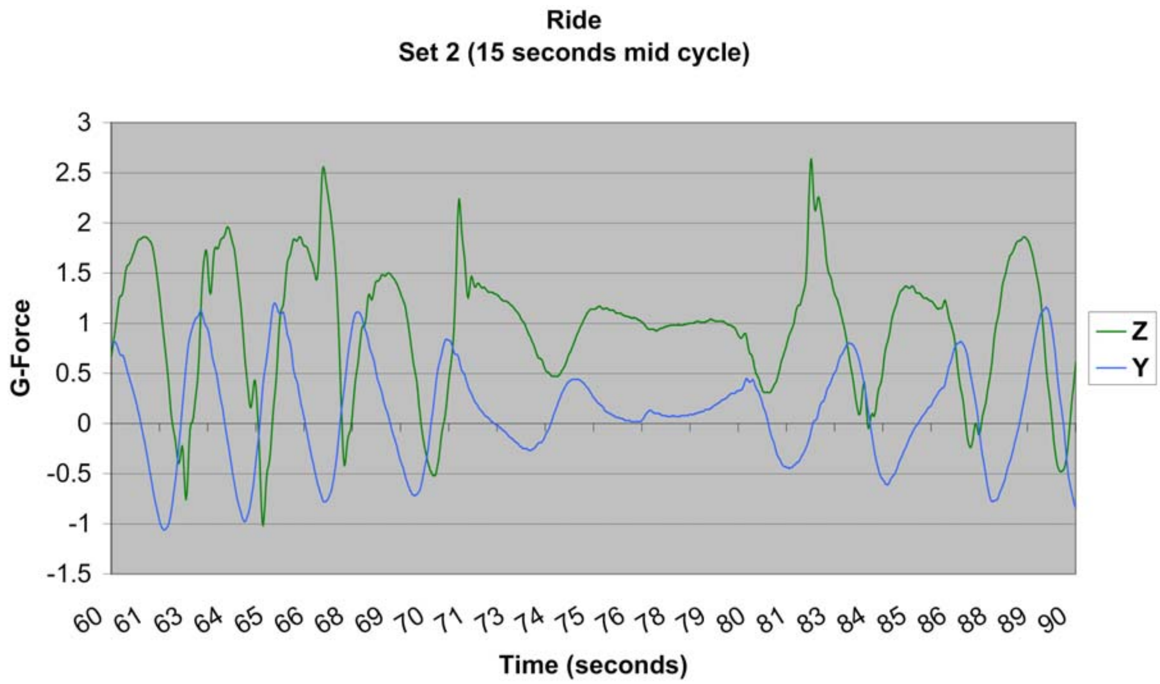
Figure 1 SDC Tagada datasheet

2 INVESTIGATION

2.1 BACKGROUND

Problems with Tagada rides were highlighted by Mrs Melanie Dalby of HSL Ergonomics Team in an e-mail dated 7 July 2010 when she investigated the accelerations experienced by Tagada occupants.

Figure 2 shows an extract of accelerometer data recorded by Mrs Dalby. Mrs Dalby attached an accelerometer to one of the ride occupant positions, and then the ride was operated. The seating position selected was typical of all seating positions on the ride. The extract shown is typical of the data recorded by Mrs Dalby.



Crazy Dance Data.xls (supplied by Melanie Dalby, HSL Ergonomics Team)

Figure 2 Accelerometer data

The rate of acceleration of a body due to gravity, g is $9.81 m/s^2$. The amount of force required to produce this level of acceleration is equal to the mass of the body multiplied by g, and it is sometimes referred to as a 1g-force.

The green line labelled 'Z' represents the vertical component of acceleration expressed as a 'g-force'. The blue line 'Y' represents acceleration on a horizontal axis.

Since the seat was on an inclined plane, it is possible that the vertical acceleration figures plotted as 'Z' may have been affected by lateral accelerations.

I believe that Mrs Dalby's accelerometers worked by measuring the dynamic forces which would be experienced by a mass during acceleration. They also registered the force due to gravity, ie a continuous $9.81 m.s^2$ in a downward (Z) direction.

Where Z is greater than one, the occupant position is accelerating in an upward direction. This would have the effect of forcing an occupant into the seat, making the occupant feel heavier than normal. Where Z is less than 1, an occupant would feel lighter than normal.

There are periods on this graph where the Z line drops below 0. This indicates that the occupant position is dropping at a rate greater than g ($>9.81 m/s^2$), ie faster than an object would free-fall due to gravity. If this happened whilst a person was sitting in the position occupied by the accelerometer, then a force would be required to stop the person from moving upwards relative to the seat. Friction with the seat back may provide some of this force, but this would be dependent on the contact surfaces between the occupant and the seatback. Without such a force, it is possible that the occupant could potentially be thrown upwards from the seat. If this happened then the rider could experience a 'bump' at the point of landing back on the seat. In extreme cases a rider could be thrown out of the ride. These would be possible causes of injuries.

2.2 OPERATOR CONTROLS

An unusual feature of this ride is that to some extent the ride is manually controlled by an operator who watches the ride and operates the two rams which raise and lower to adjust the inclination angle of the axis of rotation. I understand from publicly available video (Reference 1) that it is also possible for the operator to stop the ride, and reverse the direction of rotation.

2.3 EUROPEAN STANDARD

The European Standard, (BS EN 13814:2004) 'Fairground and amusement park machinery and structures – Safety' (Reference 2), has a section 6.1.6.2.4 entitled 'Application criteria from restraint devices resulting from risk assessment'.

According to the standard, occupant restraints are required on rides which accelerate downwards at a rate greater than 0.2g (over and above the effect of gravity). This would be shown as <-0.2g in Figure 2. For such rides, an individual restraint is required for each passenger. The restraint requirements include automatic control and start inhibition.

The data recorded by Mrs Dalby (Figure 2) shows a ride which subjected riders to a dynamic force equivalent to an acceleration of 1g downwards (over and above the force of gravity). This dynamic force could cause riders to lift from their seats.

2.4 RIDE INSPECTIONS

I examined two versions of the ride. The first was named Trauma Towers and was used in a fixed location at Blackpool Pleasure Beach. The second was named Crazy Shake and operated at various fairground sites by Scott Gray.

2.4.1 Trauma Towers

According to the information provided by Mr Trowell of the National Fairground Archive (Appendix A), this ride was manufactured by Soriani and Moser. The ride had been incorporated into a haunted house type of attraction. I viewed the ride on 11 August 2010. At the time of my inspection the ride was out of commission, and in darkness, but I examined its workings as far as possible.

The Soriani and Moser ride was rotated by means of an electric motor. The bowl was lifted by means of two pneumatic rams. Air was supplied by a compressor (Figure 3) into an air receiver (Figure 4), and was supplied to each ram (Figure 5) through valves (Figure 6). These valves had electrical signal wires linking them to a control box. The valves appeared to be of a solenoid type, which would have provided open or closed positions, rather than any kind of proportional control.

DSC00660.JPG (Robert White)

Figure 3 Trauma Towers compressor

DSC00663.JPG (Robert White)

Figure 4 Trauma Towers air receiver

DSC00666.JPG (Robert White)

Figure 5 Trauma Towers vertical movement ram

DSC00669.JPG (Robert White)

Figure 6 Trauma Towers vertical movement control valve

2.4.2 Crazy Shake

I viewed 'Crazy Shake' (Figure 7) a Tagada operated by Mr Scott Gray at Harlow Town Park on 20 April 2011. According to the information provided by Mr Trowell (Appendix A), this ride was manufactured by Farr Fabri.

DSC01129.JPG (Robert White)

Figure 7 Crazy Shake Tagada

At the time of my inspection the ride was being set up for use by Mr Gray. It was also being subjected to a NAFLIC (National Association For Leisure Industry Certification) inspection by Mr William Thurston of DMG Technical Services

This ride also used an electric motor to power the rotation. On this version the bowl (Figure 8) was raised by pneumatic rams (Figure 9). The air used by the rams was pressurised using three compressors (one is shown in Figure 10) in sequence with compressed air being stored in air receivers (one is shown in Figure 11) at two intermediate pressures and at full working pressure. I understand from Mr Gray that there was a means of adjusting the pressure of air stored in the receivers, and each air receiver was fitted with a pressure gauge (Figure 12).

DSC01134.JPG (Robert White)

Figure 8 Crazy Shake seating within bowl

DSC01138.JPG (Robert White)

Figure 9 Crazy Shake vertical movement ram

DSC01135.JPG (Robert White)

Figure 10 Crazy Shake pneumatic compressor

DSC01136.JPG (Robert White)

Figure 11 Crazy Shake air receiver

DSC01141.JPG (Robert White)

Figure 12 Crazy shake, air receiver pressure gauge

The bowl of the ride was not powered in the downward direction. When the ride bowl was lowered, the compressed air that was exhausted from the rams was fed into one or other of the intermediate air receivers. This had two benefits. It slowed the rate at which the bowl accelerated downwards, and it conserved the energy of the compressed air.

I understand from Mr Gray that this feature was a modification from the standard design. Mr Gray informed me that the unmodified versions would emit hissing sounds as pressurised air was 'dumped' to atmosphere.

I do not know exactly how the multi-stage air compression in this ride was operated, but I presume that since the air was exhausted to an air receiver at a constant pressure, the rate at which the ride accelerated downwards would depend only on the weight and weight distribution of the ride's occupants.

A system was employed to slow the downward movement of the ride during the lowest 200mm (approximately) of travel. This was to avoid the possibility of the ride coming to a sudden stop upon reaching the limit of travel. The system used a proximity switch to determine when it had reached the final 200mm of travel. I do not have any information about what system was used to slow the ride, but it is possible that the air exhausted during lowering was vented to the higher pressure intermediate air receiver (this would have slowed the ride, and the slowing effect would have been greater than had the air been vented to the lower pressure intermediate air receiver).

3 ASSESSMENT

All versions of this ride rotated about a non-vertical axis, and this type of rotation creates a cycle of upward and downward acceleration at the occupant positions. The rides also subject occupants to lateral accelerations, but these have not been examined in this report.

Figure 13 shows some approximate cross section dimensions of a Tagada bowl, in its fully raised position based on information provided by Mr Trowell, relating to the SDC version of the ride. The SDC datasheet (Figure 1) shows a maximum speed of 10rpm. However, Reference 1, shows publicly available video footage of a ride which Mr Trowell lists as being manufactured by SDC. I timed the rotation of the ride using a stopwatch, and found that it rotated at approximately 15rpm.

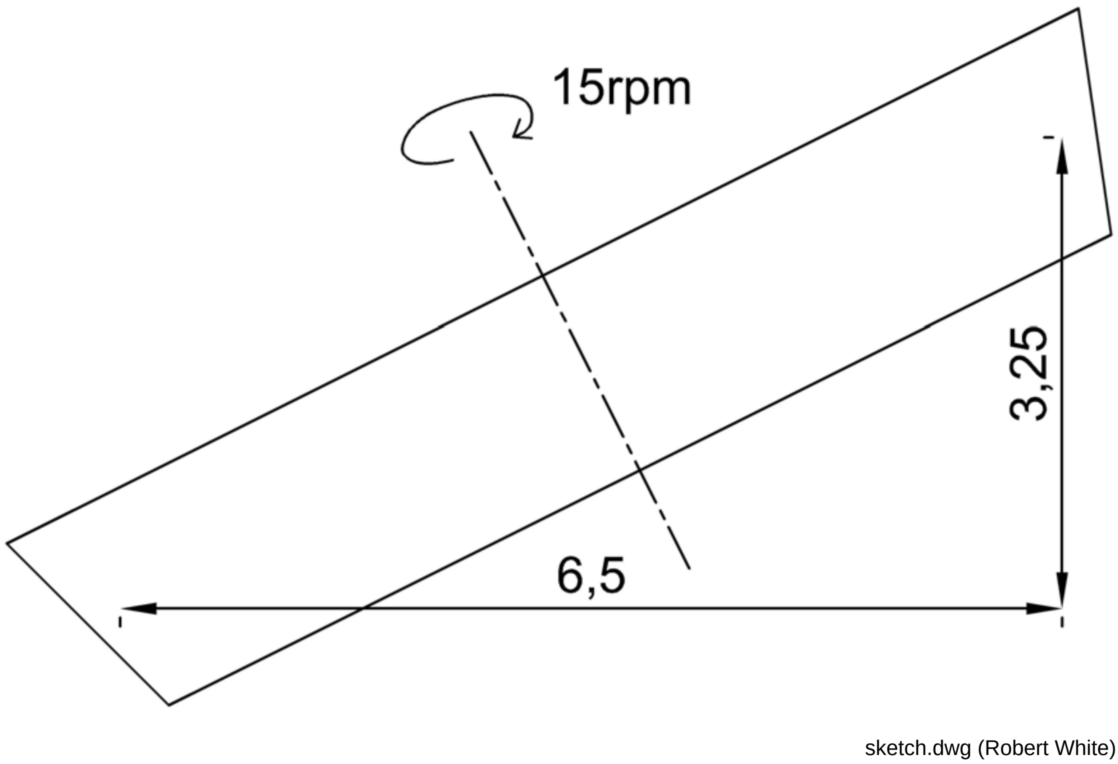


Figure 13 Ride geometry (dimensions in metres)

I do not know whether any ride has these exact dimensions, and rotates at this exact speed. However rides of this type generally have dimensions and speeds of this order. I will perform a calculation using these figures to demonstrate how to determine the vertical acceleration which Tagada ride occupants would be subjected to. I will use the figure I calculate as an example of a possible rate of acceleration.

A person on a ride with the dimensions shown in Figure 13, rotating at 15rpm would be raised and lowered by 3.25m, 15 times per minute. The vertical displacement profile would be sinusoidal.

15 revolutions per minute equates to 0.25 revolutions per second or 1.57 radians per second. The vertical motion, 'y' of an occupant of this theoretical ride could be expressed as:-

$$y = \frac{1}{2}h + \frac{1}{2}h\sin\omega t$$

where h is the total vertical displacement of the ride and ω is the angular velocity.

In this case:

$$y = 1.625 + 1.625\sin 1.57t$$

where y is the instantaneous vertical displacement of the rider at time t.

The vertical displacement of the rider can be calculated by differentiation with respect to time:

$$\frac{dy}{dt} = \frac{1}{2}h \times \omega\cos\omega t$$

$$\frac{dy}{dt} = 1.625 \times 1.57\cos 1.57t$$

and the acceleration is given by:

$$\frac{d^2y}{dt^2} = \frac{1}{2}h \times \omega^2 \times -\sin\omega t$$

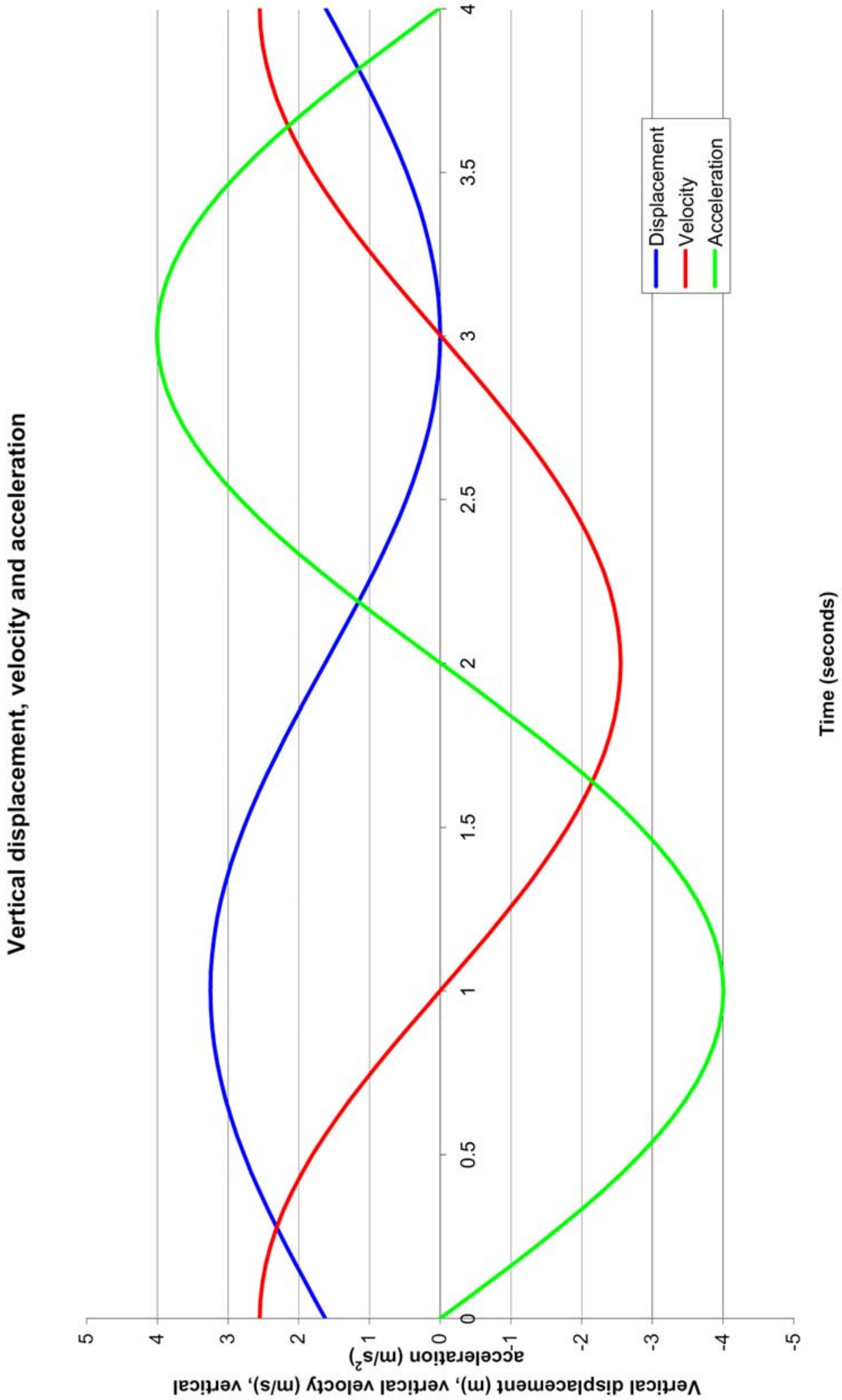
$$\frac{d^2y}{dt^2} = 1.625 \times 1.57^2 \times -\sin 1.57t$$

This peaks when -sin ωt = 1, and therefore the peak acceleration is given by:

$$a_{peak} = \frac{1}{2}h \times \omega^2$$

$$a_{peak} = 1.625 \times 1.57^2 = 4.0m/s^2$$

The vertical displacement, vertical velocity and vertical acceleration plotted against time, during one revolution, are shown in Figure 14.



Height, speed, acceleration.xls (Robert White)

Figure 14 Displacement, Velocity, Acceleration

The maximum downward acceleration due to the rotation of the ride would occur at an occupant position on the highest point on the ride, when the high side of the ride was in its raised position. The maximum total downward acceleration would occur at this point, when the high side of the ride was being lowered from the highest position.

I have no data about the rate at which Tagada rides raise or lower due to the rams which altered the inclination of the axis. On the Crazy Shake ride that I inspected, the downward movement of the bowl was not powered, and the rate of downward movement was further slowed because air was exhausted into a tank of air at a pressure greater than atmospheric pressure.

If a ride with the geometry and speed shown in Figure 13, were allowed to freefall, then the total downward acceleration would be approximately 4 m/ s^2 (due to rotation) + 9.81 m/ s^2 (due to gravity) = approximately 14m/s^2. As this is greater than 9.81m/ s^2 (1g), occupants would be at risk of moving upwards relative to the ride, unless they were restrained by some other force, (as identified in the data recorded by Mrs Dalby).

The peak downward acceleration would increase with increased rotation speed, increased vertical movement distance (between the highest point and lowest point of the rotation cycle) and the rate of acceleration in the downward direction (whilst the ride was being lowered).

3.1 WAYS OF LIMITING THE DOWNWARDS ACCELERATION OF THE RIDE

The peak downward acceleration could therefore be limited in three ways:-

- Reduce the speed of rotation
- Reduce the distance between the highest and lowest point on the ride (this would be achieved by reducing the maximum angle of inclination).
- Reduce the rate of downward acceleration caused by lowering the lifting rams.

Since the downward acceleration comes from two separate movements, providing the correct degree of limitation would require consideration of its origin and may require a combination of parameters to be changed.

3.1.1 Reducing the speed of rotation

Although I understand that the direction of a Tagada ride can generally be reversed, I am not sure to what extent Tagada rotation speed can be controlled. On a ride without any provision to control the speed of rotation, it may be possible to install a motor speed control unit, or substitute the motor for a less powerful or more controllable version.

3.1.2 Reducing the distance between the highest and lowest point on the ride

Another way to reduce the peak downward acceleration would be to reduce the distance between the highest and lowest point of the ride during a rotation cycle. This could most easily be achieved by limiting the stroke of the raising and lowering rams, or substituting them for shorter versions.

3.1.3 Reduce the rate of downward acceleration

The rotation of the ride generates a cycle of upward and downward accelerations, and the lowering of the bowl introduces an additional downward acceleration. If the bowl is lowered by allowing it to freefall, or if it is powered in the downwards direction such that it drops faster than freefall, then the combination of the two downward accelerations would almost certainly mean that the ride dropped at a rate faster than 1g, and an occupant would be likely to move upwards relative to the ride.

It would appear to me that some system to reduce the downward acceleration of the ride could allow the ride to conform to the British Standard (Reference 2). It is possible that the geometry of the ride, or friction in the moving parts may cause a slowing effect. Other ways of limiting the downward acceleration could be to vent the fluid exhausted during downwards travel into a receiver, pressurised above atmospheric pressure (as seen in the Scott Gray, Crazy Shake Tagada), or to use a flow control valve to restrict the flow of exhausted fluid during downwards travel. These two methods are discussed in Sections 3.1.3.1 and 3.1.3.2.

3.1.3.1 Venting fluid exhausted during downwards travel into pressurised receiver

The weight of the ride, and occupants on the ride would give rise to a downward force, producing a pressure in the lifting cylinders. If this pressure was not opposed by a lifting pressure, then the ride would accelerate downwards. The rams would provide only a small restriction in the rate of downward acceleration, as the valves would restrict flow to some extent. There may also be some friction and resistance in the moving parts.

It may be possible to exhaust the fluid vented during downward travel, into a receiver held at greater than atmospheric pressure. The downward force originating from the weight of the bowl and occupants would be opposed by an upward force determined by the pressure within the receiver. The result would be that downward acceleration would occur at a reduced rate.

The rate of downward acceleration would depend upon the pressure within the receiver, which could be set at a suitable level with a pressure relief valve or regulator. The weight of the ride and its occupants would also affect the rate, and therefore when setting up the ride it would be necessary to consider the worst case, which would probably be when the ride contained the heaviest possible combination of occupants.

This method of controlling downwards acceleration was employed on the Scott Gray Tagada.

3.1.3.2 Use of a flow control valve

Flow control valves are available for pneumatic and hydraulic applications, and if such a valve were used to restrict the fluid exhausted during lowering of the bowl, then the maximum rate of downward acceleration could be set.

Some flow control valves produce a variable rate of flow dependent on the pressure of the flowing fluid. These types of valves are usually adjustable. Selection and adjustment of such a valve would need to cater for a worst case pressure (which would probably occur when the ride was populated with the maximum possible weight of occupants).

There are also pressure compensating flow control valves, that are designed to compensate for the effects of pressure. These valves are less likely to be adjustable. A selection of flow control valves is shown in Figure 15.

http://www.snap-tite.com/snaptite_QD/products/construction_mobile/flow_control_valves/ (6th September 2011)

Figure 15 Flow control valves

More complicated servo pneumatic and servo hydraulic valves are available which could link to computer control. These valves would be capable of more accurately controlling flow rate irrespective of pressure.

3.1.4 Other considerations

The best method of controlling downward acceleration is likely to differ from ride to ride.

Having selected and employed a method to reduce the downward acceleration, a ride operator would need to monitor the effectiveness of the method and it may be necessary to make adjustments. The operator would need to refer to the requirements of the standard.

If downward acceleration was not restricted it may still be possible to conform to the standard by incorporating occupant restraints.

I have not examined any of the ride accelerations apart from the downward acceleration. With downward acceleration problem addressed, there may be other aspects of BS EN 13814:2004 that the ride does not comply with. For example the standard has details of permissible lateral accelerations. A Tagada operator may be able to rapidly pulse the ride upwards on alternate sides, which could create high lateral accelerations. It is possible that such movements may exceed the requirements of the standard, and it is possible that they may increase the likelihood of riders being injured.

4 CONCLUSIONS

4.1 The vertical motion of the Tagada ride is generated by a combination of two movements. As the ride spins on a non-vertical axis, riders are cyclically raised and lowered. The ride also has two rams which change the angle of the bowl by raising and lowering it.

4.2 In my opinion based on data from one particular Tagada it appears possible for the downward acceleration of this ride to fall within a category that would require occupant restraints according to BS EN 13814:2004 Fairground and amusement park machinery and structures – Safety (Reference 2). However the rides are not generally equipped with occupant restraints.

4.3 The downward acceleration of the ride due to rotation could be reduced by reducing the rotating speed, or reducing the inclination from vertical of the axis of rotation.

4.4 The downward acceleration caused by lowering of the rams could be reduced by employing a flow control valve.

4.5 An alternative method of controlling the downward acceleration originating from the rams was employed on the Crazy Shake Tagada operated by Scott Gray. This ride vented the compressed air exhausted during downward travel into an air receiver held at above atmospheric pressure. This reduced the ride's downward acceleration. I have not taken measurements to quantify the effects of this modification.

4.6 If downward acceleration was not restricted it may still be possible for the ride to conform to the British Standard if occupant restraints were fitted.

5 REFERENCES

1 http://www.youtube.com/watch?v=dUfOmLL_i_Q accessed on 27th September 2011

2 BS EN 13814:2004 Fairground and amusement park machinery and structures – Safety, pages 65 to 66, European Committee for standardisation

6 APPENDIX A

List of Tagada rides. Received from Ian Trowell, National Fairground Archive, 30/7/2010.

Safeco

TG1 G. Reeves (import Belgium 1996) - John Allen Jnr (1997) – Harry Jones (2003) – Jordan Cowie (2008) themed 'Beverley Hills 90210'

SDC

TG0 David Wallis (import 1989) exported 1993 - William Roberts (import 2006) was themed 'Disco Fieber'
TG2 Brandon Connell (import 1997 Belgium ex Lauwers) – Keith Turner (2006) themed 'Odeon'
TG3 Harry Jones (import 1989 Swiss) exported Belgium (1994) - Gavin Stirling (re-import 1999) - J. A. Cowley (2000) – Colin and Darren Noble (2001) – Matthew Fendick (2003) – Richard Tuby (2009) themed 'Zodiac' then 'Wild Thing'
TG15 Joey Whitelegg (import 1999 France)
TG17 Adam Williams (import 2004 France)
TG19 Charlie Hart (import 2007 France) – Jonathon Barker (2008)

Soriani and Moser

TG4 Edward Danter (import 1996 Sweden) – Billy Stevens (2004 used abroad) themed 'Disco'
TG5 Guy Evans (import 1997 France) themed 'Hurricane' (ex Lauwers or Zeppieri Belgium)
TG6 Harry Ayers (import 1991) – Stanley Freeman - Bobby Freeman – Bob Green (2000) – B.J. Butlin (2003) – Joe Crick (2007) themed 'Tic Tac' then 'Shaker'
TG8 Dave Pidgeley (import 1990 Sweden) - Brian Hickey (1992) themed 'Tic Tac' then 'Firestarter'
TG16 Blackpool Pleasure Beach (1987) incorporated into 'Trauma Towers' 1998.
TG18 Craig McKay (import Axels 2009)

Far Fabbri

TG7 Billy Crow (import 1994 Italy) - Stanley Gamble (1997) – Cullens (Ireland) (2008) themed 'America' ex Ramsaurer Swiss
TG11 Walter Murphy (import 2000 France) – Charles Church (2003) – Scott Gray (2010) themed 'Crazy Shake'
TG12 Donald Print (import 1997 Italy) – Raymond Pearson (2003) – Alan Crow (2005) exported 2006 themed 'Flashdance'
TG20 Henry Evans (import 2008 Sweden)

Emiliani Luna Parks

TG10 Philip Wheatley (import 1995 Switzerland) - Sheldon Lock (2000) - Michael Searle jnr (2007) themed 'Shockwave'
TG13 Irvin Stringfellow (import 2000 Italy) – Scott Pullen (2004) – Anthony Cubbins jnr (2006) themed 'Oba Oba' then 'Extreme'

Unknown / self built

TG9 Tony Litliernhurnest (self built 1991) scrapped 2006 themed 'Rave' then 'Twister'
TG14 John White (import 1999)