Health and Safety Executive

Field Operations Directorate
East and South East Region

EAST & SOUTH EAST SPECIALIST GROUP

Baggage handling in narrow-bodied aircraft: Identification and assessment of musculoskeletal injury risk factors.

Authors: Sarah Tapley
HM Inspector Health and Safety (Ergonomics)

David Riley
Senior Ergonomist, Health and Safety Laboratory

January 2005

TABLE OF CONTENTS

LIST OF TABLES

1.Summary

Research indicates that the manual loading and unloading of baggage onto narrow-bodied aircraft has been identified as a high risk operation for more than 20 years but little had been done in the UK to address the issue to date. The aviation industry, however, has recently adopted a voluntary 32kg single bag weight limit, which appears, according to industry figures to be reducing the numbers of reported incidents.

The aim of this project was to re-examine the musculoskeletal risk factors and potential risk reduction measures associated with this manual baggage handling operation.

There is mixed opinion as to whether it is better to handle in confined spaces when stooped or when kneeling. A review of the literature would, on balance, indicate that handling while kneeling for short periods inside the hold would be preferable to handling while stooping.

The highest risk elements of the task are during the internal baggage handling operation, especially the stacking of bags during the on-load operation. Repetitive handling of bags and with the hands at a far distance from the low back are also high risk factors. Unloading baggage onto flat bed lorries with a handler stood in the hold doorway also represented a high risk of injury. At some airports equipment has to be pulled and pushed into position exposing staff to associated risks.

A range of immediate risk reduction measures have been identified including the use of belt loaders for all baggage loading and unloading operations, job rotation to decrease exposure to the highest level of risk and better labelling of bags.
Longer-term risk reduction includes establishing an industry forum to identify and review equipment and methods to reduce the risks, passenger education and reduction in the bag weight limit based on robust research.

2. Introduction

Musculoskeletal Disorders (MSD's) are responsible for 40% of all personal injury incidents at airports reported to HSE, of this figure the majority are reported by ground handlers.
The loading and unloading of passenger bags onto narrow bodied aircraft for passenger usage has been of concern to both the air industry, HSE and other European enforcement agencies for many years now.
HSE field intelligence has highlighted a variety of different methods used to load and unload these aircraft. However there has been little evidence that the task has been assessed adequately. Assessments have failed to assess all the relevant risk factors and so ensure the risk is reduce to a level as low as practicable. Many assessments have concentrated on the height of the aircraft sills to decide on the work method.
HSE and the air transport industry are working closely together via the Revitalising Health and Safety in Air Transport (RHSAT) Strategy group. This group was established to work in an integrated manner to achieve the targets set out in the revitalising health and safety statement.

This report has been commissioned by the Air Transport Sector in HSE to identify the MSD risk factors present during loading and unloading of 737 series aircraft. This information is intended to allow both HSE and industry via the RHSAT steering group to choose work methods to ensure risks from baggage handling are reduced as far is as practicable. The findings and recommendations would also be useful to inform risk assessment for other narrow-bodied aircraft.

3. Project aims and objectives.

3.1 Aim:

To identify the MSD risk factors present during the manual loading and unloading of 737 series aircraft. This will provide information to ensure best working practices are utilised to reduce the risk of manual handling injuries to staff when loading and unloading 737 series to a level as low as reasonably practicable.

3.2 Objectives:

1. To identify physical risk factors when loading/unloading outside the aircraft;
2. To identify physical risk factors when loading/unloading inside the aircraft;
3. To identify physical risk factors from pushing and pulling activities during the loading/unloading operation;
4. To identify risk reduction measures.

3.3 Methodology:

Observation was used to gather data, including dimensions and force measurements, video recordings, and interviews with staff during fieldwork carried out at 3 UK airports observing low cost operations.

Complete turnarounds (off-load and onload) were observed for the following aircraft:
737/800; 737/200; 737/300; 737/700

Pulling forces were measured using a calibrated Mecmesin dynamometer. Pulling forces were recorded three times and average force calculated.

Assessments were made using the Manual Handling Assessment Chart (MAC) . The MAC was developed, using ergonomics and medical research, to assist in making an initial assessment of the physical risk factors for manual handling injuries (Monnington et al 2002,Tapley 2002)

4. Background

4.1 MSD incident data

Standard Industrial Classification (SIC) codes are used as a reference when recording work activity. Data collected by HSE from reports made under RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995) are coded under the main activity; this means some accidents will be coded for specific activities such as catering, security etc., rather than SIC 63230 for Supporting Activities to Air Transport. SIC 62100 etc refers to a series of codes covering scheduled and non-scheduled passenger and freight air transport.

The figures quoted are official HSE data for accidents coded under the specific SIC codes. We are aware that the total number of accidents at airports is likely to be higher than the quoted figures, but can only give the validated data allowed by the HSE data recording system.

Most of these MSD reports relate to manual handling of baggage and cargo onto/off dollies and trailers and into/out of aircraft holds. Heavy bags (usually not labelled as heavy) and packages are frequent contributory factors, along with cramped or restricted conditions in and around the aircraft and hold. Reports also include sprains and strains due to manipulation of heavy, awkward or difficult to move equipment, hold doors, cargo transfer equipment etc. There are also problems for catering, engineering and maintenance staff lifting and manoeuvring heavy equipment in confined spaces, and cleaning operations, which includes replacing or removing aircraft seats and audio/video units.

Year	SIC 63230		SIC 62100 etc		
	Major	Over 3 day (O3D)	Major	Over 3 day (O3D)	Totals
1997/98	12	303	10	235	560
1998/99	13	334	16	245	608
1999/00	8	338	7	266	619
2000/01	8	345	9	329	691
2001/02	17	411	13	362	803

Table1: MSD Injury data statistics

4.2 Industry Passenger bag weights initiative

There are now a number of initiatives underway to reduce individual baggage item weights at airports. Bag weights are only part of the problem, but are a factor that can be addressed fairly easily – by informing passengers of limits, and enforcing those limits on outgoing baggage. There has been resistance to introducing weight limits as airlines do not wish to upset passengers, or to be less competitive than other international operators. It is also not possible to restrict the weight of incoming bags, as this is governed at the airport of departure.

- IATA intend to introduce a recommendation of a 32 kilo per bag limit in their next issue of the Airport Handling Manual.

- Two ground handling contractors have introduced a maximum 32-kilo per bag weight limit and passengers will be asked to repack into boxes if items are overweight.
- British Airways introduced a 32-kilo weight limit in 2003 and a reduction in MSD injuries related to heavy bags of about 17% has been recorded.

- BAA led the way with the introduction of a bag weight limit at Heathrow Airport. A project has also been introduced at Gatwick airport with the support of major ground handling contractors and British Airways. Other airports plan to introduce the limit.

- In the USA, Occupational Safety and Health Administration (OSHA) has formed an Alliance with airlines and is looking specifically at ergonomics and baggage handling issues. They are recommending a 25-kilo bag weight limit to passengers and are now involved in raising passenger awareness of the issue.

(Barringer, HSE 2004)

5. Literature Review

5.1 Manual handling injury risk factors

Ergonomics and medical research has helped to clarify the main risks of back disorder associated with manual handling. Physical activities associated with an increase risk of back disorder are: heavy physical work; lifting and handling of loads; and awkward postures (e.g., bending and twisting) (Bernard, 1997; De Beeck and Hermans, 2000). The use of objective measures of the extent of physical loading to the lower back (e.g. spinal loading) during manual handling has contributed to the strength of these associations (De Beeck and Hermans, 2000).
The specific factors that modify the extent of the loading to the lower back are as follows (HSE, 1998):

- **The load**
  - The weight of the load, its size, shape, stability and grip.
- **The task**
  - The postures adopted (twisting, stooping and reaching), repetition, duration of the activity and carrying distance.
- **The environment**
  - The space available to move, floor condition, changes in levels and weather conditions.
- **The individual**
  - The capability and characteristics of the operator, level of knowledge and experience, underlying health problems.

Manual handling within the hold of narrow body jets is a specialised area. It is therefore not surprising that there are relatively few studies specifically concerned with this topic. However, there a several sources indicating the extent of the MSD problem amongst in-hold baggage handling workers, and others relating to the risk factors for MSD for in-hold baggage handling work. There are also some relevant general references concerned with manual handling activities performed in reduced headroom, and the relative risks of lifting and handling while stooping versus kneeling. These are described in turn below.

5.2 Baggage handling specific literature

Statistical evidence of the problem

Andersson et al (1984) undertook a survey of SAS baggage loading employees using the Nordic Musculoskeletal Questionnaire (NMQ, Foundation for Occupational and Environmental Medical Research and Development, Orebro, 1989). Sixty two percent were found to report low back pain (in last year). There was also a 45% annual prevalence for knee pain, and 33% annual prevalence for neck and shoulder pain.

Stålhammar et al (1986) in their in depth study of the postural, epidemiological and biomechanical aspects of baggage handling in aircraft holds, also administered the NMQ to participating baggage handlers, revealing 60% annual prevalence of low back and knee pain, over 50% annual prevalence of shoulder pain and 40% neck pain.

These figures are high in relation to comparative data from HSE and elsewhere. HSE reference data across all industries shows a mean low back annual prevalence of around 40%, knee prevalence ~25%, and neck/shoulder prevalence ~27% (Dickinson, 1994). Comparing with other sources, the baggage handler low back annual prevalence figures are equivalent to those seen in Railway Track Maintenance workers (Riley, 2004), and exceed those reported by Lumberjacks and Construction Workers (Foundation for Occupational and Environmental Medical Research and Development, 1985/86/87)

Dell (1997) presents the results of a survey on the causes and prevention of baggage handler back injuries. This was a survey of airline and baggage handling safety professionals, looking at injury rates, associated business costs and the recorded causes of MSD injury amongst baggage handling staff. In addition to gathering injury/absence data, the safety professionals were asked to rank work locations in order of those most likely to be associated with a reported injury. The most highly rated location was ‘inside narrow bodied aircraft baggage compartments’. Similarly, manual handling tasks were rated in terms of risk, the following were the two most highly rated:

- Stacking baggage inside the baggage compartment of narrow bodied aircraft
- Pushing baggage inside the baggage compartment of narrow bodied aircraft

Dell continued this work in 1998 by carrying out a review of baggage handler opinions as to what they perceived to be high back injury risk tasks, what parts of the baggage and system equipment present problems and also possible solutions.
The majority of respondents (70%) felt working inside narrow-bodied holds the most likely workplace to cause injury. Pushing and stacking bags (87%) was felt to be the task most likely to cause injury followed by transferring bags from the baggage cart direct to the hold (83%).
The most popular redesign solution was felt to be development of in-plane baggage and cargo stacking systems. The most popular procedural solution was the use of ‘heavy tags’ to warn staff a bag was heavy followed by improved bag handler training especially training to work in the confined space of the aircraft hold. Dell suggests in this paper that there is ‘a need for an industry wide solution to the heavy baggage problem’.

5.3 Physical research

There are two main references reporting the physical risk factors of in-hold working: Stålhammar et al (1986); and Rückert (1992). Both used a multifaceted approach. Stålhammar et al conducted a laboratory study using experienced baggage handlers in a mock up of a DC-9 baggage hold (1000mm high). This included video observation, EMG measurement on Trapezius and Erector Spinae muscles, force platform and Intra Abdominal Pressure (IAP) measures. The experimenters used baggage with a weight range of 9 to 19kg, with an overall mean of 15kg, which it is interesting to note that they report to be the average weight of luggage items on intra-European flights.
The main findings were that stooped and combined stooped and rotated trunk postures were adopted for 50% of luggage movements in the hold. Three techniques were examined: kneeling, squatting and sitting:

- Squatting produced the highest IAP and was judged as stressful on the low back;
- EMG for the Erector Spinae was lowest when sitting;
- EMG for the Trapezius was lowest for kneeling and highest when sitting;
- Kneeling was the most effective posture but loads the back;
- Sitting is strenuous for the shoulders and the back is kept maximally flexed;
- Squatting is stressful as judged by the IAP criterion;
- Loading was found to be more stressful than unloading. This was because of frequent lifting in a stooped and rotated posture while supporting the weight. During unloading the operation was more of a pulling action, with less need to support and control the load. Loading also required more control in positioning and final adjustment.

The authors recommend varying the working posture: Start off sitting when loading a low stack; move to kneeling as the stack height rises to reduce the load on the shoulders.
No specific advice is given in relation to the pushing / propelling of baggage along the hold.

Rückert (1992) also used a psychophysical approach in a mock up hold handling 11kg, 22kg and 33kg standardised loads for notional 8hr shift (by novice subjects). As weight increased, so handling frequency decreased. Overall weight moved was analysed; with performance on 11kg loads taken as 100%, performance decreased 13% for 22kg, and 35% for individual 33kg loads. Using computer modelling of spinal compression based upon the postures observed, for the 737-200 hold (55-113cm high), the compressive force was 37% higher than for that in the hold of an Airbus A 300 with higher ceiling (176cm).

5.4 Summary of baggage handling in hold research/publications

The MSD injury risk for baggage handlers working in the holds of narrow body aircraft has been recognised as a significant problem worldwide for over 20 years. Annual prevalence rates for low back pain and knee pain are high compared with those exhibited in other occupations. Mean baggage item weight is reported to be in the region of 15kg for European flights.

5.5 General handling in low-headroom literature

There are established causal links between knee disorders and occupations involving kneeling or squatting combined with heavy physical work (e.g. carpet layers), however, risk of any associated handling related injury appears to be poorly documented. Incidences of manual handling accidents while kneeling reported to HSE are few in number. It is therefore difficult to determine whether this is due to the handling method being relatively 'safe' compared to other techniques, due to the inaccurate reporting, or simply that it is an uncommon posture for handling.

There is a considerable body of research that has investigated the biomechanical and physiological demands of lifting in reduced headroom, much in relation to mining (Davis & Stubbs, 1977, 1978, MHRU 1980, Mital et al 1997).

Boocock (1997) reports that strength measures (particularly isometric measures) have not always shown a disadvantage to kneeling compared to standing, and in some instances kneeling has produced higher force capabilities. However, generally, psychophysical studies have shown consistency with work performed in a standing posture; weights of lift decreasing as the height of lift increases and as subjects move from a two-handed to one-handed lifting task.

However, some of the findings appear to be contradictory in terms of the relative risks of injury associated with kneeling and stooped lifting. In particular the findings of Ridd are at odds with those of Gallagher and co-workers (1987, 1989, 1991, 1994).

Ridd (1985) using Intra Abdominal Pressure (IAP) as an indicator for disc compression, reports that a 40% reduction in lifting capacity occurred in the first 10% reduction in headroom (expressed as a percentage of stature) when standing stooped in postures of up to 90 degree forward trunk flexion. By comparison kneeling to accommodate working in 75% headroom resulted in a 10% reduction in lifting capacity.

The studies by Gallagher and co-workers (Gallagher 1987, 1989, 1991, Gallagher et al 1994) all point to the fact that kneeling is disadvantageous compared to standing:

- Muscle recruitment of the major back extensors when kneeling compared to standing stresses the back musculature to a greater percentage of its total capacity, thus, exposing it to a greater risk of injury;
- Kneeling yielded an 11% lower lifting capacity when compared to stooping;
- Kneeling gave a higher spinal loading when compared to stooped standing lifting, suggesting that lifting 15kg when kneeling presented an equivalent spinal loading to lifting 25kg when standing stooped.

Graveling et al (2003) estimate that this means that kneeling may present 22% greater risk than stooping, and generally advocate standing stooped rather than kneeling.

Smith et al (1992) investigated a wide range of non-standard postures, allowing the comparison of kneeling with squatting. Kneeling was found to be preferable to squatting as kneeling produced a greater maximum acceptable weight of lift (MAWL) and there was not found to be any practical difference in MAWL/Carry whether one or two knee kneeling was employed.

Graveling et al (2003) draw attention to another finding by Smith et al (1992) in relation to standing and carrying (3 metres) stooped in headroom at 60% of stature, where a 'very flexed trunk and knees' posture yielded higher a MAWL/C than the stationary kneeling lifting operation.

There is a significant difference between standing-stooped handling and kneeling handling that is observed in the context of baggage handling. When handling while stooped the upper arm is held almost vertical, and the moment at the shoulder will be low. When kneeling, the upper arm is used in a position away from the vertical, and moments at the shoulder will consequently be increased. This is supported by Gallagher and Unger (1990).

As part of the work for HSE in producing the consensus document on the principles of good manual handling, the Institute of Occupational Medicine (IOM) (Graveling et al 2003) undertook a review of literature relating to various non-symmetrical lifting scenarios, including handling in limited headroom. To summarise, they state that it is difficult to present definitive guidance due to the relatively limited information in this area and the apparent contradictions in findings between researchers. However, on the basis that the postures in the study by Ridd (1985) are somewhat unrealistic, the findings of Gallagher et al (1994) are favoured. The resulting guidance is therefore that in terms of minimising injury risk to the low back, all the other principles for good manual handling that they present should be adhered to as closely as possible, before resorting to kneeling, i.e. provided that the remaining principles are followed, standing and lifting while stooped is preferable to kneeling. This decision is largely influenced by the consideration that subsequent movement with the load is typical and that kneeling is unlikely to be a practical option in this case.

Boocock (1997) concludes that, overall, the evidence suggests that manual handling in a kneeling posture compromises a person's stability, restricts movement capabilities and increases stresses on the lower back. There are also likely to be increased physical demands placed on the musculature of the back and upper extremities as a result. This may increase the rate of onset of fatigue. Generally, the MAWL when kneeling is judged to decrease by approximately 15% in comparison to stooped and standing postures. This reduction in capability relates solely to lifting and not to pushing and pulling. This 15% reduction in MAWL has been adopted in our risk assessments for the kneeling baggage handling operations.

A further point of relevance to baggage handling in the hold is that when performing one-handed force exertions in a kneeling posture, support for the upper body by using the free hand appears to offer significant benefits. This not only helps maintain balance, but is also believed to reduce the load imposed on the back. Bracing against the floor or other parts of the body seems to assist when exerting forces (Graveling et al 2003, Ferguson et al 2002, Ridd 1985).

5.6 Implications for baggage handling

Undoubtedly, kneeling to perform a manual handling operation must be viewed as presenting a greater risk of injury than when standing upright (assuming all other conditions are the same). Unfortunately, working in the hold forces workers to adopt kneeling and stooped postures, and in terms of risk of injury, the distinction between these two approaches becomes less clear in the literature.

From observation of baggage handlers standing stooped in the hold, it is considered that one of the principles for good manual handling, that of ‘Keep the load close to your waist’ (with the aim of minimising the horizontal distance between the load and the low back) is impractical for the workers to adopt, and that the degree of departure from this principle when stooped is greater than when kneeling.

However kneeling is likely to result in a greater load being placed on the upper arms and trunk due to the need to clear the knees in front of the body.

On balance, it is not possible to unequivocally recommend one approach over the other, but based upon observations of the operations, in relation to the two handling main tasks performed within the hold it is possible to make the following suggestions:

- For the task of manual stacking and unstacking of baggage in the hold the postures of standing stooped and squatting are not recommended – sitting and kneeling are recommended, although the shortcomings of these postures must be recognised. It is worth considering altering posture during the operation, from sitting while the stack is low, to kneeling when it is higher in order to reduce the relative load on the upper body.

- For the task of moving the baggage items between the hold doorway and the worker doing the stacking and vice versa, the posture of standing stooped can be adopted as an alternative to kneeling or sitting. Squatting is again not recommended.

- Prolonged periods of work in a full kneeling position should be avoided as this may restrict blood circulation in the lower limbs, and cause pain and discomfort in the knees.

- Kneeling on one or both knees does not appear to have any practical implications. Alternating between kneeling sides is likely to be beneficial.

Lifting with both hands is preferable to lifting with one hand. If lifting with one hand is unavoidable, then bracing the body and / or using the one hand for additional support is recommended, as it will assist the handling task and reduce the risk of injury.

6. Baggage handling operations assessments

Observations were carried out in order to assess the factors affecting the load, the individual, the environment and the discrete task elements that go to make up baggage handling operations. These are discussed in turn below

6.1 The Load

Companies vary widely at what weight check-in staff will label a bag as ‘heavy’. This ranged from 15kg to the 32 kg limit, some check in staff will write the actual weight onto the label, others will not. Manual handling training for check-in staff training was also very variable with many companies only providing training at induction with no task specific training.

It is difficult to obtain information about bag weight percentages, as there is no automated recording system at check-in desks.

At one small airport a survey over a morning shift found that 30 to 50% of baggage weighed in excess of 20kg, and on average 10% weighed over 25kg. The 32kg ‘limit’ was not exceeded for any bags during the shift. At this same airport check in staff were seen to be very proactive in labelling bags as ‘heavy’ if they were over 20kg. Stålhammar et al (1986) report an average baggage weight of 15kg for intra-European flights.

A consistent complaint from baggage handlers during the project was poor labelling and information about the baggage supplied by check-in staff.

Narrow-bodied aircraft can carry between 130 to 189 passengers depending on the aircraft type. The number of baggage items varies depending on destination, number of passengers and time of year. Size and shape of baggage is also variable and may be awkward for example bicycle boxes, golf clubs, skis and pushchairs.
The frequency of handling pieces of baggage will depend on these variables and how many staff are in the handling team.

Using the MAC assessment charts it is possible to allocate a level of risk when handling bags at various weights and frequencies outside the aircraft. This is set out in the table below.

MAC lifting score for one operator outside the aircraft				
Bag weight	**One lift every**			
	5 seconds	**9 secs**	**14 secs**	**30 secs**
Less than 10kg	Green	Green	Green	Green
10 kg	Amber	Amber	Green	Green
15 kg	Amber	Amber	Amber	Amber
20 kg	Red	Red	Amber	Amber
25 kg	Red	Red	Red	Amber
32kg (IATA max)	Purple	Purple	Red	Red

Table 2 MAC scoring for one operator outside the aircraft

Colour coding:
Green: low level of risk
Amber: Medium level of risk, task should be examined closely
Red: High level of risk, prompt action needed
Purple: Very high level of risk

6.1.1 In-hold handling load weights:
The literature review suggests that the psychophysical based data set of Snook and Ciriello (1992) used in the MAC and L23 guidance for the load frequency interaction can be used for handling while kneeling on one or both knees, but with a load reduction of 15% applied (Boocock 1997). The literature does not suggest that a reduction should be applied for pushing and pulling exertions however. An amended table is set out below showing the difference in MAC scoring for an operator inside the hold. The remaining aspects of the MAC are also used in the assessments with special consideration of the implications of kneeling.

MAC lifting score for one operator inside the aircraft				
Bag weight	**One lift every**			
	5 seconds	**9 secs**	**14 secs**	**30 secs**
Less than 10kg	Green	Green	Green	Green
10 kg	Amber	Amber	Green	Green
15 kg	Red	Amber	Amber	Amber

20 kg	Red	Red	Amber	Amber
25 kg	Purple	Red	Red	Amber
32kg (IATA max)	Purple	Purple	Purple	Red

Table 3: MAC scoring for one operator inside the aircraft hold

Colour coding:
Green: low level of risk
Amber: Medium level of risk, task should be examined closely
Red: High level of risk, prompt action needed
Purple: Very high level of risk

6.2 The Individual

Baggage on/off-loading is carried out under extremely tight time restraints, low cost carriers typically work on a 25-minute slot on the ground between flights, this requires the team to off-load and then on-load baggage extremely rapidly.

Baggage handlers typically work in teams of 4 or 5, but numbers may be reduced especially at night. Teams are almost exclusively male. It was reported that crews at one airport were reduced to 3 during the late shift when aircraft are on final flight to home base between 22.00h and 23.59h. Team make up, shift, and task rotation is variable but typically there will be a team leader directing, with all team members trained and able to carry out each part of the operation. Rotation was reported to be variable and informal. Some team members prefer to be inside the craft for example.

Individual performance will be affected by the need to wear personal protective equipment (PPE) such as hi-visibility and weatherproof jackets and hearing protection.

6.3 The Environment

The baggage handling operation is an 18 hours per day all year round operation.

Handlers will be exposed to the whole range of weather conditions, which will have an effect on them. Risk of MSD injury is increased with extremes of temperature. In cold weather handlers will need thick protective clothing and gloves when working outside the aircraft but may need to discard them inside the aircraft. Wearing gloves can reduce the ability to grip and so increase the muscular activity, as more effort is required to maintain an effective grip, this can lead to more rapid and increased muscular fatigue.

The floor surface around the aircraft will be clean and free from debris as this is vital to ensure aircraft and engine safety. However in wet and icy weather the ground may become slippery and so increase the risk of slipping.

All off-load operations were observed from aircraft hold to a flat bed lorry, the base of which is approximately 670mm tall. This may present an increased risk of slips and trips with the potential for falls from the lorry.

The area around an aircraft is normally a hearing protection zone requiring staff to wear ear defenders while loading/unloading. Constant exposure to noise increases fatigue.

Lighting on the ramp is generally to a good standard to allow safe movement around the aircraft and prevent damage. There is however the potential for shadows which may increase the risk of slips, trips and equipment collision.

6.4 The Task

The baggage handling operation consists of a series of discrete tasks, which are discussed in turn below:

6.4.1 On-load operations:
Observations external to the aircraft.

6.4.1a Loading bags from cart to belt loader

Risk factor	Observations	MAC risk rating
Load/frequency	Average frequency rate of 1 lift per 6 seconds.	
	Bags below 10kg	Low
	Bags between 10kg and 18kg	Medium
	Bags between 18kg and 25kg	High
	Bags above 25kg	V. High
Hand distance from low back	Top of stack 1600mm, hands at shoulder height for 1 layer of bags	High
	Base of stack 600mm, hands at knee height for 1 layer	Low
	Bags from far back of carts, approx 15% of bags, hands may be far from low back	High
Vertical lift region	Top of stack 1600mm, hands at shoulder height, bags pulled forward then dropped down to belt loader	High
	Base of stack 600mm, later transfer at knee height	Low
Trunk twist	If cart is positioned correctly (45° angle to loader) there should be no twist during the load	Low
Postural constraints	1 handler will have no postural constraints, if there are 2 or more then communication is important to prevent getting in each others way	Low
Carry distance	Approximately 2 to 4 metres, provided cart is positioned correctly	Low
Grip on load	Grip ranges from good to poor. If items have handles, there is often only one. If they do not have handles they are more awkward to grasp. The typical example would be a suitcase; the single handle may be useful for pulling on, but not useful for lifting, due to lack of space on the handle for both hands and because of the resulting orientation of the case. Grip will therefore be around the corners of the case. Softer items such as holdalls can be easier to grasp in a power grip and may have more handles. There are also large awkward and bulky items like bicycles in boxes, golf club bags, folded pushchairs, etc. Outside handlers are able to present bags to allow inside handlers optimum grip as the item arrives at the hold door. Insider handler is able to see item and plan lift	Low Medium

Table 4: Loading bags from cart to belt loader

6.4.1b Loading bags from cart direct to 200 series front hold with no belt loader
(Sill height is 1168mm, which is between shoulder and elbow height for the majority of British males)

Risk factor	Observations	MAC risk rating
Load/frequency	Average frequency rate of 1 lift per 6 seconds.	
	Bags below 10kg.	Low
	Bags between 10kg and 18kg.	Medium
	Bags between 19kg and 25kg.	High
	Bags above 25kg	V.High
Hand distance from low back	Hands will always be far from low back when placing and pushing bag into hold.	High
	Top of stack 1600mm, hands at shoulder height for 1 layer of bags.	Medium
	Base of stack 600mm, hands at knee height for 1 layer.	Low
	Bags from far back of carts, approx 15% of bags, hands may be far from low back.	Medium
Vertical lift region	Bags are moved across body and pushed up and into the hold, hands will usually be above shoulder height when placing and pushing bags into hold.	High
	Top of stack is an almost lateral transfer with push up and into hold.	Medium
	Base of stack will involve a lift from below knee height to shoulder height or above.	High
Trunk twist	If cart is positioned correctly there is no twist.	Low
Postural constraints	As above if cart is positioned correctly there are no postural constraints.	Low
	If more than 2 handlers are working, communication is important to prevent them impeding each other.	Medium
Carry distance	Approximately 2 to 4 metres, provided cart is positioned correctly.	Low
Grip	See above.	Low
		Medium
	Items are not delivered in optimum handling position for internal handler. Inside handler is unable to see item until it comes through the hold doorway, this makes it less easy to plan the lift.	Medium

Table 5:Loading bags from cart direct to 200 series front hold with no belt loader

6.4.2 On-load operations internal to the aircraft

6.4.2a Stacking bags inside hold.
General observations for this task are set out in the table below

Risk factor	Observations
Load/frequency	On-load operations have a slightly slower handling rate of one item every 5 to 6 seconds. The bag weight varies. Data indicates that bags weighing between 20 and 32kg make up 30 to 50% of the load.
Hand distance from low back	Workers were observed to regularly be at the extremes of reach when reaching to grasp and when placing items into the stack.
Vertical lift region	Between knuckle level (at floor level) and head level (ceiling height).
Trunk twist	Workers typically handled from one side of the body to the other, with the feet/legs/pelvic girdle remaining fixed due to kneeling. A 45-degree twist to either side is typical and a 90 to 90 degree twist is possible. Twist and sideways bending was observed to be routine.
Postural constraints	The flat area of the hold floor limits the amount of space available for kneeling. The headroom limits postures to kneeling, squatting, sitting or lying.
Carry distance	N/A
Grip	Grip ranges from good to poor as above.

Table 6: General observations

6.4.2b Transferring bags from the hold door to the in-hold stacker.

Risk factor	Observations
Load/frequency	On-load operations have a slightly slower handling rate of one item every 5 to 6 seconds. The bag weight varies. Data indicates that bags weighing between 20 and 32kg make up 30 to 50% of the load. These workers were observed to either lift and throw the items or to slide them with a pushing action. Forces exerted for propelling items along the hold are unquantified.
Hand distance from low back	There are two main possibilities, the worker is kneeling or standing stooped. When standing stooped it was typical for the worker to rest the hands on the knees/thighs for support between items. Workers were observed to be close to the extremes of reach when reaching to grasp items from the conveyor and when pushing items away. Generally hand distance from lower back was less compared with the stacking worker.
Vertical lift region	The worker can be kneeling or stood stooped, and they can throw or slide the items along the hold. If the worker lifts the items before propelling them along the hold, the vertical lift distance is between knuckle (floor) and elbow level (against trunk). If the worker is kneeling the range is between knuckle (floor) and shoulder level.
Trunk twist	Trunk twist was frequent, and was combined with sideways bending on occasions.
Postural constraints	Posture can be constrained by the amount of space available between the conveyor and the loaded luggage and the co-worker. The hold door opens inwards and reduces headroom in the region of the hold door. This is likely to either increase the extent of stooping while kneeling and/or restrict the positions that the worker can be in while performing this task. The headroom limits postures to standing fully stooped, kneeling, squatting, sitting or lying.
Carry distance	N/A
Grip	Grip ranges from good to poor as above.

Table 7: Transferring bags from the hold door to the in-hold stacker.

6.4.3 Off-load operations

During the internal operation it appears to be routine for a single worker to start the off-load process in most cases due to space constraints. Once there is sufficient room for the co-worker to be in the hold and to be of assistance, they will go into the hold. General observations for the internal task are set out in the table.

Risk factor	**Observations**
Load/frequency	Off-load operations have a higher handling rate. The mean handling rate observed for off-load operations was slightly faster than one item every 4 seconds. This represents a high or very high risk of injury if bags are above 15kg. The main approach is to pull items from the stack, although some were lifted/lowered to the hold floor. The force requirements of the push/pull elements are unquantified.
Hand distance from low back	There is a considerable amount of trunk movement involved in bending and reaching for baggage items. The trunk and arm posture is still such that hand distance from low back is routinely extreme.
Vertical lift region	Items were lifted and pulled from the stack and lowered to the hold floor before being pushed out onto the conveyor. Handling took place between shoulder/head level and knee height (floor level).
Trunk twist	Workers typically handled from one side of the body to the other, with the feet/legs/pelvic girdle remaining fixed due to kneeling. A 45 degree twist to either side was typical. Greater twist was seen. Twist and some a degree of sideways bending was observed to be routine.
Postural constraints	The flat area of the hold floor limits the amount of space available for kneeling, especially in small holds where the worker is alone in the hold. The headroom limits postures to kneeling, squatting, sitting or lying.
Carry distance	N/A
Grip	Grip ranges from good to poor as above.

Table: 8: For single worker in hold general observations

6.4.3b worker un-stacking in hold

Risk factor	Observations
Load/frequency	Off-load operations have a higher handling rate. The mean handling rate observed for off-load operations was slightly faster than one item every 4 seconds. This represents a high or very high risk of injury if bags are above 15kg.The main approach is to pull items from the stack, although some were lifted/lowered to the hold floor. The force requirements of the push/pull elements are unquantified.
Hand distance from low back	There is a considerable amount of trunk movement involved in bending and reaching for baggage items. The trunk and arm posture is still such that hand distance from low back is routinely extreme.
Vertical lift region	Items were lifted and pulled from the stack and lowered to the hold floor before being pushed towards the co-worker. Handling took place between shoulder/head level and knee height (floor level).
Trunk twist	Workers typically handled from one side of the body to the other, with the feet/legs/pelvic girdle remaining fixed due to kneeling. A 45 degree twist to either side was typical. Greater twist was seen. Twist and some a degree of sideways bending was observed to be routine.
Postural constraints	The flat area of the hold floor limits the amount of space available for kneeling. The headroom limits postures to standing fully stooped (depending on aircraft type), kneeling, squatting, sitting or lying.
Carry distance	NA
Grip	Grip ranges from good to poor as above.

Table 9 Worker un-stacking in hold

6.4.3c For worker transferring bags from the in-hold stacker to the hold door.

Risk factor	Observations
Load/frequency	Off-load operations have a higher handling rate. The mean handling rate observed for off-load operations was faster than one item every 4 seconds. This represents a high or very high risk of injury if bags are above 15kg. Loads are lifted/lowered/supported and pushed/pulled. The force requirements of the push/pull elements are unquantified.
Hand distance from low back	Workers were observed to stand on occasions, in a severely stooped posture, with the hands working close to floor level. The workers did rest the hands on the knees between items where possible. When kneeling, the trunk and arm posture is still such that hand distance from low back is extreme.
Vertical lift region	Lifting items was not typical. Items were pulled towards the worker and then pushed away out of the hold door to drop onto the conveyor.
Trunk twist	Workers typically handled items from one side of the body to the conveyor in front of them (or to one side), with the feet/legs/pelvic girdle remaining fixed due to kneeling. A 45-degree twist to the side was typical. Greater twist was seen. Twist and some degree of sideways bending was observed to be routine.
Postural constraints	Posture can be constrained by the amount of space available between the conveyor and the loaded luggage and the co-worker. The hold door opens inwards and reduces headroom in the region of the hold door. This is likely to either increase the extent of stooping while kneeling and/or restrict the positions that the worker can be in while performing this task. The headroom limits postures to standing fully stooped, kneeling, squatting, sitting or lying.
Carry distance	N/A
Grip	Grip ranges from good to poor as above.

Table 10: Worker transferring bags from the in-hold stacker to the hold door.

6.4.4 External offload observations

6.4.4.a Unloading from hold to flat bed lorry with belt loader

Risk factor	Observations
Load/frequency	Average frequency rate of 1 lift per 7 seconds.
	Bags below 12kg low risk.
	Bags between 12kg and 18kg medium risk.
	Bags between 19kg and 27kg high risk.
	Bags above 27kg very high risk.
Hand distance from low back	If handler takes bag from end of belt, hands will be at moderate distance from low back end of belt.
Vertical lift region	Handler is taking bag from belt at knee height and stacking. First layer will be below knee height on the base of the lorry, one layer will be at shoulder height for the top stack. The majority of bags will be moved between elbow and knee height.
Trunk twist	There was no observed trunk twist or bend.
Postural constraints	There is limited room at the back of the lorry if maximum bags are loaded, but until this point there are no postural constraints.
Carry distance	Between 2 and 4 m
Grip	Grip ranges from good to poor as above.

Table 11: Unloading from hold to flat bed lorry with belt loader

6.4.4b Unloading from hold to flat bed lorry - handler on lorry

Risk factor	Observations
Load/frequency	Average frequency rate of 1 lift per 6 seconds.
	Bags below 10kg low risk Bags between 10kg and 18kg medium risk Bags between 19kg and 25kg high risk Bags above 25kg very high risk
Hand distance from low back	Hands are at full reach for whole operation as handler was reaching into the hold to pull the bags out before throwing them behind him down the lorry bed
Vertical lift region	The handler was pulling and throwing rather than lifting bags
Trunk twist	Handler was stooped, bent forward and sideways twisted to reach bags
Postural constraints	Handler constrained by hold door and height of lorry bed, 670mm
Carry distance	Handler did not straighten up for the entire off-load operation, approximately 6 minutes
Grip	Grip ranges from good to poor as above.

Table 12: Unloading from hold to flat bed lorry - handler on lorry

6.4.4c Unloading from hold to flat bed lorry - handler on lorry

Risk factor	Observations
Load/frequency	Average frequency rate of 1 lift per 6 seconds.
	Bags below 10kg low risk
	Bags between 10kg and 18kg medium risk
	Bags between 19kg and 25kg high risk
	Bags above 26kg very high risk
Hand distance from low back	Handlers on ground were handling with hands at moderate distance from low back
	Handlers on back of lorry were at full reach to pick bags up from bed of lorry and then stack them
Vertical lift region	Handlers on ground were transferring bags between elbow and shoulder height. Handlers on lorry were lifting from floor height on bed of lorry up to above shoulder height for top layer of bags and to elbow height for majority of bags,
Trunk twist	Handlers were observed to twist while picking up bags from bed of lorry with some sideways bending as well
Postural constraints	Handler on back of lorry in hold doorway has to stoop and twist. Space becomes more constrained as the lorry becomes full.
Carry distance	Less than 2 m.
Grip	Grip ranges from good to poor as above.

Table 13: Unloading from hold to flat bed lorry - handler on lorry

6.5 Pushing/pulling baggage carts

At one airport the loaded baggage carts are pulled into place by a tug swinging in from back of the aircraft and round in a loop to bring them close to the belt loader already in position. The train of carts was left connected and as each one was emptied the train was moved along by the operator using the tug.

At other airports the current system is for baggage carts to be delivered to the edge of the stand and handlers then push/pull the individual full carts into position.
A variety of observations were made for this process:
3 full carts put into position by 2 handlers; 1 or 2 full carts pushed/pulled by single handler. Once carts were unloaded they were typically pulled out of the way by 1 handler.

	Average initiating force for pulling baggage carts	
Baggage cart condition	Airport 1	Airport 2
Empty cart	181 N	153 N
Loaded cart	444 N	437 N

Table 14: Force measurements for pulling baggage carts

Assessment:
Guidance on the Manual Handling Operations Regulations specifies a pushing and pulling risk filter value of 200 Newtons for males and 150 Newtons for females. Forces for the empty carts fall below the risk filter value, moving the loaded carts requires an initial pulling force of approximately 440 Newtons. This is more than twice the risk filter value and indicates that pushing and pulling loaded carts should be a two person operation at all times and a detailed risk assessment is required.

6.6 Pushing/pulling belt loaders
At most airports powered belt loaders are used. The handler drives the loader into position with a second handler guiding the final approach to the aircraft to avoid potential aircraft damage
At one airport smaller belt loaders are used which have to be manually pushed/pulled into position.

	Forces for pulling manual belt loaders	
Type of belt loader	Initial	Sustained
Small	522 N	280 N
Large	544 N	250 N

Table 15: Force measurements for pulling manual belt loaders

Assessment:
Guidance on the Manual Handling Operations Regulations specifies a pushing and pulling risk filter value of 200 Newtons for males and 150 Newtons for females. The initial forces are more than twice the risk filter value explained above and the sustained forces are above the risk filter values of 100 and 70 Newtons for males and females respectively.

7. Summary/Conclusion

The key risk areas during the baggage handling operation are:

- Handling inside the hold, in particular stacking bags;
- Frequency and weight of bags handled;
- Handling with hands extended far from the low back;
- Handling below knee height and above shoulder height;
- Pushing and pulling equipment.

8. Risk reduction measures:

- Job rotation to reduce exposure to stacking operation;
- Reduce bag weights and frequency of handling;
- Tugs should be used to move the baggage carts around the aircraft to eliminate need to push and pull. If it is not possible to use tugs then this operation must be a two person operation;
- Powered belt loaders eliminate the need for pushing and pulling and would be the preferred equipment rather than manual belt loaders;
- Reduce need to handle above shoulder height/below knee height;
- Eliminate direct to hold loading practice;
- Reduce the height of top layer of bags on carts;
- Use belt loader to unload to flat bed lorry;
- Task specific training for handling inside hold to be included in manual handling training. This should include using heavy bags as the base of the stack to reduce the need to lift bags into place.

9. Recommendations:

9.1 Short term:

- Job rotation;

- Belt loaders to be used for all 737 series aircraft baggage handling operations, eliminating direct to hold loading practices;
- Specific training;
- Improved bag labelling and information from check in staff;
- Decrease handling frequency. This could be achieved by increasing load/unloading time or by increasing numbers of handlers so each member of staff handled fewer bags;
- Pre employment screening to ensure staff fit to do job;
- Early symptom reporting and fast track treatment to prevent long term sickness absence;
- Research to establish MAWL for handling inside holds.

9.2 Medium/longer term:

- Passenger education about weight and size of luggage at point of sales;
- Industry education e.g. travel agents, travel press;
- Establish dialogue with baggage manufacturers;
- Develop technology to reduce risks;
- Reduce bag weight limit from current 32kg limit based on research identified above;
- Plane design to eliminate the need for manual loading/unloading operations.

9.3 Recommendations for further research

- Establish an industry forum to review and research and develop alternative methods of loading/unloading, including design of lorry;
- Undertake a musculoskeletal health survey of baggage handlers – using the HSEMSSQ (modified NMQ).
- Undertake an in-depth study of aircraft baggage handlers using approaches such as the RPE scale, heart rate, etc, to investigate the effect of workload and to measure the exertion associated with sliding / throwing items the length of the hold;
- Make a direct comparison of work practice and MSD risks with traditional methods versus the use of the Rampsnake and or similar equipment.

10. References

Andersson, G., Biering-Sørensen, F., Hermansen, L., Jonsson, B., Jørgensen, K., Kilbom, Å., Kuorinka, I., and Vinterberg, H. (1984) Nordiska frägeformulär för kartläggning av yrkesrelaterade muskuloskeletala besvär. Nordisk Medicine, 99, 54-55.

Boocock, M. (1997) Manual materials in a kneeling posture, HSE Internal Report (EWP/97/16).

Davies P. R. and Stubbs D. A. (1977) Safe levels of manual forces for young males (1). Applied Ergonomics, 8, 141-150.

Davies P. R. and Stubbs D. A. (1977) Safe levels of manual forces for young males (2). Applied Ergonomics, 8, 219-228.

Davies P. R. and Stubbs D. A. (1978) Safe levels of manual forces for young males (3). Applied Ergonomics, 9, 33-37.

De Beck, O. and Hermans, V. (2000) Research on work- related low back disorders. Bulbar: European Agency for Safety and Health at Work.

Dell, G. (1998) Airline baggage handler back injury: a survey of baggage handler opinion on causes and prevention. Safety Science Monitor. Volume 2, Issue 2, Article 6.

Dickinson, C.E., (1998) interpreting the extent of musculoskeletal disorders. In Hanson M.A. (Ed) Contemporary Ergonomics 1998, pages 36-40 London: Taylor and Francis.

Ferguson SA, Gaudes-Macharon LL, Marras WS, Waters TR, Davis KG (2002). Spinal loading when lifting from industrial storage bins. Ergonomics; 45: 399-414.

Foundation for Occupational and Environmental Medical Research and Development, Orebro (1989) Reference data for the YMK form. FHV 002D 003D 007D. FHV version March 1985. Clinic of Occupational Medicine. Regional Hospital, 701 85 Orebro. HSE Translation 89/90.

Gallagher S, Hamrick C, Love AC, Marras WS (1994). Dynamic biomechanical modelling of symmetric and asymmetric lifting tasks in restricted postures. Ergonomics; 37: 1289-1310.

Gallagher S. (1987) Back strength and lifting capacity of underground miners. Human Engineering and Human Resources Management in Mining, Proceedings: Bureau of Mines Technology Transfer Seminar, Pittsburgh, Pennsylvania, July 7-8, 1987; Information Circular 9145, pp 21-32.

Gallagher S. (1989a) Static and dynamic back strength of underground coal miners. In: Advances in Industrial Ergonomics & Safety I (A. Mital), Taylor & Francis, London, pp 531-536.

Gallagher S. (1991) Acceptable weights and physiological costs of performing combined manual handling tasks in restricted postures. Ergonomics, 34, 939-952.

Gallagher S. and Unger R. L. (1990) Lifting in four restricted lifting conditions: psychophysical, physiological and biomechanical effects of lifting in stooped and kneeling postures, Applied Ergonomics, 21, 237-245.

Graveling, R.A., Melrose, A.S., and Hanson, M, A. (2003). The principles of good manual handling: Achieving a consensus. Prepared by the Institute of Occupational Medicine for the Health and Safety Executive RESEARCH REPORT 097.

Materials Handling Research Unit (1980) Force Limits in Manual Work. IPC Science and Technology Press, Guildford.

Mital A., Nicholson, A. S. and Ayoub M. M. (1997) A Guide to Manual Materials Handling. 2nd Edition, Taylor and Francis, London

Monnington, S. C, Pinder A. and Quarrie, C.(2002) Development of an Inspection Tool for Manual Handling Risk Assessments, HSL report 2002/30.

Ridd JE (1985). Spatial restraints and intra-abdominal pressure. Ergonomics; 28: 149-166.

Riley, D (2004) Manual Handling in the Rail Sector in South Wales. HSL Internal Report ERG/04/10.

Smith J. L., Ayoub M. M. and McDaniel J. W. (1992) Manual materials handling capabilities in non-standard postures. Ergonomics, 35, 807-831.

Stålhammar, H.R., Leskinen, T.P.J., Kourinka, I.A.A., Gautreau, M.H.J., and Troup, J.D.G. (1986) Postural, epidemiological and biomechanical analysis of luggage handling in an aircraft luggage compartment. Applied Ergonomics, 17.3, 177-183.

Tapley S.E (2002) Reliability of Manual Handling Charts (MAC) developed for health and safety inspectors in the UK: A field study. HSE http://www.hse.gov.uk/msd/mac/pdf/reliability.pdf