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Typical Manual Handling Activities Performed in Retail Carpet Stores: The risks, and how to reduce them.

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of this report is to draw together the information obtained from various site visits to carpet retailers and to identify the risk factors associated with manual handling activities and the risk of musculoskeletal injury. This report also offers recommendations in order to reduce the risk of musculoskeletal injury.

FINDINGS

The typical high risk manual handling tasks identified in this investigation that employees in this industry perform include:

1) Unloading delivery vehicles and handling in the warehouse environment;
2) Handling underlay;
3) Handling carpet rolls within the store and changing display racks;
4) Handling of vinyl rolls when changing the display racks;
5) Handling roll ends; and
6) Hanging rugs.

A high to very high level of risk is associated with each of these tasks. The key risk factors that contribute to the level of risk are:

1) The weight of the loads handled;
2) The awkward postures adopted; and
3) The frequency of handling

RECOMMENDATIONS

These operations and their risk factors, including psychosocial factors need to be considered by the industry with the aim of developing alternative methods of working, and / or new work equipment. This would be most effectively achieved through the industry stakeholders working together to bring about improvement. Key recommendations are to:

1) Make a long-term commitment in the industry to investigate alternative display methods. For example mechanised equipment (e.g. carousel or paternoster), or mobile hoists and pulley systems, and other manual handling aids.
2) Communicate with suppliers to ensure deliveries of items require a minimum of manual handling and are clearly labelled.
3) Assess how storerooms are organised and implement any changes to ensure adequate access to all products, and to minimise manual handling.
4) Provide sufficient and suitable manual handling training for all employees. Training should be practical and specific to the tasks that employees perform.
5) Provide store managers with suitable training, to ensure they are competent in dealing with manual handling operations.
6) Ensure that shop designers are aware of the issues surrounding safe access to display racks.

1 INTRODUCTION

An initial project was carried out by HSE Specialist Inspector Sarah Tapley and the author, with the Local Authorities in Norfolk to assess the musculoskeletal disorder risk factors associated with carpet and flooring retail operations. Following ten site visits, typical manual handling operations and their associated risk factors with handling carpets and vinyl-flooring rolls were identified. In addition to these visits, a request from Herefordshire Council was made to investigate an accident that occurred when an employee was changing a carpet roll on a display stand. The aim of this report is to bring together all the information obtained in one document to present the risk factors, and to offer some solutions to the problems the carpet retail sector is currently facing. This report will only consider the retail environment and excludes carpet manufacturing and carpet fitting.

2 THE TASKS

The manual handling tasks identified for inclusion in this work are as follows:

1) Unloading delivery vehicles and handling in the warehouse environment;

2) Handling underlay;

3) Handling carpet rolls within the store and changing display racks;

4) Handling of vinyl rolls when changing the display racks;

5) Handling roll ends; and

6) Hanging rugs.

2.1 VEHICLE UNLOADING AND HANDLING WITHIN THE WAREHOUSE

A variety of techniques were observed when performing this activity. A large number of delivery vehicles are equipped with forklifts and booms to assist in the unloading activity. The carpet rolls are then placed into a 'carpet buggy' or 'carpet barrow' (Figure 1) and then pushed to where they are required.

Alternatively, deliveries were observed where carpet rolls were pushed out of the delivery vehicle by the driver to store employees who would then place the rolls on their shoulders either individually or in pairs depending on the size of the roll and carry the rolls into storage shelves.

Figure 1. Example of a carpet buggy / barrow.

2.2 HANDLING UNDERLAY

Rolls of underlay are either delivered as individual rolls where they need to be manually handled from the delivery vehicle or they may be delivered on a pallet and then may be moved by hand to either get them into the storage position or where they are required within the store. Storage of underlay within store warehouses was stored in a 4 x 4 roll pattern to approximately 1.5 metres high. Generally the underlay was stored in such a way that access to it was restricted (e.g. it could be accessed from the front or side only). Employees are generally required to

move underlay when they prepare orders for fitters, or when retrieving it from the storeroom for customers who are present in the shop and want to take the product away with them.

2.3 HANDLING OF CARPET ROLLS WITHIN THE STORE AND CHANGING RACKS

A variety of display racking exists (Figure 2), from wall mounted racks, to freestanding racking which may also be moveable (e.g. on wheels). Various levels of racking exist, from three level racking up to five level racking. Some racking systems have fixed height intervals whereas others can be adjusted to accommodate an additional level.

Figure 2. Examples of display racking.

When delivered rolls are unloaded they may be pushed using the carpet buggy directly into the showroom where they are tipped out near the racking where they are required. Because the display racks are at different heights employees must plan how they are going to change the display racks. The methods involved in using the carpet manipulator (Figure 3) are outlined below:

1) Firstly, the old carpet roll needs to be unwound off the rack if there is still a lot of carpet left on the roll. This is done by using a single arm crank or a wheel.

2) Once that has been unwound to a certain level the two employees can then remove the remaining carpet roll and bar to the ground. The wheel was observed to be used when lifting the bars to the ground as it allows the employees to get a better grip on the load. This could not be done using the single arm crank.

3) The new carpet roll is attached to the metal bar (approximately 15 kg to 20 kg) and clipped into place.

4) The employees then lift the bar into the racking.

5) A wheel or handle is then used to wind the carpet from the manipulator onto the racking.

This process is outlined further in Section 3.4. Alternatively, it was reported that, if employees are in a hurry the manipulator may not be used and they will perform this activity by hand: 1)

lifting the old roll off the racking, and 2) lifting the new roll onto the racking (depending on the weight). This could also involve employees having to 'climb' the display stand in order to be able to reach the highest racking level, and then handle the carpet roll in one hand.

Figure 3. Examples of carpet manipulators.

2.4 HANDLING OF VINYL ROLLS AND CHANGING RACKS

Vinyl rolls can also be moved into the showroom using the carpet buggy. A central bar or spindle is pushed through the roll and then employees will have to manually lift the roll into the racking, using a T-bar to increase the area they have to grip. There may be other methods used to display and handle these products however, these were not observed during the site visits.

2.5 HANDLING OF ROLL ENDS / REMNANTS

When carpet rolls become diminished (approximately less than 6 metres remaining on the roll) they may then be sold as remnants or roll ends. These require employees to lift the rolls out of the display rack where they are then lowered onto the ground. This may involve reaching above head height or below knee height. Once the roll is on the ground it is taped up and then lifted from the ground. One individual usually performs this part of the activity which involves:

1) One end of the roll is lifted off the ground by the employee to approximately shoulder height.

2) Then the roll is raised up on its end by 'walking' their hands up the roll.

3) Once upright, the roll is then lifted by the employee and placed up against the wall at a slight angle. The roll has to be lifted into this display position, as there are generally barriers that prevent the rolls from slipping out.

An example of how roll ends are displayed is shown in Figure 4, and the risk factors associated with manual handling of remnants will be discussed in greater detail in Section 3.6, Figure 26 and 27.

Figure 4. Example of the typical method used to display roll ends / remnants.

2.6 HANGING RUGS

Large rugs can be displayed in stores from hanging frames (Figure 5). These are generally lifted by two employees but may sometimes, be lifted by one person. The display racks are approximately 4 metres high and require the employees to use a stepladder. Employees attach a hook mechanism to the rug when on the floor and then must climb the ladder whilst holding the rug. The rug is then typically hooked onto a horizontal, hinged bar of the display racking using one hand, whilst the other hand holds the bottom of the rug, therefore the employees cannot grip the ladder. The bottom of the rug is then released and the employees can climb down the ladder.

Figure 5. Example of a hanging rug display.

3 RISK FACTORS

3.1 OVERVIEW OF MANUAL HANDLING RISK FACTORS

Bernard (1997) and Op De Beeck and Hermans (2000), have performed literature reviews to help clarify the main risks of back disorder associated with manual handling activities. Physical risk factors associated with the increased risk of back disorder are:

- Heavy physical work,
- Lifting and handling of loads,
- Awkward postures (e.g. bending and twisting).

The observations made within this report identify the presence of all of these activities when carpet rolls (and other similar products) within retail outlets are manually handled. Each of the identified activities that employees within stores may perform and the risk factors associated with these activities will be outlined and discussed. Generalized information is outlined below with regard to the weight of products. In addition, typical risk factors relating to the task, the environment, the individual and psychosocial aspects are presented.

3.1.1 Load

A variety of carpet weights exist, depending on the pile. Most carpet rolls have a width of 4 metres, however, some may be 5 metres. Table 1 shows some examples of different roll widths and lengths and the different weight ranges that may exist. For a 4 metre roll with a 30 metre length, weight ranges may vary from 93 kg up to 336 kg. Other observed weights during the site visits ranged from 33 kg up to 170 kg. The roll width x length of 4 m x 6 m represents possible weights of carpet remnants / roll ends.

Table 1. Example weights of carpet rolls depending on the weight / m^2, the length, and width.

Weight kg / m^2	Roll weight in kg (width x length)		
	4 m x 30 m	5 m x 30 m	4 m x 6 m
0.78	93.6	117	18.72
1.12	134.4	168	26.88
1.4	168	210	33.6
1.68	201.6	252	40.32
2.8	336	420	67.2

In addition to the weight of the load being handled other factors should be considered such as:

- Carpet rolls are bulky and awkward to handle;
- They are wrapped in plastic making them more difficult to grip;
- They are moved around the premises on a daily basis.

3.1.2 Tasks

All of the tasks observed and described in the following section have common attributes in that they often involve:

1) Handling while stooped, bent sideways, or twisted;

2) Handling with hands far from the lower back;

3) Handling through a large vertical lift range (floor to above head);

4) Handling at height.

3.1.3 Environment Factors

The main two work environments that employees operate in are:

1) The warehouse / unloading vehicles:

a) During vehicle unloading the employees will be exposed to the elements if they have to go outside to the delivery vehicle. A factor present in all of the stores visited was the lack of space available in the warehouse area, this was generally quite limited, which can make moving and handling large carpet rolls difficult, and may compromise employee posture even further.

b) Carrying items from the delivery vehicle into the warehouse may also expose employees to an increased risk of slipping or tripping hazards. For example large carpet rolls may impair an individual's vision, and their view ahead. In addition if it is raining the floor may become slippery.

c) Lighting may be an important issue, particularly during the winter months if warehouses or outside loading bays are not sufficiently lit, and may further impair an employee's vision when handling products.

2) Within the store:

a) Changing carpet rolls or vinyl rolls on the display racks, handling remnants, and hanging rugs, are all activities that occur within the store and therefore employees have to be aware of customers who may be walking around.

b) The environmental conditions are typically reasonably good, however in some stores there is a lack of space that employees can work in. It was noted that in some stores the racks are so close together that employees do not have enough room to use stepladders. Working within the store and often in confined spaces may make handling of large rolls more difficult. Working in confined spaces may also increase the risk of injury due to the awkward postures employees may have to adopt when working.

3.1.4 Individual Factors

Individuals may be exposed to high levels of musculoskeletal injury risk, dependent on the work methods adopted when performing the various manual handling activities. An individual's likelihood of being injured or developing a MSD may be influenced by:

1) Any underlying health problems they have, for example a history of low back pain;

2) Their knowledge and experience of the products being handled and the best way of manually handling these awkward and heavy loads;

3) Differences in strength capabilities, particularly differences between males and females.

4) When team-handling operations occur a good level of co-ordination and communication is required. It is therefore important that employees with similar characteristics (e.g. height and strength capability) work together to ensure the weight of the load is equally distributed between the two employees.

3.1.5 Psychosocial Factors

A range of psychosocial risk factors may be found within these work environments such as:

1) Employees having a lack of control over their work and how it is performed;

2) There may be a lack of social support from managers or co-workers;

3) The job activities may become repetitive and monotonous;

4) Employees may have to operate to tight deadlines and feel pressured due to time constraints. For example when changing carpet rolls there may be pressure from managers to complete a set number of jobs before the end of the day. This may lead to employees taking short cuts such as 'climbing' on the racking to access top racks rather than following the companies outlined operating procedures.

3.2 VEHICLE UNLOADING AND HANDLING WITHIN THE WAREHOUSE

3.2.1 Task

On average, carpet deliveries will occur approximately twice per week, however this may be dependent on customer orders and sales. There is very little manual handling when vehicles arrive with a lift truck and boom and the rolls can be unloaded straight onto a buggy to be pushed into the warehouse or showroom, or can be placed directly into the shelving units. The duration of the delivery is variable but could take approximately 1 hour depending on the number of products to be off-loaded and the method of used.

Other delivery vehicles may not come equipped with any handling equipment and may therefore require the employees to manually handle the carpets from the delivery vehicle into the warehouse (Figure 6). This is normally done by one or two employees depending on the weight of the product. The carpet rolls will be placed on one shoulder and then carried into the

warehouse for storage in the shelving units. This activity may involve the employees bending down to place the rolls at knee level or below or lifting the rolls above head height.

Figure 6. Typical handling activities when unloading a delivery vehicle without using a forklift and boom.

Once the roll has initially been placed onto the shelf it must then be pushed into the correct position (Figure 7). This may also involve pushing with the arms raised above the head or below the knee. Employees will perform the handling task until all the products are off-loaded.

In order to retrieve the carpet roll the employees will grip the plastic surrounding the carpet roll and pull it out of the shelving. This may be quite difficult if other rolls are on top of the required roll.

Pushing forces were obtained when carpet rolls were being pushed into storage shelves. Pushing forces of various product weights ranged from 170 N to 500 N (Newtons). The guidelines in L23 specify that if forces of greater than 200 N are obtained to initiate movement of a load, a detailed risk assessment should be performed.

Figure 7. Handling of carpet rolls into storage shelves.

3.2.2 Load

As mentioned in the first section the weight of the rolls is variable, and this is not always clearly visible. Weight limits were labelled on the majority of rolls but this was in a small typeface and was not immediately obvious that the figures displayed were referring to the weight. The size of the rolls also makes them difficult to handle, and because of their length they may be difficult to balance. As the rolls are also wrapped in plastic it is difficult for employees to get a good grip on the load.

The guidelines outlined in the Manual Handling Assessment Charts (MAC) suggest that:

- 2-person handling of loads up to 50 kg, if the correct technique is used and the lift occurs between knee and elbow height would represent a medium level of risk.

- If the weight of the load is above 85 kg for a 2-person lift then the load presents a serious risk of injury to employees regardless of the frequency of handling.

The majority of the carpet rolls are greater than 50 kg and therefore independent of how frequently they are handled there is considered to be a high level of risk of musculoskeletal injury.

3.2.3 Summary

If loads are being manually handled during the deliveries and within the warehouse then employees will be exposed to a very high risk of musculoskeletal injury. This is predominantly due to the weight and size of the loads being handled. The MAC assessment for this activity is located in Table 6 of the Appendix.

3.2.4 Recommendations for risk reduction

The following recommendations are specific to the manual handling operations that occur during vehicle unloading and warehouse activities. Additional general recommendations for risk reduction are outlined in Chapter 5.

- Delivery vehicles with lift trucks and booms when used in conjunction with carpet buggies can significantly reduce the amount of manual handling employees have to perform (Figure 8).

Figure 8. Unloading using forklift, boom, and carpet buggy.

- If delivery vehicles do not come with a forklift and boom this equipment should be available and used within stores. Additionally, one of the stores visited had the machinery, but there was a slight slope where the warehouse floor meets the outside concrete, and the fork truck could not negotiate this. Therefore the fork truck could not be taken outside and used effectively when unloading.

- Other equipment could also be beneficial such as a 'carpet tug'; a winch operated system used in conjunction with a carpet buggy, to assist delivery drivers with handling when no lift truck is present. Although not observed in use during the site visits this product looks to be an effective method of moving carpet rolls into and out of lorries. However, the effectiveness of such a device would need to be investigated further, especially as it appears that to remove carpet rolls from the lorry an individual would have to climb into the back to attach the harness (Figure 9 and 10). Furthermore, all employees should be trained in their use. Although not part of this study, delivery drivers should not have to climb into the back of vehicles during unloading to push the rolls out of the vehicle, as in Figure 10, as this clearly introduces a significant fall from height risk. It would also be beneficial if the lorries were organised so that the heavier rolls were placed at the bottom of the lorry and the lighter rolls on top of these. This way the lighter rolls could be pulled out manually, leaving the heavier rolls to be removed using the winch without such difficult access. However, this may be made more difficult if a single lorry is delivering to a number of different stores.

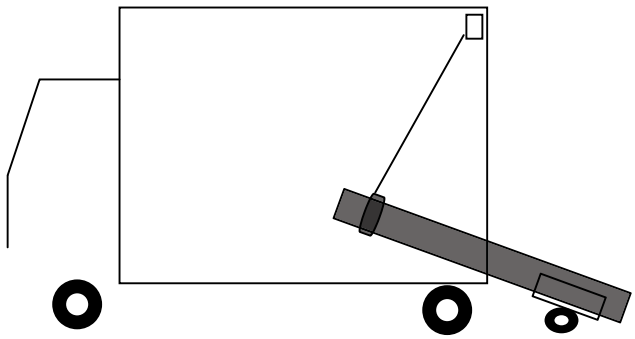

Figure 9. Illustration of the 'Carpet Tug' winch operated system during vehicle unloading.

Carpet tug winch operated system

Figure 10. Example of an employee climbing into the back of the lorry and manually pushing the carpet rolls out rather than using the 'Carpet Tug'.

- Using handling aids, such as lift trucks or forklift trucks with booms and buggies where possible, will help to reduce the risk of manual handling injury (Figure 8).

- Clearly identifying and labelling individual products with their weight would raise employees' awareness of the loads they are handling. This will also be beneficial to newer employees who do not have the experience and product knowledge about what different products weigh. These could also be colour coded to quickly identify which items are heavier than others. For example, something similar to the MAC guidelines for a 2-person team handling operation could be used: <35 kg = green, 35 – 50 kg = amber, 50 – 85 kg = red, > 85 kg purple. Companies could then use this information to control the risk by allocating handling methods accordingly. For example: have a two person team to handle loads of less than 50 kg, and loads of more than 50 kg are handed mechanically.

- Storing heavier products on middle shelves and lighter rolls on upper and lower shelves is recommended.

- Having products stored in individual rolls will help to lower the pulling forces when retrieving products as the friction force caused by the weight of products stored on top will be avoided (Figure 11).

Figure 11. Example of individual storage containers.

3.3 HANDLING UNDERLAY

3.3.1 Task

Employees may have to manually handle rolls of underlay from the delivery vehicle into the storeroom of the retail store if the underlay is not delivered on a pallet. They then will predominantly move rolls of underlay when they prepare orders for fitters, or when they collect underlay from the warehouse for customers on a 'pay and go' system. This may require employees to lift and carry the underlay into local delivery vehicles. During the site visits handling aids did not appear to be used. Access to the underlay may be restricted with access from only one side of the pallet and this will require employees to adopt awkward postures (Figure 12). For example if underlay rolls are at the back of the stack, employees will have to lean forward with their arms outstretched and pull the roll toward them. Stacks may require employees to lift from the ground to approximately shoulder height.

Figure 12. Underlay stacks with only front access.

3.3.2 Load

Different underlay types were observed with weights ranging from approximately 17 kg to 48 kg. Rolls are approximately 137 cm long and are approximately 36 cm in diameter. However, it is acknowledged that there may be other different sizes and weights of underlay that are available. Employees may be required to unload a vehicle with these products on (if they are not palletised).

3.3.3 Summary

The handling of underlay represents a medium to high level of risk depending on the type and weight of underlay handled and its position on the stack. The risk will be increased if employees are handling the underlay frequently, are operating in awkward postures (e.g. stooped, and twisting, or reaching), and the load is supported away from the body. The MAC assessment for this activity is located in Table 6 of the Appendix.

3.3.4 Recommendations for risk reduction

- On a national level stores should begin discussions with the suppliers of underlay to ensure that it is delivered palletised. This will eliminate the need of employees to manually unload the delivery vehicle and reduce the risk of musculoskeletal injury, providing individual stores have suitable handling aids to move the pallets. For example a fork truck or hand pallet truck.

- Ideally, underlay should be stored so it is easily accessible from all sides (or at least more than one side) to help prevent forward bending and reaching.

- The level at which rolls of underlay are lifted from should be restricted to between knuckle and shoulder level. This will help to avoid the need for employees to lift from low down in stooped postures. This may be achieved by raising the partially full pallet onto a stillage or onto several other pallets once the top of the stack is below approximately knuckle level.

- A trolley may be useful to transport the underlay from the warehouse area to customers' cars or vans.

3.4 HANDLING OF CARPET ROLLS AND CHANGING RACKS

3.4.1 Task

During the site visits the following methods were described and observed to be the correct or typical methods of changing a carpet roll on a display rack:

Preparing the new carpet roll for winding onto the display stand

Carpet rolls are usually moved within the store on carpet 'buggies' or 'barrows' and will be temporarily stored near to where an existing carpet on the display rack needs to be changed. Carpet manipulators are used, by placing the centre bar through the middle of the carpet roll. Two employees then pull on the lever arms on the manipulator, and this levers the carpet roll off the ground. This requires employees to adopt a stooped posture, as they have to bend down to reach the lever arm and then pull on it. This activity is discussed in greater detail in Section 3.4.2.

Unwinding the old carpet off the display stand

Employees may unwind / unroll an existing carpet, if it is to become a remnant or if it is to be displayed somewhere else, using either a wheel or single arm-crank that is on the display rack, or partially unwind a roll until it is not as heavy to lift off the rack. The display bar (15 – 20 kg) and the existing carpet roll (unwound roll) will be lifted off the display rack and lowered to the ground.

Lifting the display bar onto the rack and winding on a new roll

The new carpet to be displayed will be clipped around the bar, and this bar is then lifted back into the rack. The bar weighs approximately 15 – 20 kg. Depending on the height of the racking, employees will either stand on the ground or on a stepladder to lift the carpet roll into position on the display stand. The carpet can then be wound from the manipulator onto the display rack. These activities may involve the employees working in stooped postures (e.g. approximately knee height) or reaching above head height with the arms outstretched away from the body. The use of the carpet manipulator and the process of changing a roll is shown in Figures 13 and 14.

Figure 13. Unwinding the top roll and moving it down to the next rack level.

Figure 14. Winding on a new roll using carpet manipulator and wheel.

Figure 15 shows a biomechanical human model that was developed using the Jack ergonomics computer aided design (CAD) system. It shows a four-tier display rack, (approximately 220 cm to the bottom of the wheel) and the ability of 5th, 50th, and 95th percentile males and females to be able to reach the wheel in order to wind the roll on. It shows that the 95th percentile male (186.65 cm) can easily reach the 4th rack, and the 50th percentile male (175.49 cm) can just reach the wheel, but is likely to struggle more when manipulating it, and may have to stand on 'tiptoes'. The 5th percentile male (164.69 cm) would be unable to reach the 4th rack. If women were required to perform this task (which may be the case as they may be required to unroll carpet for customers), only a 95th percentile female (162.72 cm) would be able to just reach the wheel and this will make manipulation of it difficult. For example this means that only 5 % of the British female population would be able to reach the wheel. It is expected that female employees would not perform these heavy handling activities, however, they may be required to unwind part of the carpet for a customer and would therefore struggle to reach the wheel if stairs were not available.

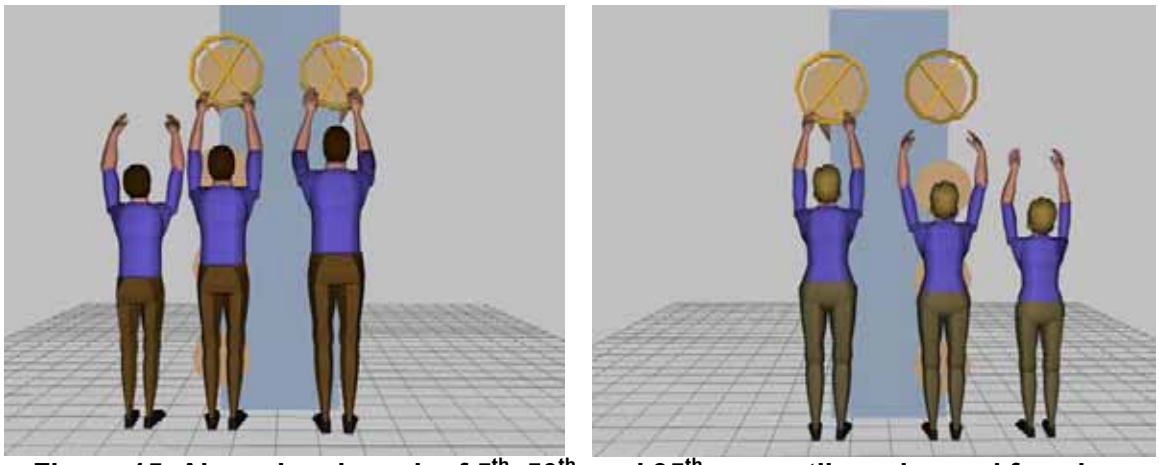

Figure 15. Above head reach of 5th, 50th, and 95th percentile males and females.

Three, four, or five level display racks were observed, and the techniques to change the rolls were reported to be the same. However, typically most of the five tier display racks were located against walls and would require the use of tall stepladders. These racks are often very difficult to access and the use of stepladders may not always be possible. It is therefore recommended that due to the increased risk of handling at height and access difficulties, five tier display racks are not used.

It was reported during the site visits that the 'correct' method of changing a roll on a display rack might not always be used for a variety of reasons, for example time constraints, and limited space available to use equipment. Therefore employees may use different methods in order to change full rolls on the racks. For example:

1) **Standing on the ground:** Two employees stand on the ground and lift a carpet roll into position. The postures adopted to perform this activity will be similar to those shown in Figure 15;

2) **'Climbing' the racking:** An employee may use the display racks to stand on whilst lifting a carpet roll into position. Figure 16 shows an employee demonstrating how the display racking may be used to 'climb' in order to reach the top rack. It was suggested that full rolls might be replaced by lifting them into position whilst standing on the rack in this manner. Handling full carpet rolls using this method is a high-risk activity principally due to:

    - Carrying a heavy load in one hand whilst 'climbing' the racking;
    - Adopting awkward, non-neutral postures and standing on an unstable base of support; and
    - Fall from height risk due to slipping off the racking.

Figure 16. Example of standing on the display rack to reach the top level.

Figure 17 shows two possible methods of 'climbing' on the racking, using the Jack ergonomics CAD system. It shows the adoption of a 'side-on' and 'front-on' posture when standing on the racking to gain access to the fourth rack. It is thought that a similar process may be performed to access the fifth rack if no steps are available and will increase the level of both musculoskeletal risk and falling from the display rack. Therefore, handling carpet using this method is not recommended.

Side-on posture **Front-on posture**

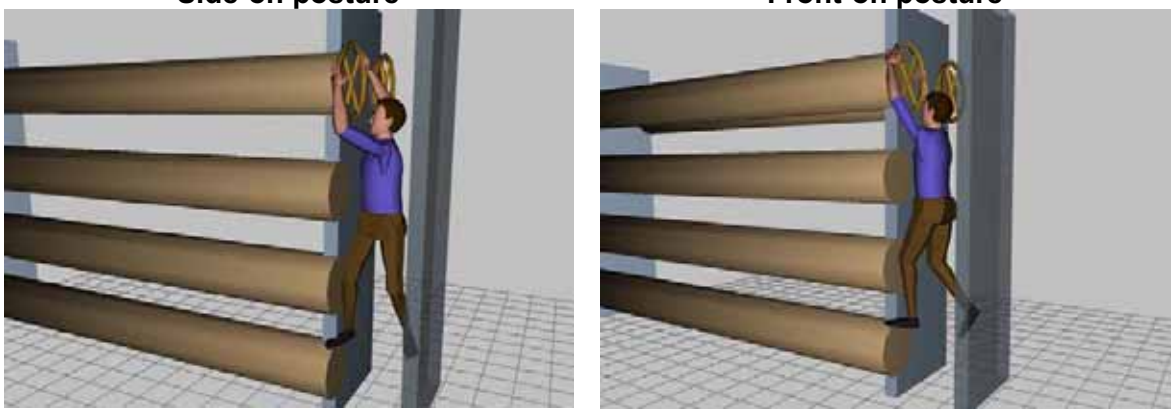

Figure 17. Fifth percentile male adopting different postures to reach the fourth rack. (Gap of 45 cm between racks).

3) **Using stepladders:** Employees may use stepladders to access the top rack and lift the carpet roll into position. The use of stepladders is important to allow employees to reach the higher racks, however, many premises visited did not have adequate steps available, they were in poor condition, or only one set was available. The use of stepladders also introduces further risks to the task:

    - Carrying a heavy load in one hand whilst climbing the stairs;
    - Reduction in the ability to adopt a neutral lifting posture (e.g. may encourage twisting, and or sideways bending);

- Fall from height;
- Winding on a new roll when standing on a small base of support that may also be unstable.

Figure 18 shows a 50th percentile male (on the left) and 5th percentile male (on the right) standing on mobile safety steps and how this will help employees gain access to the top rack. The stairs could be positioned either side-on or facing it depending on which allows for easiest access when lifting the rolls up and down. This technique would also require both employees to be using the steps. It is anticipated that if rolls were lifted by two employees at the same time the stairs would have to be positioned side-on to allow for best access.

50th percentile male: Stairs side-on **5th percentile male: Stairs front-on**

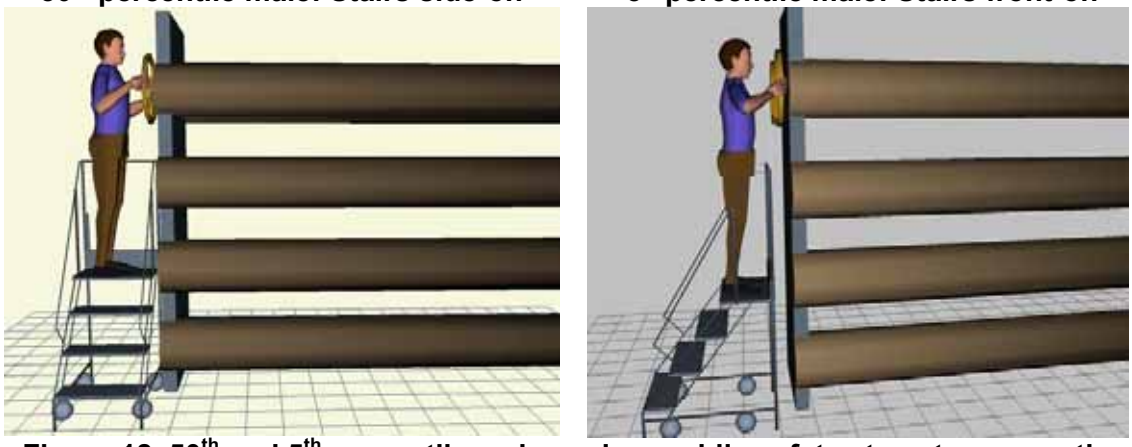

Figure 18. 50th and 5th percentile males using mobile safety steps to access the fourth rack.

3.4.2 Load

Lifting a full carpet roll onto the display rack

The metal display bars alone weigh approximately 15 kg – 20 kg, therefore if a full carpet roll is on them when either being lifted onto or off a display rack such as when employees: 1) Stand on the ground and reach above head height, 2) 'Climb' the racking, or 3) Climb up stairs whilst carrying and lifting the roll in one hand; these activities represent a high-risk activity and should be avoided by following a company's operating procedures to change rolls such as using carpet manipulators as shown in Figures 13 and 14. Furthermore, as the weight of the load increases the risk of musculoskeletal injury will also increase. In addition, this is a team lift and requires a good level of co-ordination and communication. It is important that employees with similar characteristics (e.g. height and strength capability) work together to ensure the weight of the load is equally distributed between the two employees.

Figure 19 illustrates the risk assessment filter guideline figures in '*The Manual Handling Operations Regulations 1992*', L23, (2004) for frequent lifting and lowering activities (e.g. approximately once every two minutes). These figures apply for two-handed lifts, where the operator has a good grip on the load and the handling operation occurs in reasonable working conditions. Therefore if frequent lifts are performed with loads exceeding the guideline figures, a detailed risk assessment should be performed. Although a carpet roll may not be lifted once every two minutes they are heavy, awkward to handle, and require individuals to adopt awkward postures when handling them, therefore a detailed risk assessment should be

performed. Further, the Manual Handling Assessment Charts (MAC) suggest that for a two-person team handling operation, loads greater than 85 kg present a high risk of lower back injury.

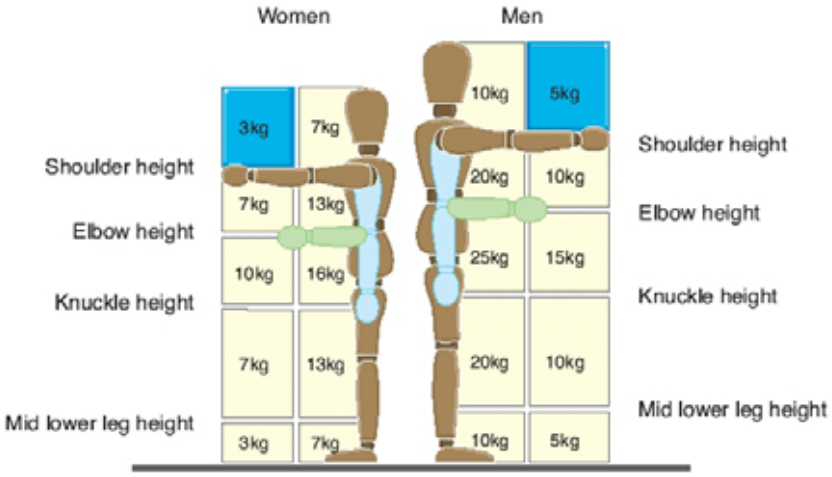

Figure 19. Guideline weights for lifting and lowering activities in the Manual Handling Operations Regulations 1992 (L23).

Mital *et al*., (1997) state that current ergonomics literature outlines that maximum weight recommendations vary between 9 and 30 kg with regard to infrequent, one-handed lifting using the stronger hand, in a standing posture. This will vary depending on the grip, the load position from the shoulder and lower back, the posture, and the age of the operator. When a carpet roll is initially lifted, the load is predominantly held quite close to the shoulder and low back but as the carpet roll is lifted into the display rack the distance from the low back will increase and place additional stress on the shoulder, arms, and lower back. Furthermore, the lift should be well co-ordinated and the load distributed evenly between the employees.

Carpet retailers reported that stairs or steps are used when changing carpet rolls on the higher display racks; however, this technique was observed on only one occasion. It is believed that the majority of the time employees may lift the carpet rolls into the racking, which may involve standing on the ground and reaching above the head or involve them 'climbing' up on the racking when replacing carpet rolls on the upper display racks. Climbing the racking exposes the employees to an increased risk of musculoskeletal injury as they are holding a heavy load and working in an unstable position, furthermore, they are likely to adopt asymmetric postures. Employees will also be at an increased risk of falling from height.

Table 2 provides a summary of the estimated low back compression (LBC) forces that have been calculated from the postures in the Jack ergonomics CAD system. This analysis is based on handling full carpet rolls onto the display rack when either standing on the ground or standing on stairs during a two person lifting operation. Therefore not following the 'correct' methods of changing a roll using the carpet manipulator to wind on a new roll (outlined in Section 3.4.1 and Figures 13 and 14). These are based on a two-person team lifting a carpet roll onto the display rack. Compression forces are calculated at the L4 / L5 junction of the spine. This location is considered to be at greatest risk of injury as this is where the greatest load is placed on the spine. The National Institute of Occupational Safety and Health (NIOSH) suggest that compression forces less than 3400 Newtons (N) offer a reasonable level of protection to most young, healthy workers, whereas forces greater than 3400 N should be considered potentially hazardous to some workers (Waters *et al*., 1993).

Low back compression forces have been calculated for a 50th percentile male when performing a two-person team lift, of rolls weighing 60 kg, 80 kg, 100 kg, or 120 kg. Table 2 identifies two different methods of performing the lifting task by gripping the wheel before lifting the roll off: 1) Standing on the ground (Figure 15); and 2) Standing on stairs (Figure 18). Table 2 also identifies areas most at risk of sustaining an injury. This is a two-person handling task, therefore the roll weights were divided in half to estimate the low back compression forces affecting a 50th percentile male (e.g. 30 kg, 40 kg, 50 kg, 60kg). These weights were then divided in half again and these loads were entered into each of the hands (e.g. 15 kg, 20 kg, 25 kg, 30 kg).

Estimated low back compression forces were not obtained for the rack 'climbing' postures shown in Figure 17. This was for a number of reasons: 1) This is not the outlined method of changing a roll; and 2) The postures modelled are complex, requiring an individual to balance on the racking system and would therefore not be suitable for application of the Jack ergonomics CAD system.

Caution is advised when interpreting these results as it is possible that these figures may underestimate the low back compression forces, as the biomechanical model is based on activities that are static in nature or occur in a slow and controlled manner, whereas the lifting activities identified in Table 2 are all dynamic and can occur quickly. Lindbeck (1995) suggested that when considering a dynamic activity (such as this) the figures might rise by 1.2 to 3 times what the biomechanical model predicts. Therefore, it is likely that these figures stated are actually underestimations of the actual low back compression forces and a range of figures are also presented in brackets in Table 2 that show the possible increase in low back compression forces based on the suggestion of Lindbeck (1995); that with dynamic activity the figures may increase by 1.2 to 3 times the estimated compression forces. When the estimated low back compression forces were multiplied by 1.2, then they would still fall below the 3400 N NIOSH action limit. However, if these figures were underestimated by 3 times, then all of the figures would exceed the NIOSH action limit of 3400 N (indicated by the red colouring) and many would exceed the NIOSH design limit of 6400 N (indicated by the purple colouring). Low back compression forces exceeding the design limit (e.g.6400 N) represent an increased risk of low back injury for most individuals, therefore, engineering controls would be required immediately to reduce the risk of low back injury.

It can also be seen in Table 2 that higher estimated low back compression forces are obtained when standing on the stairs and lifting the carpet roll into the display rack this can be explained by having the arms further away from the lower back when lifting on the stairs compared with the arms held directly above as when standing on the ground. However, this could easily vary if an individual was lifting with their arms outstretched above their head and held horizontally away from their centre of mass.

Table 2. Estimated low back compression forces and areas at most risk of injury when lifting a carpet roll onto the display stand when standing on the ground or on stairs, and the estimated increase if due to fast movement.

Carpet roll weights (kg)		Estimated low back compression forces (N)	
Roll weight handled by one person	Total roll weight	Standing on ground (Figure 15) (Estimated increase 1.2 – 3 times)	Standing on stairs (Figure 18) (Estimated increase 1.2 – 3 times)
30	60	1527 (1832 – 4581)	1655 (1986 – 4965)
40	80	1838 (2205 – 5514)	2027 (2432 – 6081)
50	100	2162 (2594 – 6486)	2411 (2893 – 7233)
60	120	2486 (2983 – 7548)	2798 (3357 – 8394)
Areas at most risk of injury		Torso, shoulder	Elbow, torso, shoulder

Using the manipulator to lever a carpet roll off the ground

Figure 20 shows an example of the posture adopted when using the carpet manipulator. The lever is used to manipulate the carpet off the ground where it can then be wound onto the display rack. The forces required to lever the carpet roll off the ground using the carpet manipulator were modelled using the Jack ergonomics CAD system. The estimated forces required to perform this activity are shown in Table 3. Due to the use of the lever this creates a long moment arm therefore requiring less effort compared with lifting the roll directly. The calculations used in the Jack ergonomics CAD system are based on half the roll weight at either end when in the manipulator (e.g. 30 kg at each end of the manipulator for a 60 kg roll). It was estimated that the mechanical advantage of the lever would reduce the actual force applied by a factor of three. Therefore, the roll weights handled by one person (e.g. 30 kg, 40 kg, 50 kg, 60 kg) were all divided by three and the resulting loads were then entered into each of the hands (e.g. 5kg, 6.7 kg, 8.3 kg, and 10 kg per hand respectively). Table 3 also shows what the estimated forces could be if they were increased by 1.2 to 3 times as outlined by Lindbeck (1995). Those forces highlighted in red indicate that the NIOSH action limit of 3400 N has been exceeded and the purple indicates where the NIOSH design limit of 6400 N has been exceeded, indicating that immediate engineering controls to reduce the risk of injury are required.

Figure 20. An example of using the carpet manipulator in the store and in the biomechanical model, during the initial lift on the manipulator lever arm.

Table 3. Estimated low back compression forces and areas at most risk of injury when using the carpet manipulator to lever a carpet roll off the ground, and the estimated increase due to fast movement.

Carpet roll weights (kg)		Estimated low back compression forces (N)
Roll weight handled by one person	**Total roll weight**	**Levering the roll (Estimated increase 1.2 – 3 times)**
30	60	1943 (2331 - 5829)
40	80	2159 (2591 - 6477)
50	100	2365 (2838 - 7095)
60	120	2581 (3097 - 7743)
Areas at most risk of injury		Elbows, torso, shoulders

Winding / unwinding a carpet roll onto or off a display rack

When the new carpet is being 'rolled on' as when using the 'correct' operating procedures outlined in Section 3.4.1, an increased level of force will be required when more carpet is on the roll. This also involves the employee working with their hands held away from the body, and depending if they are standing on stairs or not, may involve reaching above head height and standing on 'tip toes'. Additionally depending on the size of the rolls in the display rack, if they are large and rub on each other the force required to turn the wheel will be increased even further.

Forces were obtained using a handheld dynamometer when employees were pulling on a single arm crank to unwind some carpet for a customer (Figure 21.1 and 21.2). The average force to perform this task was 680 N. This is well above the recommended 200 Newtons (N) or 20 kg force required to initiate pushing or pulling of a load in the Manual Handling Operations Regulations (1992). Therefore a detailed risk assessment should be done for this activity. It is very likely that by reducing the amount of carpet on each of the rolls so they do not touch each other will dramatically reduce the force required to perform this activity. Figure 21.3 also shows an employee using a 'wheel' whilst standing on the ground to wind on the last bit of carpet of a full roll that becomes more difficult when there is more carpet on the roll.

The recommended maximal isometric force capacity when operating machinery for pushing in a standing posture for a work activity is 200 N, and 145 N when pulling as stated in the British Standard BS EN 1005-3:2002 (*Safety of machinery – Human physical performance – Part 3*). Therefore manufacturers of machinery that require individuals to apply a muscular force exertion need to consider the physical strength of the individuals who may have to use the equipment and the postures they have to adopt, how quickly the activities occur, the frequency, and duration of the activities. For example activities that occur frequently or last for a long duration will cause muscle fatigue to develop resulting in a reduction of the maximal force that can be generated. Strain on the musculoskeletal system results, leading to fatigue, discomfort, and potentially a musculoskeletal disorder. Therefore the activity of unwinding or winding on a carpet roll in some circumstances, for example when loaded with a lot of carpet as in Figure 21 will increase the risk to employees of developing a musculoskeletal disorder due to the high levels of force required to operate the arm crank or 'wheel'.

1. **2.** **3.**

Figure 21. Different methods of unwinding / winding carpet rolls on the display rack.

3.4.3 Summary

The activities of changing the carpet on the display racks can represent a high risk of injury and depending on the method adopted may represent a very high risk of injury. The MAC assessments for the different lifting activities when changing a carpet roll on the display rack are presented in Table 7 of the Appendix.

If the reported 'correct' method of changing a roll (e.g. winding off the old roll, using the manipulator, and winding on a new roll from the manipulator) were used then the risk of injury would be moderate. However, even though many companies report this practice, due to a number of reasons, this 'best practice' may not always occur. It is understood that common practice is to climb the racking whilst lifting the bar into the position. This represents a high risk of musculoskeletal injury and also significantly increases the risk of falling from height, making it a very high-risk task.

3.4.4 Recommendations for risk reduction

- Lifting and handling on five tier display racks should be eliminated due to the excessive reaching involved and the unsafe methods of changing the rolls on the top rack. For example holding the carpet roll whilst climbing and standing on the racking or negotiating steps on a stepladder.

- Companies should consider the use of mechanised systems to avoid awkward handling postures (e.g. a paternoster or carousel). Employees should not have to climb the racking in order to reach the appropriate level to change a roll.

- The procedures for correct roll changing should be followed at all times. For example, remove the metal bar / spindle from display rack, clip on new roll and replace on the display rack (using suitable steps if at the top rack), use manipulator and 'wheel' to wind on new roll (again, standing on a suitable platform if on the top rack).

- Lowering the weight of the spindles / metal bars will help to reduce the loads that employees are manually handling. For example hollow steel, aluminium, or carbon fibre could be used.

- A suitable platform could be something similar to mobile safety steps that have handrails, and a sufficient platform to work from with a guardrail (Figure 22).

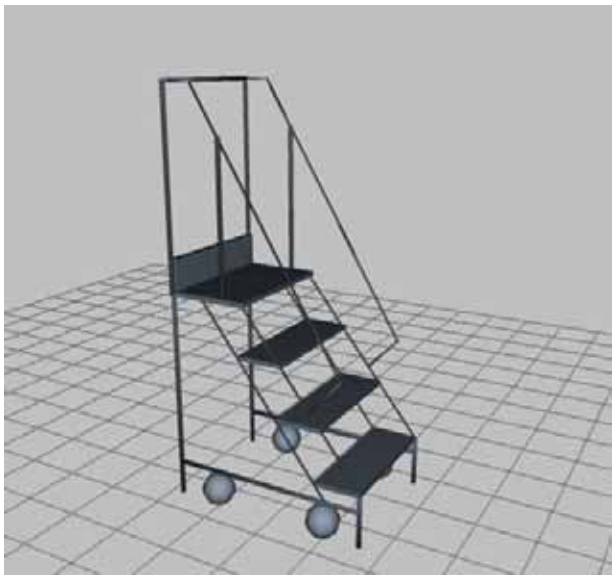

Figure 22. Example of mobile safety steps.

- A review of the current work systems should be performed to ensure that employees have sufficient time to perform the task, and that they have the proper equipment available to them at all times (e.g. if the fourth rack was being changed both employees would need a suitable platform to work from). However, if a paternoster or carousel system were used there would not be a need for employees to negotiate steps.

3.5 HANDLING OF VINYL ROLLS AND CHANGING RACKS

3.5.1 Task

Handling of vinyl rolls into storage racks requires employees to adopt awkward work postures, stooping to lift rolls between knee level or below and approximately head height. The top layer of racking shown in Figure 23 is approximately 1.8 m from the ground. This is a team lift and requires good co-ordination and communication. The risk factors associated with this operation are very similar to those identified for the roll change on the rack operation, however it is understood that the rolls will be lifted from a carpet buggy or trolley and therefore require the individuals to stoop and reach below knee level.

Figure 23. Example of vinyl display racks.

3.5.2 Load

Vinyl rolls may weigh up to 135 kg, and when handling with the central racking bar (approximately 15 – 20 kg) the total weight is approximately 150 kg – 155 kg. MAC guidelines indicate that loads of greater than 85 kg when handled by a two-person team represent a very high level of risk, independent of the lifting frequency and posture. Figure 24 provides an example of the typical postures adopted when reaching the top display rack, approximately 1.8 m from the ground and accessing the lower rack.

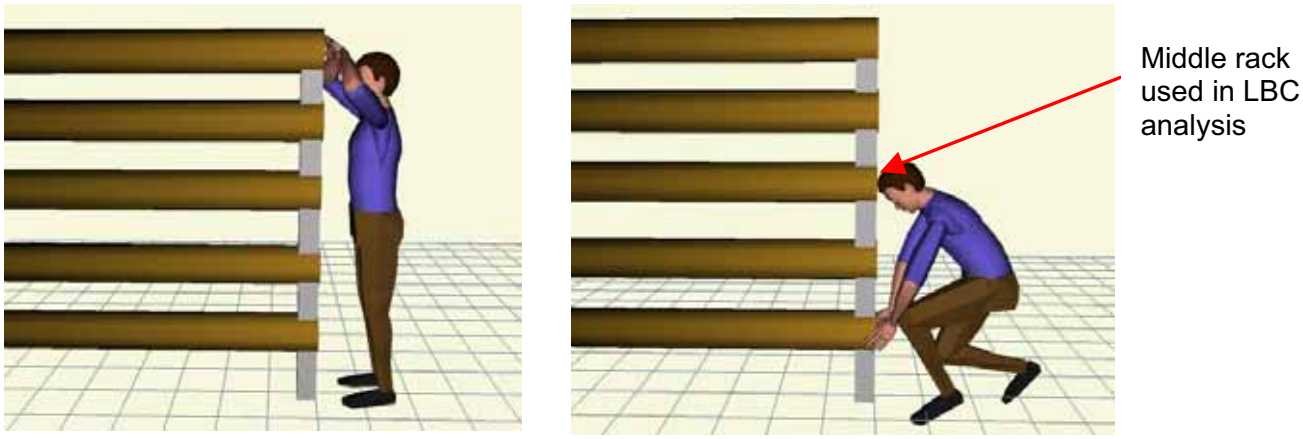

Figure 24. Example of postures involved in accessing the top rack and the bottom rack of a vinyl display stand.

Table 4 shows the estimated low back compression forces for the postures adopted in Figure 24. These were estimated on carpet rolls weighing, 80 kg, 100 kg, and 150 kg, whereby two people would lift these loads and therefore the individual loads lifted would be 40 kg, 50 kg, and 75 kg (with loads in each of the hands: 20 kg, 25 kg, and 37.5 kg). The load placed on the lower back of a 50th percentile male when lifting a 150 kg vinyl roll (during a two person team lift) to the top rack exceeds the NIOSH back compression action limit of 3400 N which may expose some employees to an increased risk of low back injury. It is therefore recommended that this activity be modified to reduce the low back compression forces.

The NIOSH low back compression action limit of 3400 N was exceeded when lifting any of the loads onto the lower rack of the display stand. This identifies that lifting heavy loads onto lower levels places an increased amount of stress on the lower back. Therefore this task should be modified to minimise the risk of low back injury, for example by using mechanical handling aids, or storing heavy rolls in the middle racks. Further analysis showed that to remain beneath the 3400 N action limit during a two-person team lift onto the bottom rack the roll should weigh no more than 65 kg (e.g. 32.5 kg per person).

However, the stated low back compression forces are likely to increase by 1.2 to 3 times (Lindbeck, 1995) as this is a dynamic lifting activity. Therefore, caution is advised when interpreting these results. Handling rolls of 80 kg even onto the middle rack may in fact exceed the NIOSH action limit of 3400 N (indicated by red colouring) and if the three times rule is applied the estimated compression force is 5661 N. This factor is particularly important when lifting rolls onto the lower racks as the estimated compression forces already exceed the NIOSH action limit. Forces in excess of the NIOSH design limit of 6400 N are indicated by the purple colouring in Table 4 and indicates that the majority of the working population would be at risk of sustaining a low back injury and therefore redesigning the tasks is urgently required.

Table 4. Estimated low back compression forces when lifting 80 kg, 100 kg, or 150 kg vinyl rolls onto the middle, top, or bottom rack of the display stand, the areas at most risk of injury and the estimated increase due to fast movement.

Carpet roll weights (kg)		Estimated low back compression forces (N)		
Roll weight handled by one person	**Total roll weight**	**Middle rack**	**Top rack**	**Bottom rack**
		Estimated increase: 1.2 – 3 times	**Estimated increase: 1.2 – 3 times**	**Estimated increase: 1.2 – 3 times**
40	80	1887	2111	3718
		(2264–5661)	(2533–6333)	(4461–11154)
50	100	2244	2479	4506
		(2693–6732)	(2975–7437)	(5407-13518)
75	150	3134	3412	6018
		(3760-9402)	(4094–10236)	(7221-18054)
Areas at most risk of injury		Elbow, torso, shoulder	Torso, elbow, shoulder	Torso, hip, knee, shoulder, elbow

3.5.3 Summary

This activity represents a high level of risk of injury to employees due to the heavy loads being handled and the awkward and stooped postures individuals have to adopt; this is despite the fact that this is a team handling activity. A MAC assessment was not completed for this activity as the key risk factors will be virtually the same as when lifting a carpet roll when changing the display rack, as shown in Table 7 in the Appendix.

3.5.4 Recommendations for risk reduction

- This task needs to be redesigned to eliminate the need for employees to handle these loads, as the weight of the product cannot be altered unless the length of rolls is reduced.

- Companies should consider some form of mechanised system such as a paternoster / carousel or mobile lifting device. They should also consider if a similar work method could be used as when changing carpet rolls (e.g. winding on a new roll from a manipulator).

- If the vinyl rolls are being lifted from a low level trolley or carpet buggy then this will require employees to adopt awkward, stooped postures. Therefore, improving the trolley / buggy design by raising the height at which loads are lifted from them is important in order to minimise the amount of forward stooping. Alternatively, hooking suitable long handles into the roll ends could help employees to maintain a more upright posture when handling rolls at a low level (Figure 25).

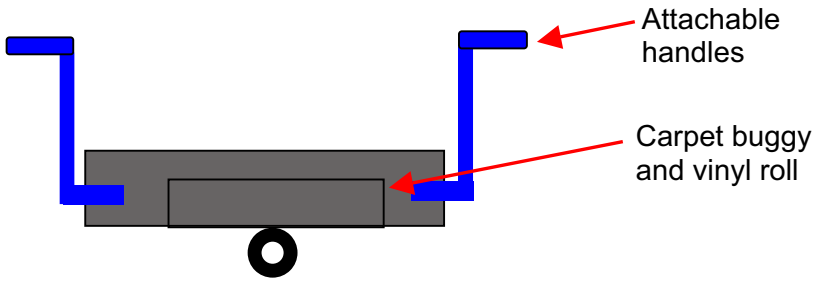

Figure 25. Example of handles that could be used to lift vinyl rolls from the carpet buggy on to lower racks.

3.6 HANDLING OF ROLL ENDS / REMNANTS

3.6.1 Task

It was reported that once there is less than approximately 6 metres left on a roll, it can become classed as a remnant. The carpet remnant will be removed from the display rack, which involves two employees lifting it off and lowering it to the ground. This may require employees to lift from above head height and to stoop down to below knee height. The metal bar is removed from the carpet roll when on the floor. The roll is then taped secure before being handled further. The process of raising the roll remnant and moving it to the remnant display is shown in Figure 26 where one employee lifts one end to above their head and then 'walks' their hands down the roll until it is in an upright position. The roll will then be lifted, carried and placed vertically in the display. This involves 'hugging' the carpet and supporting it between

the shoulder and the neck. Placing the roll into the display involves holding the roll with the arms held away from the body.

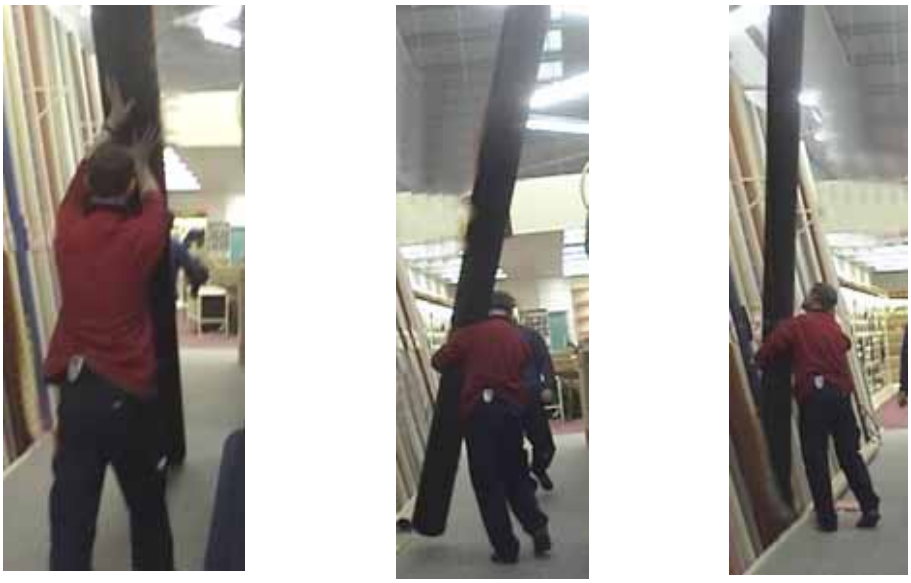

Figure 26. Typical method for handling roll ends / remnants.

3.6.2 Load

The carpet roll weights will vary depending on the length of carpet that is being handled and the type of pile that is used. It is possible that remnants could weigh up to 67 kg (refer to Table 1), however, it is likely that most would weigh less than this (estimated 20 kg); the weights of the carpets are not labelled. The Jack ergonomics CAD system was used to look at low back compression force when performing the initial lift off the ground and when standing and walking the hands along the carpet roll into an upright position, for a 50th percentile male (Figure 27).

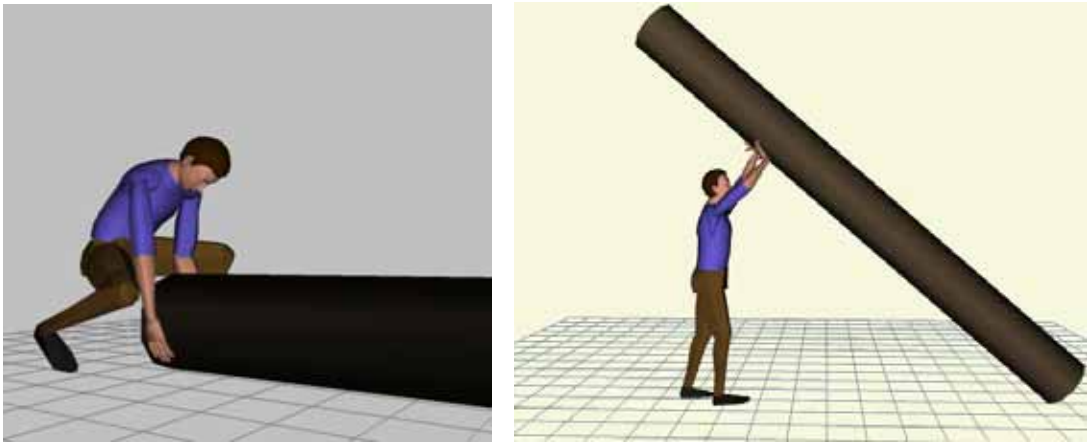

Figure 27. Typical postures adopted when lifting a roll end / remnant and 'walking' it into an upright position.

The estimated low back compression forces are illustrated in Table 5 and were calculated for a 30 kg and 40 kg roll weight. During the initial lift the load lifted by the individual was estimated to be half the total roll weight. When the individual was 'walking' their hands down the roll into an upright position the load was estimated to be two thirds of the roll weight (e.g.

20 kg and 26.6 kg, for a 30 kg and 40 kg roll respectively). These loads were divided by two and were entered into each of the hands (e.g. 10 kg and 13.3 kg).

It can be seen that these activities fall below the NIOSH action limit of 3400 N, however, when increased by a factor of 1.2 to 3 times as suggested by Lindbeck (1995) for dynamic activities the low back compression force at the beginning of the lift exceeds the NIOSH design limit of 6400 N (indicated by the purple colouring), and suggests that this activity is altered immediately. In addition, a squat posture was used for this analysis, had a stooped posture been adopted the low back compression forces would have been greater than those reported in Table 5. When 'walking' the roll into an upright position the low back compression forces were well below the NIOSH action limit of 3400 N and were not multiplied by 1.2 or 3, as this is not a dynamic activity at the back.

Table 5. Estimated low back compression forces and areas at most risk of sustaining an injury when handling remnants weighing 30 kg or 40 kg, during the initial lift and when walking the roll into an upright position, and the estimated increase due to fast movement during the initial lift.

Carpet roll weights (kg)		Estimated low back compression (LBC) forces (N)	
Roll weight handled	Total roll weight	Initial lift off the ground (Estimated increase: 1.2 – 3 times)	Walking into upright position
15	30	2150 (2580 – 6450)	1663
20	40	2412 (2894 – 7236)	1978
Areas at most risk of injury		Knees, torso, hips	Torso, shoulders, knees

3.6.3 Summary

This task represents a medium to high level of risk of injury depending on the weight of the roll being handled. The carpet rolls are large and awkward to handle and employees have to work in postures that involve stooping to ground level at the beginning of the lift, working with the arms above the head, and lifting with the arms held away from the body. The MAC assessment for this activity is located in Table 7 of the Appendix.

3.6.4 Recommendations for risk reduction

- It is possible to give a 'best estimate' of the weight of individual rolls as the length remaining on the roll should be known and the pile weight should also be known. Therefore the rolls can be labelled which will inform both employees and customers of the roll weight.

- The area where the roll is being prepared prior to the lift should be cleared of any obstructions to allow sufficient room for the individual performing the task.

- Sufficient and practical manual handling training should be given to all employees who have to perform this task and it should be specific to this activity.

3.7 HANGING RUGS

3.7.1 Task

Rugs are awkward to handle, even when rolled up and must be carried up a ladder. This will make it even more difficult to handle, as one hand should be in contact with the stepladder when climbing. This will also constrain the working postures, and employees will have to bend forward slightly whilst reaching with the arms outstretched holding the rug when trying to clip it into the display (Figure 28). A pinch grip is used to hold onto the rug and this type of grip can require a significant amount of hand force, and the rug is also liable to slip. This task is not considered to be repetitive with only a couple of rugs being replaced on a weekly basis. This activity also exposes employees to a fall from height risk.

Figure 28. Example of a method of displaying rugs and access to them.

3.7.2 Load

A 'standard' large rug weighs approximately 28 kg, however, this is dependent on the type of pile used. This is usually a two-person lift and therefore the weight of the load is shared by the two employees. This activity places employees at an increased risk of musculoskeletal injury when climbing the ladder holding the rug whilst trying to maintain their balance. In addition clipping the rug into the metal bar is done with the arm extended away from the body, therefore placing considerable strain on the shoulder and additional strain on the low back. HSE guidance risk assessment filter value (Manual Handling Operations Regulations 1992, L23), on handling loads with the arms outstretched at shoulder height is 5 kg for men when there is a good grip on the load and when working from a stable platform. This figure is for a repeatable operation however (e.g. one lift every two minutes), above this guideline figure a detailed risk assessment should be performed.

3.7.3 Summary

This task represents a moderate to high level of risk of musculoskeletal injury to employees. This is principally due to the weight of the loads being handled and the restricted postures that

employees operate in with the body flexed forward slightly and the arms outstretched away from the body. These are known risk factors in the development of musculoskeletal injuries. Working on a stepladder adds to the risk by constrained posture and foot positioning and increasing the need for careful balance as well as introducing a significant fall from height risk. The MAC assessment for this activity is located in Table 7 of the Appendix.

3.7.4 Recommendations for risk reduction

- Alternative means of hanging the rugs should be considered. For example a simple pulley system or winch, would allow the rug to be hung whilst standing on the ground. This would eliminate the need for employees to carry the rug whilst climbing the ladder.

- Other means of working at height could be considered, such as elevated work platforms (e.g. a mini cherry picker, or work assist vehicle - WAV).

- In the short term, more stable stepladders should also be considered, for example, mobile safety steps that have a stable platform and guardrails.

- A review of working practices should be performed and detailed risk assessments for this activity need to be undertaken.

3.8 SUMMARY OF RISK FACTORS

All of the carpet, underlay, vinyl flooring and rug handling tasks identified can present a high or very high level of risk of musculoskeletal injury to employees that could be reasonably reduced. The most significant physical risk factors in all of the tasks are:

- The weight of the loads handled;

- The awkward postures adopted; and

- The frequency of handling.

However companies need to also consider psychosocial risk factors that include aspects of the work design such as:

- How much control employees have over their jobs;

- How much support from employees get from work colleagues and supervisors;

- Intensified workload; and

- Monotonous work.

MSDs are multifactorial in origin and it is thought that both physical and psychosocial risk factors work together to increase the risk of MSDs (Op De Beeck and Hermans, 2000). Therefore it is important that employers consider their current operational practices and all the risk factors that are present within their companies and the influence these may have on their employees.

4 DISCUSSION

All of the tasks described require the employees to handle heavy and awkward loads, often adopting awkward postures. It would be impossible and unnecessary to eliminate all manual handling activities involved in this industry and due to the nature of the product the ability to reduce the weight is restricted. One approach could be to put less carpet on individual rolls if the product is known to weigh more (e.g. kg / m^2). However, companies should be doing more to protect their employees from the risk of musculoskeletal injury. "*Because its always been done this way*" is not a sufficient reason that the industry should continue to operate in the manner that it is. Modern technology can assist in the developing of new handling aids and display racks that may help to reduce the need for individuals to handle products and lower the risk of developing musculoskeletal injuries. For example the industry should be researching the use of paternosters or carousels and mobile lifting aids, hoists or winches, and how these may help their business whilst minimise manual handling for their employees.

The MAC suggests that 2-person team lifting of carpet rolls greater than 85 kg is a very high risk task, independent of the handling frequency. The industry needs to undertake an assessment of their current work practices and develop methods of adapting them to minimise the risk of injury to their employees. The biomechanical modelling assessing the low back compression forces shows that stooped postures result in greater compression forces, such as when using the manipulator and lifting roll ends, than postures where the spine is maintained in a more neutral, upright position.

Underestimations of the low back compression forces are likely to have occurred as the biomechanical model is based on static or very slow and controlled movements. Therefore the compression forces obtained for the lifting activities should act as a guide only to demonstrate the postures and activities where individuals will be exposed to a greater risk of lower back injury. It is possible that these figures could be 1.2 to 3 times greater when considering dynamic activities, such as lifting carpet rolls, as outlined by Lindbeck (1995). In addition, forces were likely to be greater than reported, particularly when 'climbing' the racking whilst holding onto the carpet roll. When performing this activity the individual will have unsure footing and will be likely to be working in an awkward posture.

In the short-term it is recommended that employees follow the outlined method of changing the display racks by winding on a new carpet roll from the manipulator onto the required display rack, rather than lifting it directly into the display rack. Suitable equipment such as mobile safety steps, mobile hoists or winches, or other handling aids could be investigated and trialled to determine if they are effective and reduce the amount of lifting employees have to undertake. In the longer term, the industry as a whole needs to review their current work practices involving the manual handling of carpet rolls and underlay from delivery to when the product leaves their premises. Research and trialling of manual handling aids such as mobile hoists and winches and alternative display systems such as paternoster or carousel style display racks need to be undertaken to determine the long-term benefits. This is likely to result in becoming more efficient at handling products whilst experiencing fewer injuries as a result of manual handling. Not only might this benefit carpet retailers, it will also benefit and reduce the risk of musculoskeletal injury of their employees.

5 RECOMMENDATIONS

Specific task recommendations have been provided in the previous sections. Below are general recommendations the industry should consider:

1) Reducing the amount of product on carpet rolls for the products that have a high kg / m^2 ratio, will help to lower the weights of individual rolls. Alternatively making the rolls a standard length so that they weigh more and therefore cannot be manually handled.

2) Communication with suppliers should occur to ensure deliveries of items require a minimum of manual handling. For example: 1) delivery vehicles with lift trucks and booms; 2) underlay delivered palletised.

3) Clear labelling of individual product weights, and of some kind of colour coding system representing the weight range of the product.

4) Assessing and re-organising storerooms to ensure adequate access to all products, and to eliminate unnecessary handling. In addition, double-handling of products within the store should be avoided. For example, once a product is being displayed on a rack it should be left there until it becomes a remnant.

5) Long-term commitment by the industry to investigate alternative display methods. For example mechanised equipment (paternoster / carousel), or mobile hoists, winches and pulley systems.

6) Sufficient and suitable manual handling training for all employees. Training should be practical and specific to the tasks that employees perform. A general manual handling training course or computer-based course is not likely to be sufficient.

7) Store managers should be provided with suitable training, to ensure they are competent in dealing with health and safety matters. They should also have access to ongoing support from health and safety advisors at the company head office.

8) Communication with shop designers and higher management who are responsible for shop layout should occur to ensure they are aware of the issues of safe access to display stands from a safe manual handling perspective.

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7 APPENDICES

7.1 MANUAL HANDLING ASSESSMENT CHARTS

The Manual Handling Assessment Charts (MAC) were used to illustrate the current level of musculoskeletal injury risk employees who perform the following manual handling operations are exposed to. These assessments are presented in Table 6 and 7.

7.1.1 Table 6

The assessments presented in Table 6 refer to manual handling activities that occur within the warehouse.

1) **Team lift during manual vehicle unloading:** This assessment is based on two individuals performing a lift when manually unloading a vehicle and placing them into warehouse storage racking. For the purposes of the assessment a load of 50 kg was assumed. Figures 6 and 7 demonstrate the typical postures observed when undertaking this activity.

2) **Carrying of carpet rolls when manually unloading a vehicle:** Once carpet rolls have been lifted out of the back of the lorry they are then carried into the warehouse and stored on the shelving units. Depending on the weight of the carpet roll will influence if one or two individuals are required. For the purposes of the assessment a load of 50 kg was assumed. Typical postures observed are shown in Figures 6 and 7.

3) **Handling underlay:** Although this task was not observed the assessments are based on the typical locations of the underlay within the warehouse and the height at which they are stored. For the purposes of the assessment a load of 35 kg was assumed. Figure 12 shows typical storage of underlay.

Table 6 shows there are a lot of high risk factors when carpet rolls are manually unloaded from a vehicle. These risk factors could reasonably be reduced by using mechanical handling aids such as forklift trucks with booms and buggies.

Table 6. MAC assessments for manual handling operations that occur within the warehouse.

Risk Factors	Manual handling activities occurring in the warehouse.		
	1. Team lift during vehicle unloading. (50 kg carpet roll)	**2. Carrying carpet rolls during vehicle unloading. (50 kg carpet roll)**	**3. Individual lift of underlay rolls. (35 kg)**
Load weight	A load of 50 kg lifted between two people represents a high risk.	If a 50 kg carpet roll is carried by two people they are both carrying approximately half the load (e.g. 25 kg). Therefore this task would represent a moderate level of risk to employees.	For an individual to lift a roll of underlay weighing 35 kg represents a moderate level of risk of sustaining a musculoskeletal disorder.
Hand distance from lower back	The upper arms are likely to be angled away from the body and the trunk bent forward, representing a moderate to high level of MSD risk.	A moderate level of risk is likely to be present when carrying carpet rolls on the shoulder whereby the hand is held away from the body.	This activity is likely to represent a moderate to high level of risk depending on how far the hands are from the lower back and the amount of forward bending.
Vertical lift region	The carpet rolls may be lifted from above head height and may be stored below knee height, representing high risk of low back injury.	Not applicable	This is likely to represent a high level or injury risk as underlay is stored on a pallet therefore rolls will be lowered to approximately ground level.

Table 6 continued. MAC assessments for manual handling operations that occur within the warehouse.

Risk Factors	Manual handling activities occurring in the warehouse.		
	1. Team lift during vehicle unloading. (50 kg carpet roll)	**2. Carrying carpet rolls during vehicle unloading. (50 kg carpet roll)**	**3. Individual lift of underlay rolls. (35 kg)**
Trunk twisting / sideways bending	There is definitely forward bending of the trunk and likely to be spine twisting also, representing a moderate to high level of risk.	**Asymmetrical trunk / load:** Supporting carpet rolls on one shoulder represents a high level of risk due to the sideways bending from handling loads on one side of the body.	Due to the location of the stored underlay it is very likely there will be both trunk twisting and sideways bending resulting in a high level of risk.
Postural constraints	The space employees have to operate in may be constrained, particularly in small warehouses when rolls are being placed into shelving units.	The posture is restricted by carrying the carpet roll on one shoulder causing sideways bending of the truck, representing a moderate level of MSD risk.	The posture will be restricted as access to the underlay is typically from one side only, representing a moderate level of risk.
Grip on the load	The grip is typically poor as the rolls are covered in plastic it is often the plastic that is grasped, representing a moderate to high level of risk.	The grip is typically poor as the rolls are covered in plastic it is often the plastic that is grasped, representing a moderate to high level of risk.	The grip is likely to be poor representing a high level of risk as the underlay is covered in plastic, and the objects are bulky and are not rigid.

Table 6 continued. MAC assessments for manual handling operations that occur within the warehouse.

Risk Factors	Manual handling activities occurring in the warehouse.		
	1. Team lift during vehicle unloading. (50 kg carpet roll)	**2. Carrying carpet rolls during vehicle unloading. (50 kg carpet roll)**	**3. Individual lift of underlay rolls. (35 kg)**
Floor surface	The floor surfaces could vary, from outside on the loading bays to inside the warehouse. Therefore a low to high level of risk may be associated with this risk factor.		
Other environmental factors	A high level of risk is scored when manually unloading the vehicles as employees may be working outside and therefore exposed to extremes of temperature and strong air movements and electrical storms.		
Communication, co-ordination and control	The level of risk will be dependent on the level of communication, co-ordination and control employees have. Typically employees operate in pairs and will be familiar with working together. Therefore the risk could vary from low to high depending on the circumstances.	**Carry Distance:** Typically the carpet rolls are carried between 4 metres to 10 metres thereby representing a moderate level of risk.	Not applicable
Obstacles en route:	Not applicable	This could vary from a low to a moderate level of risk depending on where the carpet rolls are taken and if there are other objects in their path.	Not applicable

Table 6 continued. MAC assessments for manual handling operations that occur within the warehouse.

	Manual handling activities occurring in the warehouse.		
	1. Team lift during vehicle unloading. (50 kg carpet roll)	**2. Carrying carpet rolls during vehicle unloading. (50 kg carpet roll)**	**3. Individual lift of underlay rolls. (35 kg)**
Summary of key risk factors	1) The key risk factors are the weight of the load, the vertical lift region, and environmental factors. 2) Moderate risk factors include: hand distance from the lower back, trunk twisting and sideways bending, postural constraints and the grip on the load. 3) The condition of the floor and the level of communication and control will alter depending on specific conditions.	1) The high risk factors are the asymmetrical trunk load and environmental factors. 2) The moderate risk factors were identified as the weight of the load, the hand distance from the lower back, postural constraints, grip on the load and the carry distance. 3) The risk factors associated with the floor conditions and any obstacles encountered will vary depending on specific conditions.	1) The high risk factors for this activity include the vertical lift region, trunk twisting and sideways bending, the grip on the load, and environmental factors. 2) The moderate risk factors identified were the load, the hand distance from the lower back and postural constraints. 3) The level of risk will vary depending on the floor conditions employees are working in.

Table 6 continued. MAC assessments for manual handling operations that occur within the warehouse.

	Manual handling activities occurring in the warehouse.		
	1. Team lift during vehicle unloading. (50 kg carpet roll)	**2. Carrying carpet rolls during vehicle unloading. (50 kg carpet roll)**	**3. Individual lift of underlay rolls. (35 kg)**
Recommendations	The focus should initially be on reducing the high risk factors. E.g. Rolls will weigh less if less carpet is placed on them. Using handling aids such as forklift trucks with booms and buggies to unload vehicles will reduce the amount of manual handling and thereby the level of risk employees are exposed to. All employees should receive training on how to use the equipment and also receive specific manual handling training.	The focus should be on reducing the high risk factors followed by the moderate risk factors. If mechanical aids such as forklift trucks with booms and buggies were used then carpet rolls would not need to be carried and could be pushed instead, which would help to reduce the overall level of musculoskeletal risk employees are exposed to. All employees should receive training on how to use the equipment and also receive specific manual handling training.	The focus should initially be on reducing the high risk factors followed by those scored as having a moderate level of risk. For example having deliveries of underlay arrive on pallets whereby a hand pallet truck or forklift truck can transport them to where they are required in the warehouse. Ensuring the underlay is easily accessible in the warehouse will also help to reduce the level of risk and using trolleys or carpet buggies for individual rolls would also be beneficial in reducing the risk. Specific manual handling training should also be provided.

7.1.2 Table 7

The assessments presented in Table 7 refer to manual handling activities that occur within the store.

1) **Two-person team lift of the 20 kg bar into the top rack:** This activity would occur if employees were following the 'correct' method when changing a carpet roll on the display rack. The assessment assumes that the employees are lifting the display bar into the top rack whilst standing on the ground (Figure 13 and 15).

2) **Two-person team lift of an 80 kg carpet roll (including display bar) into the top rack when standing on the ground:** This assessment is based on postures observed in Figure 13 and 15.

3) **Two-person team lift of a 80 kg carpet roll (including display bar) into the top rack when standing on the racking:** This assessment is based on postures shown in Figures 16 and 17 when an individual may have to 'climb' the display racking in order to reach the top rack.

4) **Two-person team lift of a 80 kg carpet roll (including display bar) into the top rack when standing on mobile safety steps:** This assessment was based on postures shown in Figure 18.

5) **An individual lifting a remnant from the ground:** This assessment was based on postures shown in Figures 26 and 27 for a roll end / remnant weighing 25 kg.

6) **Two-person team lift of a 25 kg rug from a stepladder:** This assessment was based on postures shown in Figure 28.

Table 7 clearly shows that the risk factors are much lower when lifting the 20 kg display bar into the racking when using the 'correct' or standard method for changing a carpet roll on a display rack as outlined in Section 3.4.1; compared to the other methods such as lifting a full carpet roll onto the racking when standing on the ground, when standing on the racking, and when standing on stairs.

Even if mechanical devices and handling aids and are introduced there is likely to be some amount of manual handling that is still required for many of the activities that were observed during this study. Therefore, it is also important that all employees receive specific manual handling training so they are able to handle products as safely as possible.

Table 7. MAC assessments for lifting activities that occur within a store.

Risk Factors	Manual handling activities occurring within the store.					
	1. Team lift of 20kg display bar.	**2. 80kg carpet roll: standing on the ground.**	**3. 80kg carpet roll standing on racking.**	**4. 80kg carpet roll standing on steps.**	**5. Individual remnant lift (25kg).**	**6. 25kg team lift of a rug up a stepladder.**
Load weight	20 kg load lifted between two people represents a low level of risk.	80 kg load lifted between two people represents a high level of risk.	80 kg load lifted between two people represents a high level of risk.	High level of risk as load is lifted in a two-person team.	Moderate level of risk due to weight of the load handled.	25 kg load between two people represents a low level of risk.
Hand distance from lower back	Arms might be extended horizontally away from the individual's centre of gravity, resulting in a moderate level of risk.	Likely to be a moderate level of risk with the arms extended away from the lower back.	When placing into the racking the arms will be extended away from the body, representing a high risk of injury.	Likely to be a moderate level of risk as hands will be some distance from the individual's centre of gravity.	Probably represents a moderate level of risk unless the individual gets very close to the roll.	High level of risk as arms hold the rug extended away from the body.
Vertical lift region	Moderate to high risk as the load is lifted from just above the ground to above head height. This may depend on the roll diameter and whether the grip is on the spindle or on the 'wheel'.				High risk as individuals lift from the ground.	Moderate to high level of risk depending at what height the initial lift occurs at.

Table 7 continued. MAC assessments for lifting activities that occur within a store.

Risk Factors	Manual handling activities occurring within the store.					
	1. Team lift of 20kg display bar.	**2. 80kg carpet roll: standing on the ground.**	**3. 80kg carpet roll standing on racking.**	**4. 80kg carpet roll standing on steps.**	**5. Individual remnant lift (25kg).**	**6. 25kg team lift of a rug up a stepladder.**
Trunk twisting / sideways bending	Likely to be some trunk twisting and sideways bending representing a moderate to high level of risk.	Possible that there may be both trunk twisting and sideways bending at the start of the lift resulting in a moderate to high level of risk.	High level of risk as significant trunk twisting and probable sideways bending when lifting into racking position.	Possible that there may be both trunk twisting and sideways bending at the start of the lift resulting in a moderate to high level of risk.	Possible that there may be both trunk twisting and sideways bending at the start of the lift resulting in a moderate to high level of risk.	Moderate to high level of risk depending on how far individuals have to reach at the end of the lift.
Postural constraints	Moderate level of risk, constrained by the bar lifted and where it has to be positioned.	Moderate level of risk, constrained by the carpet roll and where it has to be positioned.	High level of risk due to highly constrained posture from handling roll and balancing on racking.	High level of risk due to postural constraints when climbing the stairs and handling the roll.	Moderate level of risk as the individual may be operating in a confined space.	High level of risk due to lifting the load up a ladder.
Grip on the load	Moderate level of risk as using the 'wheel' provides a reasonable grip.				Moderate to high level of risk as there are no handholds on the roll.	High level of risk, due to the downward pinch grip on the rug.

Table 7 continued. MAC assessments for lifting activities that occur within a store.

Risk Factors	Manual handling activities occurring within the store.					
	1. Team lift of 20kg display bar.	**2. 80kg carpet roll: standing on the ground.**	**3. 80kg carpet roll standing on racking.**	**4. 80kg carpet roll standing on steps.**	**5. Individual remnant lift (25kg).**	**6. 25kg team lift of a rug up a stepladder.**
Floor surface	The floor surface was typically observed to be in good condition, representing a low level of risk.		Standing on the racking represents a high level of risk, as there is no proper footing when standing on the display rack.	If stairs and the top platform are in good condition they should represent a low level of risk.	Typically in good condition representing a low level of risk.	Depending on the material used on the rungs will influence the level of risk; low to moderate.
Other environmen-tal factors	These handling operations occur within the store therefore employees should not be exposed to extremes of temperature or strong gusts of wind and work in well lit environments.					
Communica-tion, co-ordination and control	Depending on the level of communication, co-ordination, and control of the lift, these handling tasks will vary from low to high risk.		Likely to represent a moderate to high level of risk due to lack of stability and control when standing on the racking.	Likely to represent a moderate to high level of risk as controlling and coordinating the lift when climbing the stairs is likely to be difficult.	Not applicable	The level of risk will vary from a low level to a high level depending on the level of communication, co-ordination, and control when climbing the stepladder.

Table 7 continued. MAC assessments for lifting activities that occur within a store.

	Manual handling activities occurring within the store.					
	1. Team lift of 20kg display bar.	**2. 80kg carpet roll: standing on the ground.**	**3. 80kg carpet roll standing on racking.**	**4. 80kg carpet roll standing on steps.**	**5. Individual remnant lift (25kg).**	**6. 25kg team lift of a rug up a stepladder.**
Summary of key risk factors.	1) The vertical lift region and trunk twisting and sideways bending are likely to represent the highest level of risk when lifting the display bar into position. 2) The horizontal hand distance, postural constraints and grip on the load all represent a moderate level of risk.	This practice should be avoided to minimise the risk of injury to employees. 1) The load weight and trunk twisting and sideways bending represent the highest levels of injury risk. 2) The vertical lift region, hand distance from the lower back, postural constraints and grip on the load all represent a moderate level of injury risk.	This practice should be avoided as it represents a very high risk of injury.	Lifting full carpet rolls up stairs to place them into the display rack should be avoided and the 'correct' roll changing practice should occur to minimise the risk of injury to employees. Key risk factors: load weight, postural constraints, hand distance from the lower back, the vertical lift region, trunk twisting and sideways bending, and the grip on the load.	1) The vertical lift region and trunk twisting and sideways bending represent a moderate to high risk of injury. 2) The weight of the roll, hand distance from the lower back, postural constraints and the grip on the load represent a moderate level of risk.	1) The hand distance from the lower back, vertical lift region, postural constraints and the grip on the load all represent a high level of risk. 2) Trunk twisting or sideways bending represents a moderate level of risk.

Table 7 continued. MAC assessments for lifting activities that occur within a store.

	Manual handling activities occurring within the store.					
	1. Team lift of 20kg display bar.	**2. 80kg carpet roll: standing on the ground.**	**3. 80kg carpet roll standing on racking.**	**4. 80kg carpet roll standing on steps.**	**5. Individual remnant lift (25kg).**	**6. 25kg team lift of a rug up a stepladder.**
Recomm-endations	The first priority should be to reduce the vertical lift region, e.g. avoid lifting loads from ground level. Focus should then be on methods to reduce the moderate risk factors. However, this method presents a lower level of risk compared to lifting a full carpet roll whilst standing on the ground, on racking, or lifting on stairs.	Following the 'correct' roll changing technique is the first priority. However, should this method be used the priority should be to determine if the weight of the load can be reduced. Further, lifting from the ground should be avoided to reduce the vertical lift region. Job specific manual handling training may also help to improve an individuals posture when lifting.	Following the 'correct' roll changing technique eliminates this handling operation, therefore dramatically reducing the risk of injury to employees.	If this practice does occur the key areas to focus on should be: 1) reduce the weight on the carpet rolls, 2) avoid lifting from the ground, 3) avoid / reduce trunk twisting and bending, 4) improve the grip on the load, and 5) provide job specific manual handling training to improve handling postures, communication, co-ordination and control.	Determine if there is another way of lifting the rolls into an upright position to avoid lifting from the ground e.g. mechanised hoist. Ensure there is enough space available to perform the lift as safely as possible and ensure employees have received specific work-related manual handling training.	The priority should be to reduce the high level risk factors. E.g. if a hoist / pulley system was used this would eliminate the need for employees to have to lift rugs up ladders and work in awkward postures.