legged supporting action will inevitably increase the risk although they were unable to quantify the extent of the increase.

*Bending of the wrist:* The wrists should be reasonably straight for the greater part of the work activity, and following are the preferred limits of deviation (bending) of the wrist that should occur in normal work:

> 15° flexion (bending towards the palm) or extension (bending away from the palm).> 15° flexion or 35° extension when gripping. > 15° radial deviation (bending the wrist towards the thumb side of the hand) or 20° ulnar deviation (bending the wrist towards the little finger side of the hand).

The hand movements are complex because of the nature of mail which varies in size, stiffness, surface friction, etc. The manipulations required to handle loose items of mail whilst not in an optimal work posture, i.e. while straddling the motorcycle, increase the difficulties of handling the mail.

Figure 8: Hand movements

*Carrying with one hand or on one side of the body:* This occurs when placing mail in letterboxes.

*Exerting force with one hand or on one side of the body:* Pushing mail into the residue mail compartment of the bag often requires a substantial one-handed push. Although the actual force may not be

great, it is done in an awkward posture (seated and while straddling the bike).

*Gripping with the fingers pinched together or held wide apart and using a finger grip, pinch grip, or an open handed grip to handle a load:* This is necessary when getting bundles from the panniers and bringing them to the front bag. All mail handling involves pinch gripping. It is often repetitive; it is sometimes forceful, although it is not often sustained. Forceful pinch gripping is a major cause of overuse injuries to the wrists.

*Exerting force while in an awkward posture including supporting items while arms or shoulders are in an awkward posture, and moving items while the legs are in an awkward position:* Although these are more often problems in heavier work, the constrained posture of a PDO on a motorcycle may induce some of the same conditions as a person performing heavier lifting but with freedom of work posture..

*The work environment or the way the work is organized*

*Hand-arm vibration:* No measurement of hand/arm vibration has been undertaken by AP but it is likely to be an issue with increased exposure to the bike.

*Whole body vibration:* The level of exposure to whole body vibration is not known as no measurement has ever been undertaken by AP. Significant exposure is probable, particularly on rounds where there is a high percentage of non-paved surfaces. The terrain may also be rough. Long tem consequences are possible.

*Wearing thick clothing that restricts movement while working in cold conditions, e.g. gloves:* This could be an aggravating factor for some PDOs.

High air temperatures are prevalent for sustained periods in summer, including southern Australia, and causes discomfort and fatigue. There would be concerns about the potential for heat stress on hard and long rounds. This is certainly an aggravating factor for all PDOs.

Radiant heat can be a hazard anywhere in Australia between October and April (varying with region). Risk as above.

*Wearing heavy protective clothing while working in hot conditions aggravates the effects of temperature and humidity:* The helmet (1.2 kg or 0.9 kg) is worn for the duration of the delivery time (except for breaks) and other protective clothing is worn (but as the PDO chooses, to some degree). The standard issue PPE will increase the effort required to complete the work could increase discomfort and fluid loss, and may lead to heat stress at some level of severity.

High humidity is frequently a problem in the summer period and particularly for sustained periods in northern Australia. Essentially it is a discomfort factor although high humidity does hinder

temperature reduction in the body because sweat is not so readily evaporated. Humidity will also be a significant fatigue factor. High humidity does reduce evaporative cooling and the potential for heat stress may be increased.

*Windy conditions combined with hot or cold weather:* This factor varies with the regions but may occur anywhere in the country. Cold winds may cause cooling of the hands and consequent reduction of dexterity. Hot winds may increase the potential for heat stress. Both cold and heat increase discomfort, and may increase fatigue and cause loss of alertness. Cross winds may destabilize riders and affect handling of mail.

*Wind chill caused by exposure to wind in low temperatures:* As noted above

*Limited opportunity for breaks:* A self-evident problem.

*No prescribed times for breaks:* As above.

# 5 Equipment issues

## 5.1 Introduction

To a large extent, the same issues with equipment were observed in this investigation as were observed in the earlier DDT work undertaken by two of the consultants involved in the current project. These are covered below, along with issues that result from the equipment changes as a result of the SBD equipment.

## 5.2 Anthropometric data

To inform our investigation of bike and FLC design, we collected anthropometric data about the participants in the trial. The participants were measured for the following:

| Body dimension | Relevance |
|---|---|
| Stature | The standard reference dimension for determining percentiles |
| Standing shoulder height | Pertinent to V-sorting frames. |
| Standing hip height | The measure of leg length. Used to determine fit to motorcycle (foot to ground capacity), and internal body proportions. |
| Shoulder to centre of grasp | Effective arm length. Has been used in a previous study to highlight the fact that many PDOs have trouble reaching back to the panniers. |
| Hand grasp maximum comfortable grip size | Provides an indication of each person's grip capacity without forcing or stretching. Important in work where grasping is a major work action. |
| Sitting eye height on the motorcycle | Important to locate the eye relative to the FLC to determine angles of sight lines.<br>Will also be pertinent when considering alternative designs for the FLC. |
| Eye position relative to seat on the motorcycle | As above for sitting eye height. |

### *5.2.1 Stature*

Because there is no adequate anthropometric data for the Australian population at large there is a tendency to use U.S. data as a substitute on the basis that both nationalities are mixes of many other racial and ethnic groups. This is not a fully satisfactory solution but is thought to work to a reasonable degree in practice.

There are various reference sources for anthropometric data and the following examples are typical.

Pheasant (1986) lists the following data:

| **US males 50th%ile stature** (unshod) | **US females 50th%ile stature** (unshod) |
|---|---|
| 175.5 cm | 162.5 cm |
| Add 2.5 cm for work boots and socks | Add 2.5 cm for work boots and socks |
| **= 178 cm** | **= 165 cm** |

Humanscale (1981) lists:

| **US males 50th%ile stature** (unshod) | **US females 50th%ile stature** (unshod) |
|---|---|
| 174.8 cm | 161.5 cm |
| Add 2.5 cm for work boots and socks | Add 2.5 cm for work boots and socks |
| **= 177.3 cm** | **= 164 cm** |

The anthropometric data recorded from the subjects in this trial is tabulated in appendix 3.

*NOTE: The expression %ile (percentile) refers to a one hundredth part of any sample of measurements taken from people. Thus 50th %ile means the 50th division (out of a hundred divisions of measurements) of a sample population.*

25 of the 40 recorded participants' were 50th %ile or less when referenced to Pheasant's figures.

All three of the females were above the 50th%ile, so 22 of the 37 males were 50th%ile or less, representing 59% of the sample. Thus this part of the sample tend to be shorter people overall.

The three tallest males were very tall. Pheasant lists 95th %ile US males as 187 cm, and if we add 2.5 cm for work boots, their stature would be 189.5 cm. Three of the male participants in the SBD trial were above this height.

These measurements should only be regarded as indicative of relative measures and not of great significance in themselves. They are helpful in determining the basis sizing of equipment but they do not preclude the necessity for conducting adequate user trials in the process of proving design ideas.

The lack of complete anthropometric data is also not of great concern and although the data used here will be indicative, factors such as secular trend (a term used to refer to the tendency of human populations to increase in size at various periods in their history) have been at work in recent generations. The general

sizing of the Australian populations will be increasing, particularly among the younger age groups, say those of 30 years of age, and younger.

### 5.2.2 Sitting height and position on the seat

Because of the lack of consistency between the anthropometric data for static body dimensions, and the on-motorcycle practices of the PDOs in respect of how they sit on the seat, this aspect of the work practices is not readily amenable to analysis. The PDOs sit in the position that makes them most comfortable and where they feel they have the best control of the motorcycle. The seat of this motorcycle is not adjustable so all of the PDOs are determining their sitting position by criteria that are individual and personal.

### 5.2.3 Head position and sight lines to the FLC

In respect of the sightlines to the FLC, the sitting position makes some difference to the angle of view.

The envelope that encompasses the extremes of the eye positions is 18 cm (vertically) by 22 cm (horizontally) as shown in Layout 1.

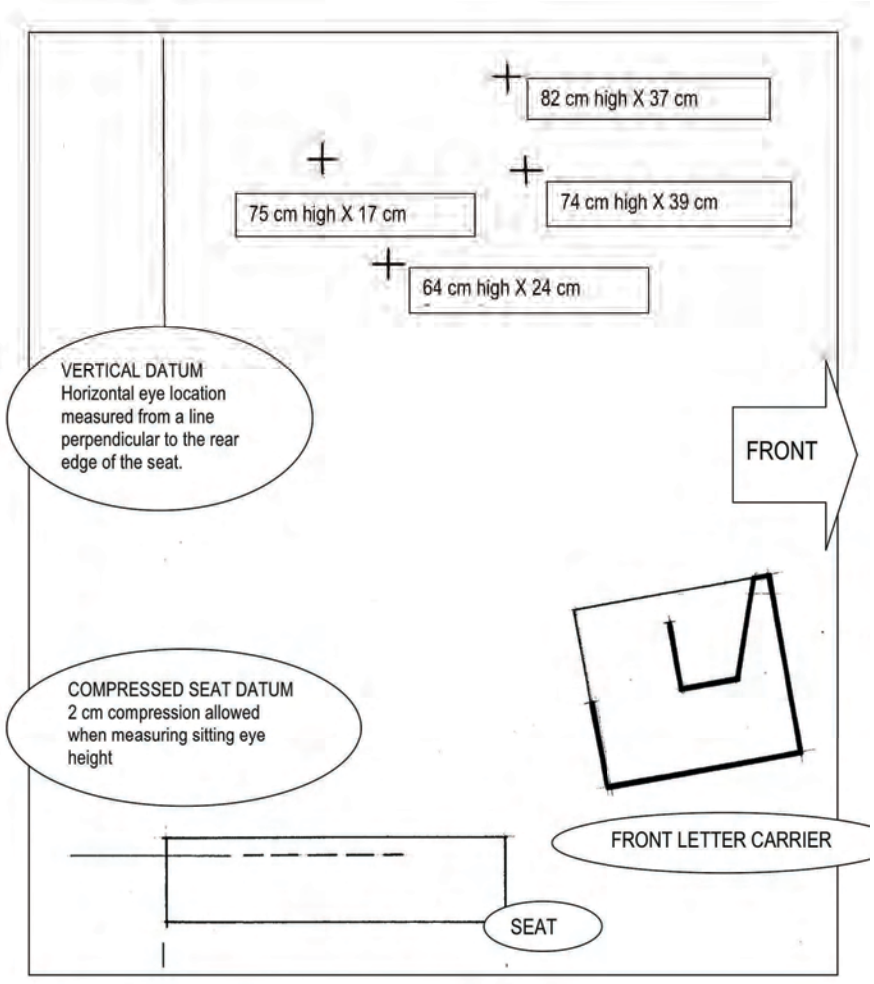



Figure 9: Layout 1. The four extreme measurements of eye position

Most of the participants were measured for eye position relative to the compressed seat and to the rear edge of the seat. The latter

measurement was chosen only because it was a constant reference point given that there is no horizontal adjustment in the seat on this motorcycle.

All participants were asked to position themselves on the seat where they would be when delivering (if this was different to riding). They were asked to look down into the FLC and hold the position while the measurements were recorded.

The four eye positions indicated are the highest, lowest, farthest rear and most forward recorded. All others fell within the area defined by these four.

In a discussion about the sources of postural stress in work, Pheasant notes that excessive forward inclination of the head and neck should be avoided. This is a well researched issue in relation to visual displays in screen-based work, but PDOs have two main visual displays – the addresses on the mail, and the pathway ahead of them. Looking ahead for riding is less of an issue as the line of sight is essentially a little below horizontal. Looking down to the mail in the FLC is clearly an issue as it was mentioned by many of the PDOs in this trial, and by analysis is a matter of concern. In this study we have not been able to establish the division of time between riding time (on the round) and reading time when stopped at a drop point but it is clearly a significant portion of the time. The preferred maximum angle of forward tilt of the head is 30° (both Pheasant and Humanscale assert this). Allowing for a comfortable downwards inclination of the eyes of 15° below the 30° of forward head tilt (neck flexion) and the final preferred maximum downwards angle of view is 45°. Layout 2 shows this. PDOs that sit further back and/or are shorter in the trunk are just able to sight the sequenced mail but are above the residue mail and can only sight that by increasing the angle of downward head tilt.

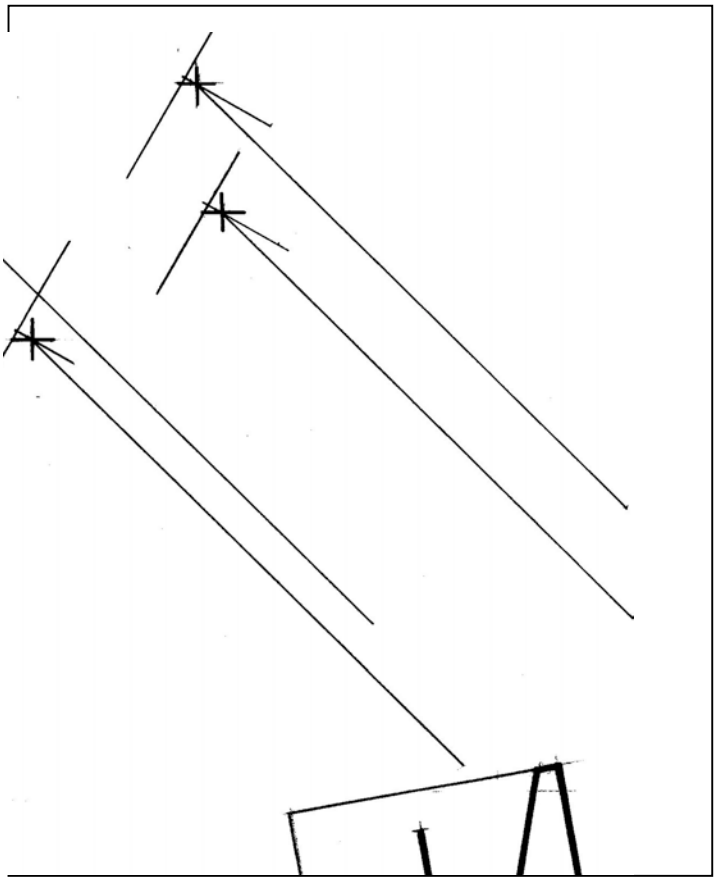


Figure 10: Layout 2. Sight lines when the head is tilted 30° & the line of vision is 15° down

The four eye positions are shown in Layout 2 with the head tilted 30° and the eyes looking 15° downwards.

This is regarded as the maximum downwards viewing angle for comfortable viewing (both Humanscale and Pheasant) and is the condition that should prevail for a task that is carried out repeatedly, which can be up to 1300 times on some rounds.

It is clear that the PDOs sitting further back and/or those shorter in sitting height can almost sight directly to the sequenced mail, but they are 15° above viewing the residue mail.

The taller and/or more forward sitters are 15-30° above the sequenced mail, and approximately 45°. Layout 2 shows this. PDOs that sit further back and/or are shorter in the trunk are just able to sight the sequenced mail but are above the residue mail and can only sight that by increasing the angle of downward head tilt.

This will clearly be fatiguing, uncomfortable, and potentially damaging to the cervical spine (neck) of PDOs.

Layout 3 shows the lines of sight when the head is inclined by 45°. Those who sit further back and/or have a lower eye height (sometimes achieved by slumping backwards, as observed and recounted by some PDOs in this study) can sight both the residue and sequenced mail quite readily, but the taller and/or more forward sitters are still above the sequenced mail and are far from sighting the residue mail.

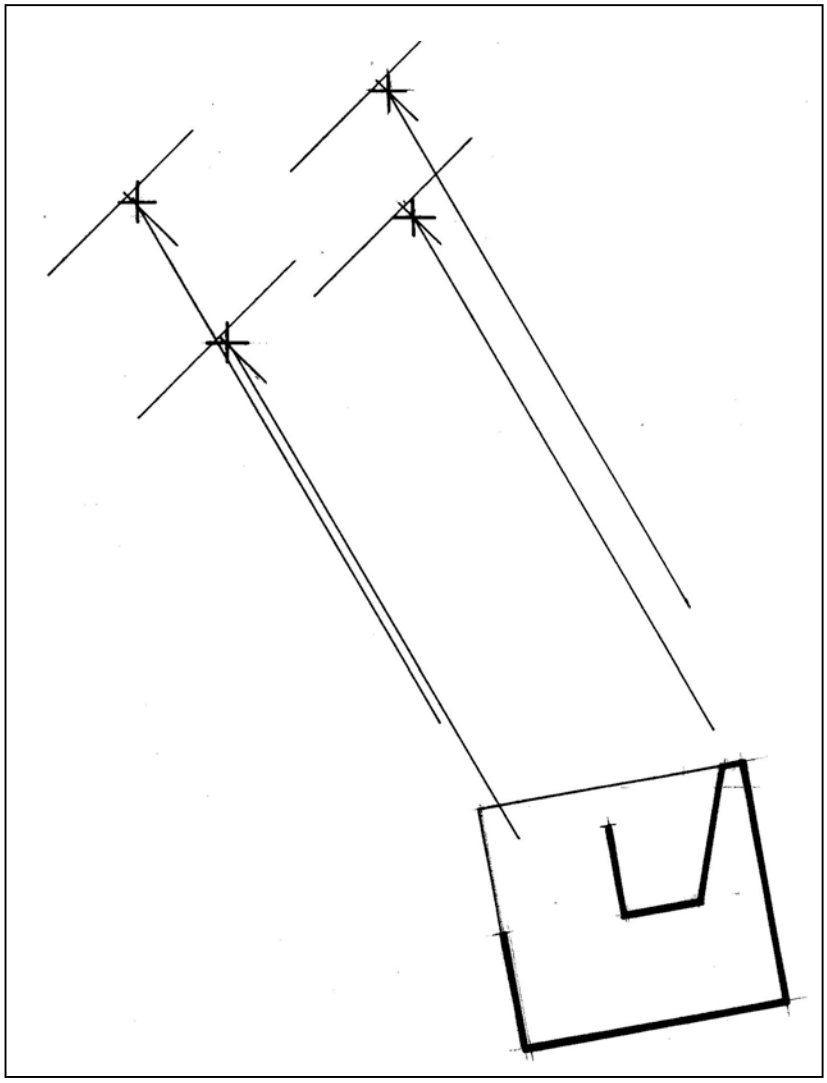


Figure 11: Layout 3. Sight lines when the head is tilted 45° & the line of vision is 15° down

45° of head tilt is still unacceptable given the number of times this occurs on a round, and the fact that the neck is supporting a helmet that weighs 1.5 kg.

For the trial sample group, the FLC is too low for comfortable viewing at the preferred angles. Having to repeatedly tilt the head forward more than the comfortable angle will be fatiguing, particularly while wearing a relatively heavy helmet.

Layout 4 shows the head inclined forward to 45° which is the maximum movement of the neck. This inclination allows all sitters to sight all the addresses but it will be at the potential cost of strain or injury to the neck.

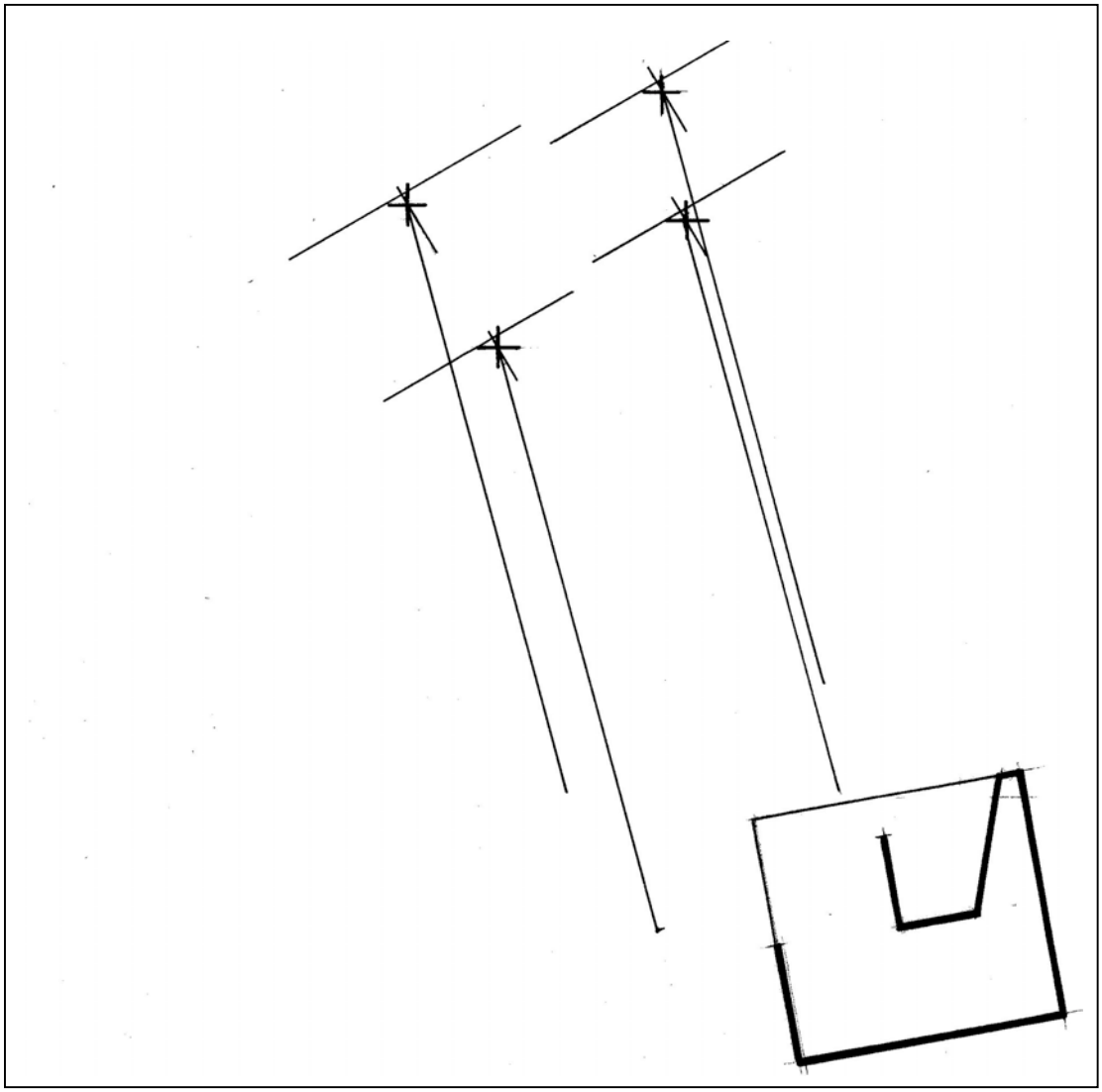


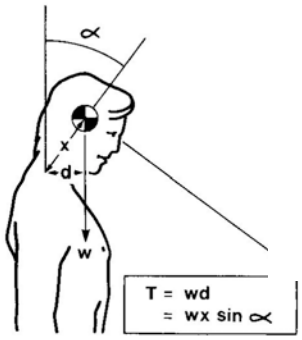
Figure 12: Layout 4. Sight lines when the head is tilted 60° & the line of vision is 15° down

Layout 4 shows the extreme eye positions for the sample of participants but with 60° of head tilt which is regarded as the maximum possible.

In this plot, taller PDOs and those who sit more forward on the seat may have to tilt their head to this angle to see the sequenced mail, but they do not quite see the residue mail.

Those PDOs who sit more forward and/or have a shorter sitting eye height will sight both types of mail at less than this maximal angle, but they are still well beyond the preferred angle of head tilt in order to do so. Those whose eye positions fit within the defined area are only marginally better placed to read the addresses of both the sequenced and residue mail.

The above analysis clearly indicates that the FLC is in the wrong position for comfortable sighting at acceptable angles of forwards head inclination. Essentially, the FLC is too low for the sequenced mail for all but a few sitters plotted in the layouts, and the residue mail in the RMC is never visible except at unacceptable angles of head movement.




Pheasant observed that once the line of sight is below that which is comfortably accommodated by the eyes.....' the head and neck are inclined forwards and the neck muscles come under tension to support the weight of the head' (p.158). This becomes a significant issue when the head is topped by a helmet and is then required to support this additional weight many times in a protracted spell of work with relatively few breaks.

*Above illustration from Pheasant 1986*

Fatigue in the neck muscles would be experienced as there would be concern for long-term consequences for the cervical spine (neck).

**The existing FLC both in its configuration and in its position on the motorcycle has to be considered a deficient design and it should not be used in this form.**

### *5.2.4 Hand grip size*

Appendix 3 (Table 2) shows the range of hand sizes for each of the participants whose anthropometric data has been listed. The data shows that slightly less than half of this particular sample has a natural, comfortable, maximum hand grip of 7 cm or less. The rest find 7 cm too wide a grip span for comfortable grasping, so they will either force their hands to grasp the 7 cm maximum bundle size for sequenced mail, or will make smaller bundles.

None of the sample has a grip size close to the 9 cm that represents the maximum bundle size for residue mail.

The significance of this, and as was in fact identified in the interviews, is that PDOs make up bundles to suit their own comfortable handling capacity, and the bundles are smaller than the 7 cm or 9 cm maximum thicknesses defined in the SOP for indoor work.

Accordingly,

a) there are more bundles for the same volume of mail, and

b) there is increased manual handling of bundles from the panniers to the FLC, and

c) there is an increase in the time required to complete rounds because of the higher frequency of bundle handling.

The conclusion to be drawn here is that the method of handling the mail is unacceptable for the frequency and difficulty of handling the bundles and this is made worse by the design and placement of the pannier bags.

We also note that the handling of mail bundles is made more difficult by the fact that he bundles are thickest in the middle and taper downwards at their ends. The hand must therefore grip a reverse taper which requires a much tighter gripping action with the potential for occupational overuse syndrome (OOS), also referred to as musculoskeletal disorder (MSD) in the National Code for manual handling.


Figure 13: Difficulties with grip size – note the white knuckle, suggesting extreme force.

Figure 14: Difficulties with bundle size

As the photographs above show, the bundles are usually held together by elastic bands, rather than the provided Velcro straps which many PDOs found to be annoying, particularly when trying to remove them from a bundle of residue mail that has been inserted in position under the sequenced mail pocket. There is little hand space to manoeuvre the strap and the hand actions are very awkward, especially for someone wearing gloves. Additionally, if the bundles are not tightly enough strapped, then the bundles fall apart when getting them from the panniers, that is the letters just slip out from under the Velcro strap.

## 5.3 Motorcycle

Anecdotally, this particular motorcycle only came to be used for postal work by chance, rather than through a process of purposeful product evaluation and selection. As noted earlier, the existing design problems with the motorcycle are exacerbated by SBD.

AP have erred in the SBD design process by assuming that the motorcycle is an unalterable design element. The current motorcycles have been used with only minor adaptation for many years and to some extent without any question as to their adequacy or appropriateness. As an example of this deficiency, the position of the speedometer has effectively locked the design of the bag into the space currently defined for it. In addition to the problems revealed by the preceding anthropometric analysis, figure 15 below shows how the current design of the FLC obscures the speedometer. The photograph was taken to show the sightline of one of the PDOs in the trial.

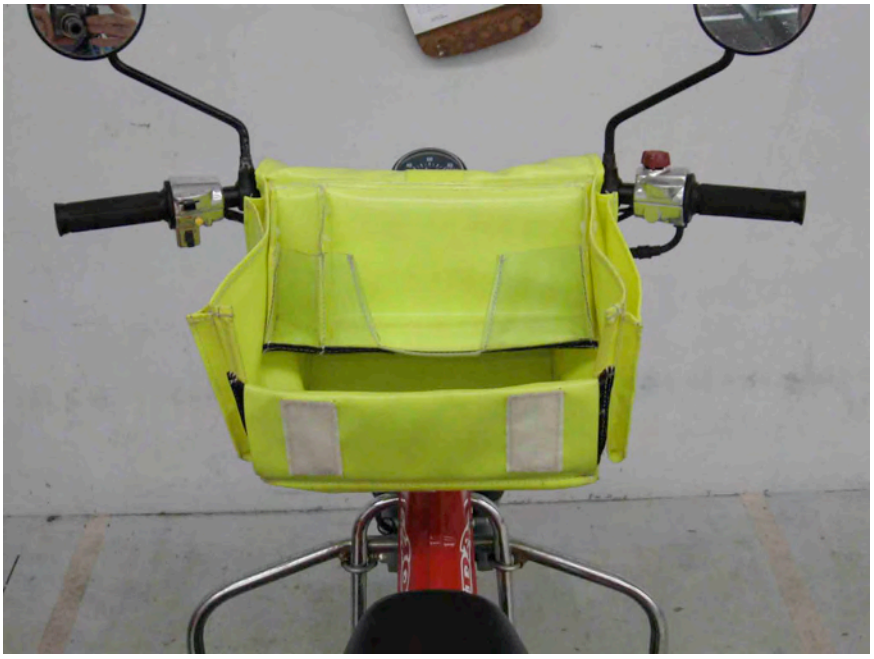


Figure 15: Visibility of speedometer with bag

## 5.4 Bag design

The design process in the SBD Trial has focussed on the development of the FLC rather than the FLC as just one

component within an entire work system. In developing the FLC (bag) for SBD, Australia Post had to find a way to keep sequenced mail and residue mail separate in line with its stated intention of keeping these types of mail apart at all stages of processing until the final delivery point.

Figure 16: Current FLC design

AP achieved this by adapting the design of the bag used for Single Bundle delivery with the addition of a separate pocket – the Sequenced Letter Insert (SLI) - for sequenced mail within the existing bag.

The decision to continue the use of an open topped fabric bag came about because the Single Bundle bag was believed to be popular with PDOs, and therefore was considered suitable for adaptation. This is another error in the design process.

Having placed the sequenced mail conveniently in front of the PDO, in roughly the same orientation as the mail in Single Bundle delivery, there was no other place to put residue mail except at the bottom of the bag. We surmise this because no alternatives were ever identified by AP during our discussions and it was evidently a perception, if not a rule, that the speedometer defined the maximum height for the top of the FLC, consistent with previous practice with the bag for Single Bundle delivery.

There have been numerous iterations of the design and many small changes, but the net result is that the FLC bag is still a major cause of dissatisfaction for PDOs. The problems are:

- The bag sits at an angle such that the addresses slope away from the line of sight of the PDO making it difficult to read addresses. This problems increases as the SLI empties and the letters fall forwards. Many PDOs complained about the angle of sight to the mail, and were conscious of the discomfort in their neck from having to sustain the weight of their head and the helmet for extended periods. We note that the latest iteration of the bag's evolution has attempted to reverse the slope of the bottom of the bag to improve the reading angle and prevent the smaller mail items slipping out of sight, but while the bag continues to be a flexible fabric construction that is not precisely located on the handlebars, this problem cannot be considered to have been resolved.

- The two bundles of mail are in different planes (vertical and horizontal). This is less an issue for reading (providing the addresses are visible) than for handling where the hands must routinely move between the diagonally opposite corners of the bag (front bottom and top rear), and take the mail in two different directions – sequenced mail is moved vertically and parallel to the PDO's body, but UMS is moved horizontally and towards the person. This is awkward and adds time to the task.

- The bag is too deep and rests on the legs of many PDOs. One or more of the trial PDOs (unofficially) raised the bag to overcome this but in so doing probably obscured their view to the speedometer. This is also a problem with the original bag, as was raised in the 2004 report by two of the present team on the DDT.

- The residue mail compartment (RMC) is too hard to fill with a new bundle of mail – the space is to tight; the Velcro strap is hard to remove; hands catch on the underside of the SLI, etc. The RMC was the most often mentioned problem with the bag.

- Residue mail does not stay in order and PDOs often find residue mail that should have been delivered to a house earlier in their round. They are instructed to return the item to the DC for next day delivery but in keeping with their pride in their work we observed that they generally preferred to return to the house to deliver it on the day of the sort.

- More frequent replenishment from the panniers is necessary because of the size of the bag and the nature of the sort. This increases the risk of MSD.

- Other problems exist with the SBD bag, including poor drainage of rain water; wetting of the edges of letters in the SLI; uncomfortable contact with sewn edges, Velcro tape, etc; excessive stiffness in the elastic webs of the front panel of the RMC, etc. Some of these are currently being addressed but their resolution, if achieved, will still not address the fundamental issue of the bag being wrong in principal and in execution.

All the above problems with the bag design arise from the erroneous design brief that began with the continuance of the existing Single Bundle bag as an unalterable design element. The preferred option at this point would have been to re-evaluate that bag to see if other and better alternatives existed or could be devised. But this process has been fundamentally flawed in that it only considered the design of a container to facilitate SBD – not all aspects of the much broader work system

Despite frequent and continuing adaptations to the SBD bag, we do not anticipate that satisfactory resolution of the current design problems will be achieved as long as AP continues to maintain the same design constraints. It is clear that the existing Single Bundle bag has always been a compromise and it is certainly a deficiency of thinking not to take the opportunity to re-think the design options.

### *5.4.1 Required improvements to FLC*

In additional to other recommendations being made in this report, we believe that the FLC is in need of substantial redesign if this physical aspect of the SBD method is to be made ergonomically acceptable. We propose the following:

1. The FLC bag should be redesigned so that the sequenced mail and the residue mail are both contained in a way that allows all of the addresses to be visible within a comfortable line of sight of the PDO without the current excessive bending of the neck. The residue mail will need to be positioned so that the current variability of the placement of addresses is accommodated.

2. This may involve positioning the mail higher in the field of view, and consequently the speedometer would need to be repositioned away from this line of sight. It could be moved close to the mirrors by making a new bracket and fitting a longer cable. There may even be electronic alternatives that do not require a stiff wire cable. A cursory examination of the Australian Design Rules does not appear to preclude moving the speedometer from its present position and fixing it away from the vehicle midline.

3. The FLC will also need to present at a more comfortable angle than at present but this is essentially a matter of the design of the bracketry.

## 5.5 Panniers

The panniers are the other part of the design of the physical work system. In a previous report on the AP motorcycle (2004) by two of the authors of this report it was recommended that the panniers be reduced in depth and moved forward to improve the manual handling of bundles from them. These recommendations were made in 2004 and the same problems continue, except that with Separate Bundle delivery, the panniers have become even more of an issue as PDOs now have to access them more frequently. Even though the SBD bundle size is smaller than previously, the one-handed manual handling of bundles of mail from beside and behind the body remains a significant problem with considerable potential for MSD.

The panniers should be redesigned so they are smaller and mounted closer to the PDO to reduce reach distances. The panniers may also be partitioned to control the bundles which presently just fall loosely around in the bag. Compared to the variety of postures used by PDOs on the bikes and the significant variation in size and weight of PDOs, moving the panniers would have limited impact on the dynamic balance of the motorbikes and there is no reason this should not be examined.

# 6 Conclusion and recommendations

The currently proposed system for SBD from a motorcycle is unacceptable from OHS and ergonomics perspectives for the following reasons:

**Organisational issues**

- The proposed work system increases the likelihood that PDOs will work for long periods without breaks in an uncontrolled environment. We were unable to determine if any alternative methods of merging mail had been investigated. It seems that SBD has been adopted without investigating any other ways of improving the efficiency and safety of the merging process.
- The cognitive demands are self-evidently increased (over single bundle delivery) as there are two reading tasks to perform per delivery point, and the sighting points are separated and may be in different orientations, requiring addresses to be read upside down. The frequency of mis-sorts also increases cognitive load.
- AP has not identified any adequate risk controls to prevent reading and riding other than administrative controls, (the weakest form of risk control), which are not able to be enforced except by surveillance of the PDOs. This practice is not only objectionable on many grounds, but is also inefficient and unproductive, requiring considerable resources for little net gain in risk control. It could be argued that the practice of surveillance increases risk because of adverse effects on psychosocial risk.
- Apart from administrative controls (SOPs, etc), AP does not have any acceptable form of management or work design to prevent PDOs having to perform long spells of continuous delivery work with insufficient breaks, this being necessary in order to meet delivery time requirements.
- The methods for determining the size, and therefore the duration, of rounds do not appear to be adaptable to the realities of the work demands. Accordingly, a previous recommendation that rounds be a maximum of five hours in duration is routinely exceeded. No allowance appears to have been made for the increased cognitive demands and the concomitant increase in time spent in delivery that SBD incurs.
- The design of the work system for SBD does not take account of contemporary expectations for a compatible work-life balance, particularly when there is inconsistency in what part of the day is occupied by work, and what part of the day is non-work. This is of particular importance to PDOs who are parents, carers, etc. There does not appear to be a coherent job description for the duties of a PDO engaged in SBD, defining the allowances and requirements for a properly structured shift of work, including the periods of work for each activity, the

breaks to be taken, and providing for the work to be performed in well-managed work circumstances.

**Working environment issues**

- There is a known high incidence of traffic accidents involving these motorcycles in delivery work (as noted in the MUARC report). Any work process that increases the time of exposure to this risk necessarily increases OHS risk unless measures to control the risk of traffic accidents at their source are also implemented. SBD causes PDOs to be exposed to peak hour traffic, on roads, footpaths and across domestic driveways, in the mornings and, for some, in the afternoons also.
- Ergonomics analysis indicates that the task involves unacceptable work postures and upper limb actions that are identified as risk factors in the *National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work.*

**Equipment issues**

- A previous study (by two of the researchers in this study) concluded that the use of motorcycles in mail delivery has an elevated level of hazard particularly when delivering in terrain that is hilly and on surfaces that are slippery and uneven. Nothing has changed since that report in respect of the design of the motorcycle or panniers.
- The motorcycles or panniers are not sufficiently adjustable to suit riders and therefore do not accord with basic ergonomics principles for the design of work equipment.
- The length of time spent on these motorcycles every day is judged to be unacceptable because the lack of adjustment will cause many PDOs to spend long periods in slumped and unsupported sitting while subject to whole body vibration (albeit at levels not yet measured but likely to be at elevated levels of risk), with expected adverse consequences for their lumbar spine, hips, and possible also shoulders and neck. Any consequences would be exacerbated by the weight of the helmet.
- The bundle sizes of 70 mm and 90 mm that are required by the design of the FLC are too large for many smaller sizes of hands. (It is acknowledged that these are maximum bundle sizes and many PDOs in fact select smaller bundles.)
- While the front letter carrier is simply an adaptation of the previous bag, the compartmental design imposes additional physical demands on the PDOs using it in respect of neck movements and upper limb actions.
- The weight of and heat generated by the current helmet combine to undermine the comfort and increase fatigue of PDOs, compounded by the neck posture required for the task.
- Even accepting that a consultative process was employed in the development of the SBD Front Letter Carrier, there are reasons to query the efficacy of the design process given that the starting points were probably erroneous. We are not convinced

that the design activity was appropriately directed and posit that the design of the bag may be fundamentally inadequate in consequence.

- The motorcycle and its attachments are not adequately developed as they should be for this type of work. While we acknowledge that AP must comply with the directives of the Administrator of the Motor Vehicle Act, there is clearly scope to negotiate an effective compromise that meets the needs of both the ADRs and OHS requirements for the work of PDOs.

## Recommendations

1. As much of the PDO's work as possible should be undertaken in a well-designed, managed work environment. Outdoor work requires the availability of shelter, ready access to facilities such as toilets, and a place to take a break from work. Indoor work requires sorting tables and V-Frames which are well-designed and adjustable for individual needs. Any changes should be justified on the basis of *improvement* to the working environment and *decrease* in OHS risk. The current proposal for SBD represents the opposite: a *deterioration* to the working environment because it increases time spent in an uncontrolled environment which presents many unpredictable and potential high risk hazards and an *increase* in risk of developing MSD.

2. Modification of any aspect of PDO work must consider **all** aspects of their work system in a coherent manner. The design process for the SBD FLC has been characterized by a great deal of consultation (for which we commend AP) but not a lot of effective outcomes as it has only focussed on one aspect of the work system, bag design. We have previously mentioned work-life balance which is a component of this issue.

3. The timing of deliveries should consider the road traffic patterns, particularly domestic and driveway traffic. Deliveries should be undertaken at the times when exposure to the risks relating to traffic and roads, pathways and driveways are the lowest possible.

4. Round times should be set realistically at times calculated using experienced operators doing the work in the safest manner possible, including appropriate pathways speeds, having time to stop and read, and allowing for adequate breaks. Appropriate times must also be considered for relievers and operators undertaking unfamiliar splits who will need more time to complete unfamiliar rounds.

5. While many PDOs reported enjoying working on the bike and the outdoor component of the work, the amount of time working on the bike should be limited as per the discussion in the 2004 DDT report.

6. All rounds must provide facilities for shelter, food and toileting, and allow time for appropriate breaks.

7. The physical and cognitive demands of the task should be reduced wherever possible either by redesigning delivery equipment and environmental aspects of the tasks as discussed in the recommendations above, or reducing the exposure to the tasks by reducing the amount of time spent on the bikes.

8. The recommendations made in the earlier report regarding bike design provided as part of the DDT remain relevant. These should be reconsidered and implemented. While mail could be delivered in accordance with OHS and ergonomics requirements while using powered conveyances, the specific design characteristics of the conveyance are critical considering the specific environments in which it is to operate. The motorcycles in current use are not acceptable and their use should not continue in their present form. We note that AP is already considering alternative modes of delivery and the motorcycles are being supplemented by these alternatives. We are aware of other possible conveyances being considered by AP but have not been briefed on any evaluation work that has been undertaken to date. The allocation of any type of conveyance for the carriage of the mail (and the PDO, where appropriate) must be determined specifically on the basis of practicality and safety.

9. The FLC needs to be substantially redesigned in order to accord with ergonomics principles for good work posture and safe manual handling. The FLC bag should be redesigned so that the sequenced mail and the residue mail are both contained in a way that allows all of the addresses to be visible within a comfortable line of sight of the PDO without having to bend their neck excessively, as is currently the case. Both bundles of mail should be handled with movements that are in the same plane, unlike the current bag where the hands move in (nearly) opposite directions. The residue mail needs to be positioned so that the current variability of the placement of addresses is accommodated and all addresses are displayed right-way-up. (We are aware of the ongoing and iterative development of the FLC but even the latest iteration of the design – sighted 24.11.10 – simply continues the deficiencies of the current bag design).

10. The motorcycle may require further development in order to accommodate SBD in a properly ergonomic manner. We anticipate that the speedometer may need to be raised to allow the FLC to be positioned higher. We also re-iterate the findings of the 2004 report on Dedicated Delivery that argued for changes to the panniers. As all changes must be agreed by the Administrator of the Motor Vehicle Act, AP could use the findings of this and previous reports as a basis for asserting the need for change.

11. The panniers should be redesigned (as per the recommendations in the earlier DDT report) so that they are

mounted closer to the PDO to reduce reach distances. The panniers should also be partitioned to control the bundles which presently are not confined within the bag and tend to fall loosely within the bag (in making this recommendation, we are aware of the safety issues pertaining to balancing the loads on the motorcycle).

12. The helmet, which must be worn during bike use regardless of whether this is on-road or on footpaths, should be the lightest possible weight (within safety standard requirements) with optimum ventilation.

# Appendix 1: Data Recording Worksheet

| SUBJECT ID. | DATE OF INTERVIEW | ROUND NO. | NO. DELIVERY POINTS | BASE LOCATION |
|---|---|---|---|---|

| Characteristics of round | none | some | a lot | Sorted and sequenced mail | TODAY | AVER | Residue mail | TODAY | AVER |
|---|---|---|---|---|---|---|---|---|---|
| TYPE OF PREMISES | | | | | | | | | |
| RESIDENTIAL | | | | NO. BUNDLES | | | NO. BUNDLES | | |
| SHOPS | | | | | | | | | |
| INDUSTRIAL | | | | TOTAL WEIGHT | | | TOTAL WEIGHT | | |

| TERRAIN | none | some | a lot | Other – UM, special deliveries | TODAY | AVER | Registered mail | TODAY | AVER |
|---|---|---|---|---|---|---|---|---|---|
| FLAT | | | | | | | | | |
| UNDULATING | | | | NO. BUNDLES | | | NUMBER | | |
| HILLY | | | | TOTAL WEIGHT | | | | | |
| GOOD SURFACES | | | | | | | | | |
| POOR SURFACES | | | | | | | | | |

BASIC INFORMATION

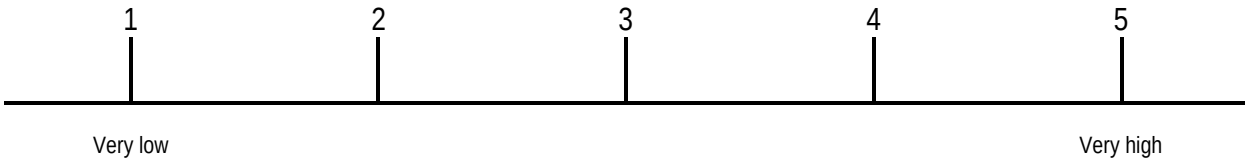
| Sex | Age | Years in AP | Years on AP motorcycle | Employment | Work hours/day | Pre SBD | SBD |
|---|---|---|---|---|---|---|---|
| | | | | FULL TIME - | | | |
| | | | | PART TIME - | PREPARATORY | | |
| | | | | (fraction) | | | |
| | | | | CASUAL - | | | |
| | | | | (fraction) | ON ROUND | | |

| Hand dominance | Vision for reading addresses | Self-Reported Health: | Injuries or impairments (voluntary info) |
|---|---|---|---|
| LEFT RIGHT | OK - Just OK - NOT OK | FIT – OK - UNFIT | |

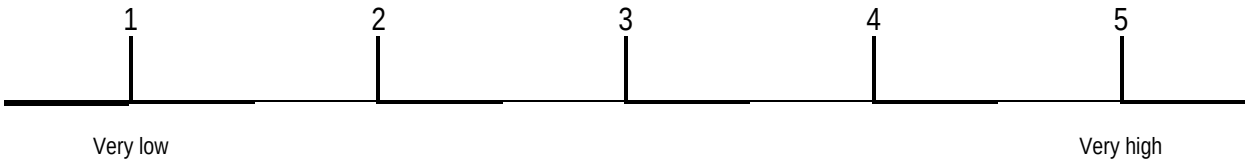
| COMFORT RATINGS | *LEFT* | *RIGHT* | |
|---|---|---|---|
| When pinch gripping 70 mm bundle – elbow @ 90° | | | *Indicate subject's perception of comfort by these figures:*<br>1. *Very comfortable*<br>2. *Quite comfortable*<br>3. *Neither comfortable or uncomfortable*<br>4. *Quite uncomfortable*<br>5. *Very uncomfortable* |
| When pinch gripping 90 mm bundle – elbow @ 90° | | | |
| Reaching back and down to the bundles in the panniers | | | |
| Gripping the bundles in the panniers | | | |
| Holding and moving the mail from the panniers to the delivery bag | | | |
| When reaching forward to the bag – sorted mail | | | |
| When reaching forward to the bag – residue mail | | | |
| Neck flexion – lateral to 30° L & R | | | |
| Neck flexion to front to 45° | | | |
| Comfort when reading the addresses on the sorted mail (front compartment) | | | |
| Comfort when reading the addresses on the residue mail (bottom comp't) | | | |
| Comfort when sitting on and riding the motorcycle while delivering mail | | | |
| Body comfort at the end of the round | | | |
| Visual comfort at the end of the round | | | |

QUANTITATIVE WORKLOAD ASSESSMENT

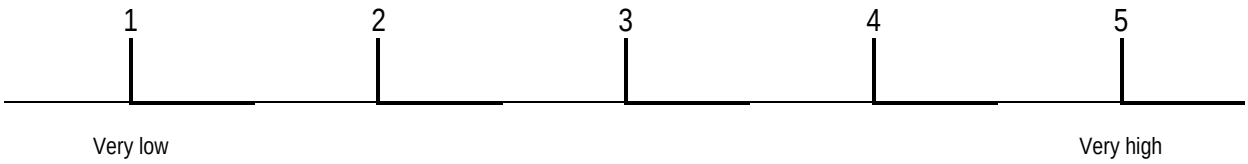
1. How mentally demanding is SBD delivery?



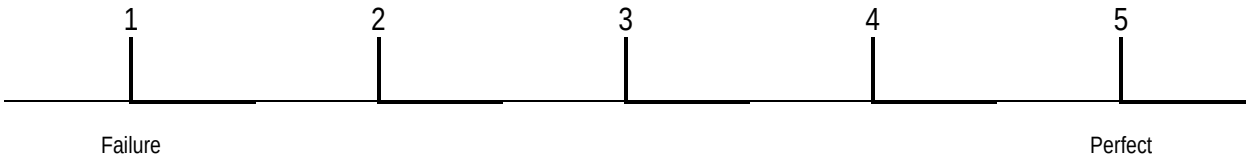

2. How physically demanding is SBD delivery?



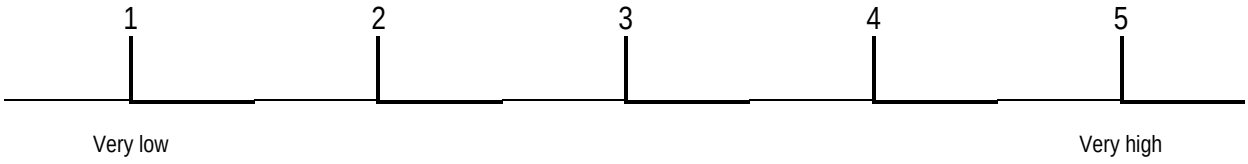

3. How hurried or rushed is SBD delivery?



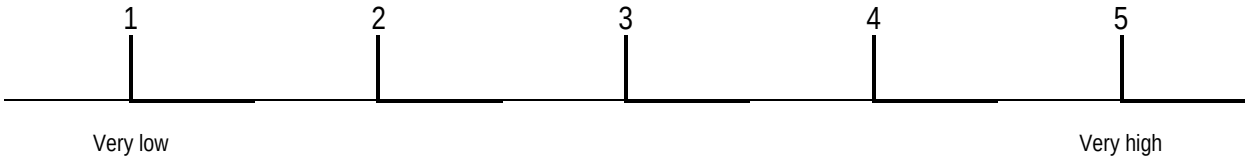

4. How successful were you in performing the work as required?




5. How hard did you have to work to achieve the targets?




6. How insecure, discouraged, irritated, stressed, or annoyed were you?

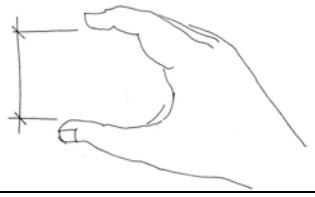


RESPONSES TO SBD VIA MOTORCYCLE

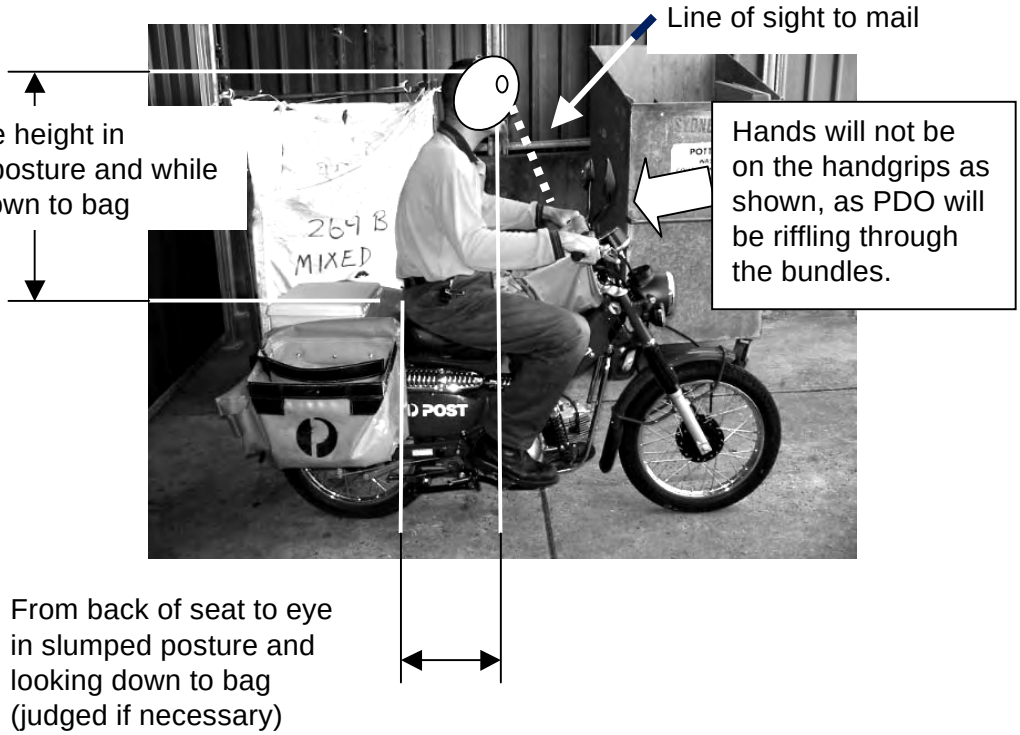
| | |
|---|---|
| 1. What do you like/dislike about working on motorcycle? Why? | |
| 2. What other forms of transport have you used? What did you like/dislike about them? | |
| 3. Do you have access to toilets on your round? And food and shelter? | |
| 4. How often do you take a break during your round?<br><br>And how long is the break? | |
| 5. What has improved about your work with SBD? | |
| 6. What has deteriorated with your work as a result of SBD? | |
| 7. How has SBD changed the time to complete your round? | |
| 8. How has SBD changed the physical effort to complete the round? | |

| | |
|---|---|
| 9. Any safety issues with SBD? | |
| 10. How could SBD be improved? | |
| 11. Comments re surveillance for 'safety' compliance? | |
| 12. Would like to continue SBD (in preference to previous)? Why? | |
| 13. Opinion re SBD vs. previous?<br><br>Why? | |
| 14. Any other comments | |

ANTHROPOMETRIC DATA

| | |
|---|---|
| 1. STATURE | |
| 2. STANDING SHOULDER PIVOT | |
| 3. STANDING HIP | |
| 4. SHOULDER PIVOT TO CENTRE OF CLOSED FIST | |
| 5. MAXIMUM HAND GRASP |  |

EYE POSITION RELATIVE TO SEAT



# Appendix 2: Risk assessment using the National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work

**Task assessed: PDOs performing separate bundle delivery while riding a Honda 110 motorcycle**

**Repetitive or sustained posture, movements or forces**

*Defined as: Repetitively = done more than twice per minute; sustained = done for more than 30 seconds at a time.*

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|---|
| | Repetitively | Sustained | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Bending the back forwards or sideways ≥ 20° | Often | Rarely | Sideways bending is usual when placing mail in letterboxes and an extended reach is required. | ✓ | ✓ |
| Twisting the back ≥ 20° | Often | Rarely | As above. | ✓ | ✓ |
| Any visible backward bending | Rarely | Rarely | Sometimes done when leaning back to read addresses in RMC (if sitting too close to front bag) | ✓ | ✓ |
| Bending the head forwards or sideways ≥ 20° | Usually | Occas'y | Neck flexion occurs every time addresses are read in the bag, particularly with residue mail. Where drop points are close together, this action may occur twice per minute or more. | × | ✓ |
| Any visible bending of the head backwards | Rarely | Rarely | May be associated with leaning back to read addresses in RMC | × | × |
| Twisting the neck ≥ 20° | Usually | Often | Occurs at almost every delivery point, and may be sustained when filling multiple boxes, such as at blocks of flats. Is almost always done to the left side. | × | ✓ |

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. ✗ = risk judged not to exist | |
|---|---|---|---|---|---|
| | Repetitively | Sustained | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Working with one or both hands above shoulder height | Rarely | Rarely | May occur where multiple letterboxes are in a large stack and some are higher than the seated PDO. | ✗ | ✗ |
| Reaching forwards or sideways ≥ 30 cm from the body | Often | Often | Most letterboxes are outside the 30 cm reach range because of the width of the motorcycle and the PDO must lean over to post the mail. | ✓ | ✓ |
| Reaching behind the body | Occas'y | Rarely | Occurs whenever reaching back to the panniers. Occurs more frequently with SBD as the bundles are smaller, and may occur every few minutes with sequenced mail. Injury potential is high as the action is one-handed and half the time involves the non-dominant hand. | ✓ | ✓ |
| Squatting, kneeling, crawling, lying, semi-lying, or jumping. | Never | Never | | ✗ | ✗ |
| Standing with most of the body weight on one leg | Often | Often | PDOs with shorter legs will incur this when stopped but supporting the motorcycle (when delivering) | ✓ | ✓ |
| Working with the fingers close together or wide apart | Often | Rarely | Both conditions occur when handling bundles.<br>AP set reference bundle thickness limits (refer SOPs for Indoor preparation, and motorcycle operation) | ✗ | ✗ |
| Very fast movements | Rarely | Rarely | | ✗ | ✗ |

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. ✗ = risk judged not to exist | |
|---|---|---|---|---|---|
| | Repetitively | Sustained | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Bending of the wrist:<br>a. ≥ 15° flexion or extension where the wrist is fairly straight during work.<br>b. ≥ 15° flexion or 35° extension when gripping.<br>c. ≥ 15° radial or 20° ulnar deviation. | Often | Often | The hand movements are complex because of the nature of mail which varies in size, stiffness, surface friction, etc. The manipulations required to handle loose items of mail whilst not in an optimal work posture, i.e. while straddling the motorcycle, increase the difficulties of handling the mail. | ✗<br>✗<br>✗ | ✓<br>✓<br>✓ |
| Lifting, lowering, or carrying | Rarely | Rarely | This reference in the Code is intended more for heavier items. | ✗ | ✗ |
| Carrying with one hand or on one side of the body | Often | Rarely | This occurs when placing mail in letterboxes. | ✓ | ✗ |
| Exerting force with one hand or on one side of the body | Often | Rarely | Pushing mail into the residue mail compartment of the bag often requires a substantial one-handed push. Although the actual force may not be great, it is done in an awkward posture (seated, straddling the bike). | ✗ | ✓ |
| Pushing, pulling, or dragging | Never | Never | This reference in the Code is intended more for heavier items. | ✗ | ✗ |
| Gripping with the fingers pinched together or held wide apart | Often | Rarely | All mail handling involves pinch gripping. It is often repetitive; it is sometimes forceful, although it is not often sustained. | ✓ | ✓ |
| Using a finger grip, pinch grip, or an open handed grip to handle a load | Occas'y | Rarely | This may apply when getting bundles from the panniers and bringing them to the front bag. | ✓ | ✓ |

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|---|
| | Repetitively | Sustained | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Exerting force while in an awkward posture including:<br>Supporting items while arms or shoulders are in an awkward posture;<br>Moving items while legs are in an awkward posture | Often | Occas'y | Although the Code intends this for heavier work, the constrained posture of a PDO on a motorcycle may induce some of the same conditions as a person performing heavier lifting but with freedom of position. | ✓ | ✓ |
| Holding, supporting or restraining any object, person, animal or tool | Never | Never | | × | × |

**Long duration**

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|
| | | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| More than two hours per shift or continually for more than 60 minutes at a time | ≥ 60' at a time is usual | Many of the risk factor actions are evident in the work which typically occupies 4 – 5 hours, or longer. While no actions are performed continuously, they are performed frequently, many of them very frequently, over the period of work. | ✓ | ✓ |

**High force**

None of the listed factors for high force are considered applicable to SBD work.

**The work environment or the way the work is organized**

Of those listed, the following are considered relevant

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|
| | | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Hand-arm vibration | Not known | No measurement of hand/arm vibration has been undertaken by Aust Post. | × | ✓<br>If at or above the critical level of exposure |
| Whole body vibration | Not known | The level of exposure to whole body vibration is not known as no measurement has ever been undertaken by Aust Post. Significant exposure is probable, particularly on rounds where there is a high percentage of noon-paved surfaces. The terrain may also be rough. Long tem consequences are possible. | × | ✓<br>If at or above the critical level of exposure |
| Low temperatures | Varies according to region | Low temperature is common in winter, especially in southern Australia. Cold reduces dexterity and could be an aggravating factor for some PDOs. | × | × |
| Wearing thick clothing that restricts movement while working in cold conditions, e.g. gloves | As above | This could be an aggravating factor for some PDOs. | ✓ | × |
| High air temperatures | Varies according to region | Can apply for sustained periods in summer, including southern Australia and causes discomfort and fatigue. May cause heat stress on hard and long rounds. This is certainly an aggravating factor for all PDOs. | ✓<br>Not injury per se, but other health consequences are possible | |

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|
| | | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Radiant heat | Varies according to region | Can be a hazard anywhere in Australia between October and April (varying with region). | ✓<br>Not injury per se, but other health consequences are possible | |
| Wearing heavy protective clothing while working in hot conditions | Usually – occasionally | The helmet is always worn and other protective clothing may also be used as the PDO chooses. Such PPE could increase the effort required to complete the work, could increase discomfort and fluid loss, and may lead to heat stress at some level of severity. | ✓<br>Not injury per se, but other health consequences are possible | |
| High humidity | Varies according to region | For sustained periods in northern Australia. Essentially a discomfort factor but significant for fatigue. High humidity does reduce evaporative cooling and the potential for heat stress may be increased. | ✓<br>Not injury per se, but other health consequences are possible | |
| Windy conditions combined with hot or cold weather | Occasionally | Varies with the regions but may occur anywhere in the country (although perhaps more frequently in southern Australia). Cold reduces dexterity. Both cold and heat increase discomfort, may increase fatigue and cause loss of alertness. May lead to heat stress at some level of severity. Cross winds may destabilize riders and affect handling of mail. | ✓ | × |
| Wind chill caused by exposure to wind in low temperatures | Occasionally | As above | ✓ | × |

| RISK FACTOR | OCCURRENCE in SBD WORK<br>By time or frequency as occurring when riding, reading, filling bag from panniers, collating mail in hand, placing in letterbox. Frequency noted as at every delivery point: USUALLY (75-100%), OFTEN (50-75%), OCCASIONALLY (25-50%) or RARELY (<25%), or NEVER | | MOST PROBABLE OUTCOME OF HAZARD<br>✓ = risk exists. × = risk judged not to exist | |
|---|---|---|---|---|
| | | | ≥ moderate likelihood of acute strain or injury | ≥ moderate likelihood of gradual onset injury |
| Systems of work...that encourage workers to skip breaks to finish early. | Usually | Is characteristic of the full time employment conditions for PDOs but not for dedicated delivery personnel. Such systems may increase the risk of OOS, fatigue, and traffic accidents. | ✓ | ✓ |
| Sustained high levels of attention and concentration | Usually | Applies to all PDOs. Sustained concentration may increase mental fatigue, may reduce alertness and vigilance, and has implications for road safety. | ✓ | ✓ |
| Workers frequently needing to meet tight deadlines | Often | Particularly when working split rounds additional to the regular round. Consequences as above for high levels of attention. | ✓ | ✓ |
| Sudden changes in workload, or seasonal changes in volume without any mechanisms for dealing with the change | Occasionally | Particularly at major periods of celebration. Such demands compound the previous work system issues. | ✓ | × |
| Levels of physical work demand that workers find difficult to maintain (pace) | Occasionally | Is a common complaint from PDOs. Increases the potential for fatigue, traffic accidents, errors, etc. Is made worse by split rounds. | ✓ | × |

**Reports of MSD associated with the work**

Reports are received and MSD are known to be a significant issue associated with the work of PDOs. The risk is known to exist of the development of both acute and gradual onset injuries.

# Appendix 3: Anthropometric data of the participants

Full measurements of 40 of the participants were recorded. They are listed here in ascending order of stature followed by sitting eye height. Stature and standing hip heights were recorded with the person wearing their work boots. Only those participants with a complete set of data are shown.

| In cm | Stature (including work boots) | Sitting eye height | Eye position relative to back of seat | Standing hip ht. (including work boots)* | Comments |
|---|---|---|---|---|---|
| 1. | 160 | 64 | 24 | 85 | |
| 2. | 164 | 72 | 35 | 94 | Two people of the same stature but the person with the longer legs sits further forward and also a little higher (less slumped?). |
| 3. | 164 | 65 | 25 | 90 | |
| 4. | 165 | 68 | 24 | 90 | Four people of the same stature but their relative position on the seat, i.e. how far forward or back they sit is not consistent with leg length.<br><br>All sit at about the same height. |
| 5. | 165 | 68 | 29 | 84 | |
| 6.f | 165 | 67 | 28 | 91 | |
| 7. | 165 | 67 | 31 | 88 | |
| 8. | 167 | 72 | 23 | 92 | Three people within 3 cm of each for stature but the person with the longer legs sits furthest forward. Thus sitting posture on the motorcycle is only partly related to leg length. |
| 9. | 168 | 68 | 29 | 95 | |
| 10.f | 170 | 68 | 28 | 90 | |
| 11. | 173 | 72 | 18 | 92 | |
| 12. | 173 | 71 | 22 | 91 | |
| 13.f | 174 | 75 | 17 | 97 | Five people of the same stature but 13 cm difference in leg length (as recorded).<br><br>Although their sitting eye heights are very similar, their position on the seat varies over a range of 17 cm. One of those with the shorter legs sits 13 cm further back than |
| 14. | 174 | 72 | 27 | 103 | |
| 15. | 174 | 72 | 34 | 90 | |
| 16. | 174 | 71 | 21 | 90 | |
| 17. | 174 | 71 | 31 | 101 | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | the other person with the same leg length (as recorded). |
| 18. | 175 | 70 | 30 | 90 | |
| 19. | 176 | 70 | 22 | 92 | |
| 20. | 176 | 69 | 24 | 93 | |
| 21. | 177 | 74 | 28 | 94 | The person with the longest legs sits farthest back on the seat but the person with the shortest legs is not the pone sitting farthest forward. As a ratio of stature, 90 cm leg length = 0.508, and 99 cm leg length = 0.559 |
| 22. | 177 | 72 | 30 | 95 | |
| 23. | 177 | 70 | 22 | 99 | |
| 24. | 177 | 69 | 27 | 90 | |
| 25. | 178 | 72 | 33 | 99 | |
| 26. | 179 | 65 | 30 | 96 | |
| 27. | 180 | 74 | 31 | 92 | Same stature, 2 cm difference in leg length, but 10 cm different in position on the seat. |
| 28. | 180 | 74 | 21 | 94 | |
| 29. | 181 | 72 | 22 | 97 | Same stature, 3 cm difference in leg length, 6 cm difference in sitting distance, but 6 cm difference in sitting height (different slumps?) |
| 30. | 181 | 66 | 28 | 100 | |
| 31. | 181 | 69 | 36 | 98 | |
| 32. | 183 | 76 | 31 | 95 | |
| 33. | 183 | 71 | 22 | 98 | |
| 34. | 184 | 74 | 39 | 103 | 4 cm difference in leg lengths, 3 cm difference in sitting eye height, but 17 cm difference in sitting distance on the seat. |
| 35. | 184 | 72 | 23 | 99 | |
| 36. | 185 | 72 | 31 | 94 | |
| 37. | 187 | 73 | 27 | 103 | |
| 38. | 191 | 80 | 29 | 99 | |
| 39. | 191 | 72 | 19 | 96 | |
| 40. | 199 | 82 | 37 | 109 | |

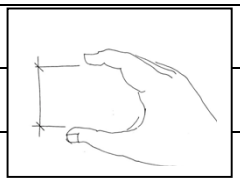
The letter ‘f’ by the number indicates that this person is female

* Some the hip height measurements may not be exact as the location of the hip point was made by the participant (with guidance)

**Table 2. HAND GRIP SIZE**

Participants were asked to make a hand grip of a size that was the maximum comfortable for them.

Dimensions were rounded to the nearest 0.5 cm.

| In cm | Stature (including work boots) | Hand grip size | Comments |
|---|---|---|---|
| 1. | 160 | 5.5 | |
| 2. | 164 | 7 |  |
| 3. | 164 | 7 | |
| 4. | 165 | 5 | |
| 5. | 165 | 6.5 | |
| 6.f | 165 | 6.5 | None of the female participants displayed smaller hand sizes for their stature, as might have been expected. |
| 7. | 165 | 6.5 | |
| 8. | 167 | 6 | |
| 9. | 168 | 6 | |
| 10.f | 170 | 6 | |
| 11. | 173 | 6 | |
| 12. | 173 | 8 | |
| 13.f | 174 | 7.5 | |
| 14. | 174 | 6.5 | |
| 15. | 174 | 7.5 | |
| 16. | 174 | 8.5 | The largest hand grip size in the sample, but not the tallest person. Is either a person with large hands, or has flexible hands, or was over-estimating their hand capacity. |
| 17. | 174 | 7 | |
| 18. | 175 | 8 | |
| 19. | 176 | 6 | |
| 20. | 176 | 6 | |

| In cm | Stature (including work boots) | Hand grip size | Comments |
|---|---|---|---|
| 21. | 177 | 7.5 | |
| 22. | 177 | 6.5 | |
| 23. | 177 | 4.5 | This person (male) has a markedly smaller hand grip size than would have been consistent with those around him. He may have a functional problem with his hand(s), or he just did not make his largest comfortable grip. |
| 24. | 177 | 6 | |
| 25. | 178 | 6 | |
| 26. | 179 | 7.5 | |
| 27. | 180 | 6 | |
| 28. | 180 | 6 | |
| 29. | 181 | 6.5 | |
| 30. | 181 | 7 | |
| 31. | 181 | 8 | |
| 32. | 183 | 7.5 | |
| 33. | 183 | 7 | |
| 34. | 184 | 6 | |
| 35. | 184 | 7.5 | |
| 36. | 185 | 7.5 | |
| 37. | 187 | 7 | |
| 38. | 191 | 5.5 | Another relatively small hand grip size for the overall size of the person (male). |
| 39. | 191 | 6.5 | |
| 40. | 199 | 7 | |