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CITY OF MILWAUKEE
BUREAU OF SANITATION

ERGONOMIC ANALYSIS
OF
SANITATION WORKERS

prepared by
OCCUPATIONAL MEDICAL CLINIC
DECEMBER 1992

The following Ergonomic Analysis was performed to identify potential hazards that Sanitation Workers encounter when removing carts, bins, and materials from residences and transferring them to a Packer Truck and/or a Recycling Truck. An injury report (Appendix A) provided by the Bureau of Sanitation reveals that strains account for 52% of the injuries incurred by the workers. Injuries resulting from handling carts and bins account for 53% of the strains, with these injuries mainly affecting the back and shoulders. Injuries resulting from entering/exiting the truck and slips account for 22% of the strains. Knee and ankle injuries are the most frequent body parts injured when entering and exiting the truck cab.

The Ergonomic Analysis is divided into three main sections: Major Areas of Concern; Potential Ergonomic Hazards; and Hazard Control Recommendations. In addition, an plan for implementing an Ergonomic Program is included.

MAJOR AREAS OF CONCERN

The following are major concerns regarding hazards and injuries expressed by Bureau of Sanitation management and employees.

1. Movement of cart: Is pushing or pulling better? Are there instances where one method of movement is preferred?
2. Moving carts down steps: How should the Workers move the carts down a flight of steps with the least risk of injury?
3. Removing carts from ledges in alleys: How should the Workers remove carts from ledges in alleys, especially when the handles and wheels are against a wall or fence?
4. Removing carts placed improperly against walls: Carts with the handles and wheels against a wall are difficult to move, especially in the winter when snow is piled around the cart, freezing it in place. How can the Workers handle the carts with least risk of injury?
5. Placing carts on the flippers: How should the Workers place the carts on the flippers?
6. Lifting recycling bins: What is the correct way to lift a recycling bin?
7. Entering and exiting the truck cab: The left side of the truck cab is confining. How can the Workers enter and exit the cab without injuring their knees and ankles? In addition, the step into the cab is bare metal and slippery, which increases the potential for slips and injuries.
8. Handles on "Toter" carts: The handles on the sides of the "Toter" carts are small. A normal size hand barely fits into the handle, and a gloved hand will not.

POTENTIAL ERGONOMIC HAZARDS

I. Awkward Postures & Positions

1. Workers often pull full and empty carts with one or both arms behind the back. A Worker may handle 300 - 400 carts per day when performing street collection (observed rate). A Worker may handle up to 800 carts per day when performing alley collection (observed rate). Placing the shoulder in this position may increase the risk of a shoulder strain.
2. When removing the newspaper bin from a recycling cart, the Workers laterally flex and twist at the waist to lift the bin from the cart. Their body is usually facing the truck with the cart at the side of the body. This lifting position increases the compressive forces on the lumbar intervertebral discs and increases the tension in the lower back muscles, thus increasing the risk of low back pain.
3. When lowering carts down a set of steps, the Workers will use one of the following methods:
 - (1) Lower the cart with their body behind the cart, the cart wheels several steps lower than their feet, and the trunk flexed forward (Figure 1.). This lowering position increases the compressive forces on the lumbar intervertebral discs, increases the tension in the lower back muscles, thus increasing the risk of low back pain. Figure 2. illustrates the compressive force.
 - (2) Lower the cart with their body in front of the cart, facing downhill, keeping the body erect, and holding the cart handles with both hands behind the back (Figure 3.). This lowering position causes the cart to push the Worker down the steps at a quicker than normal rate. The force of the cart pushing against the Worker's back increases the Worker's momentum descending the steps. Increasing the rate of the Worker's descent, increases the risk of slipping and falling with a loaded cart behind the worker. Figure 4. illustrates the compressive force on the lumbar intervertebral discs.
 - (3) Lower the cart with their body in front of the cart, facing uphill, keeping the body erect, and the arms extended in front of the body to hold the cart handle (Figure 5.). This lowering position does not allow the Worker to watch his footing

while descending the steps. In addition, holding the weight of the cart with the arms extended in front of the body, increases stress on the shoulder joint and the low back. Figure 6. illustrates the compressive force on the lumbar intervertebral discs.

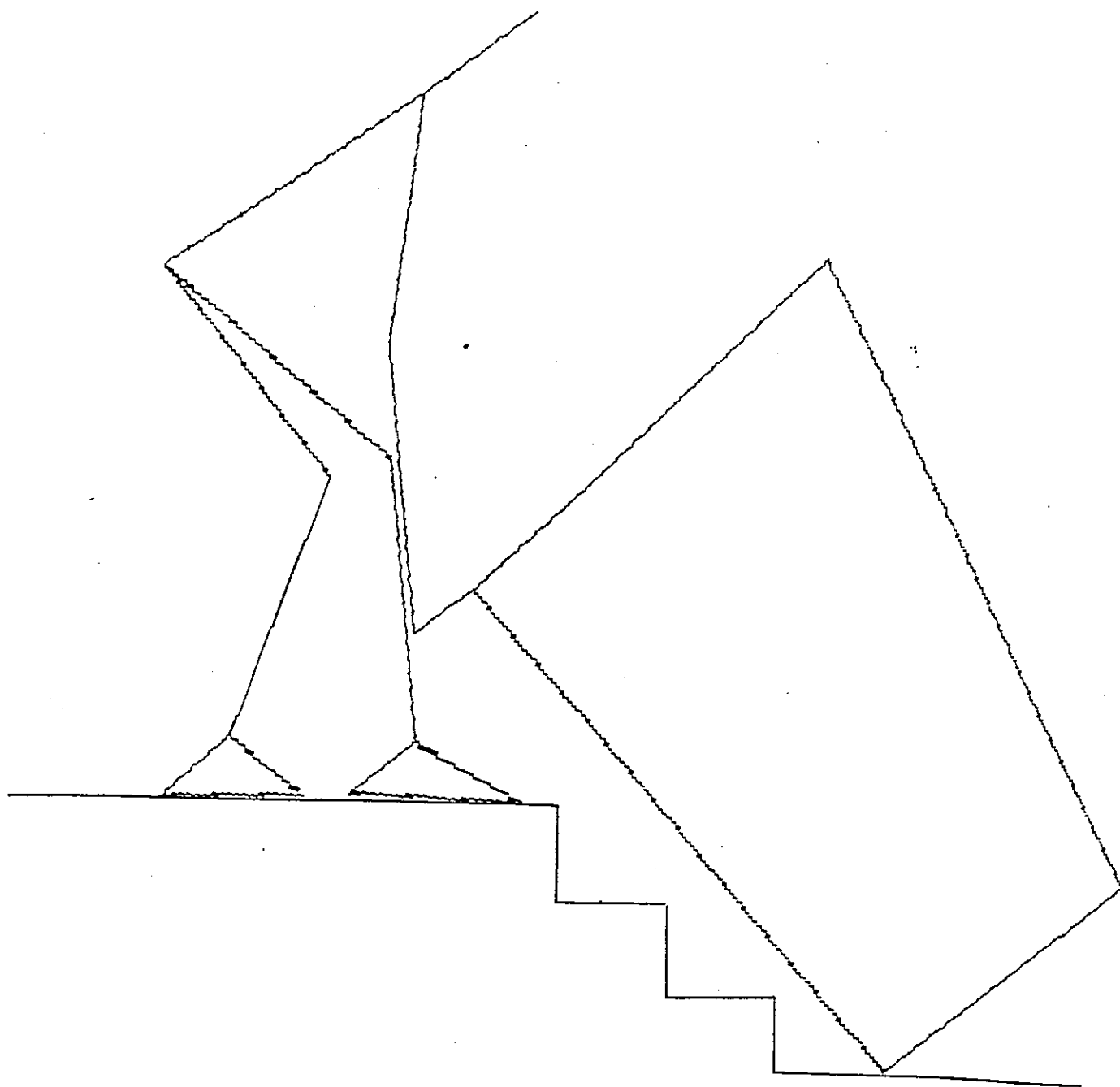
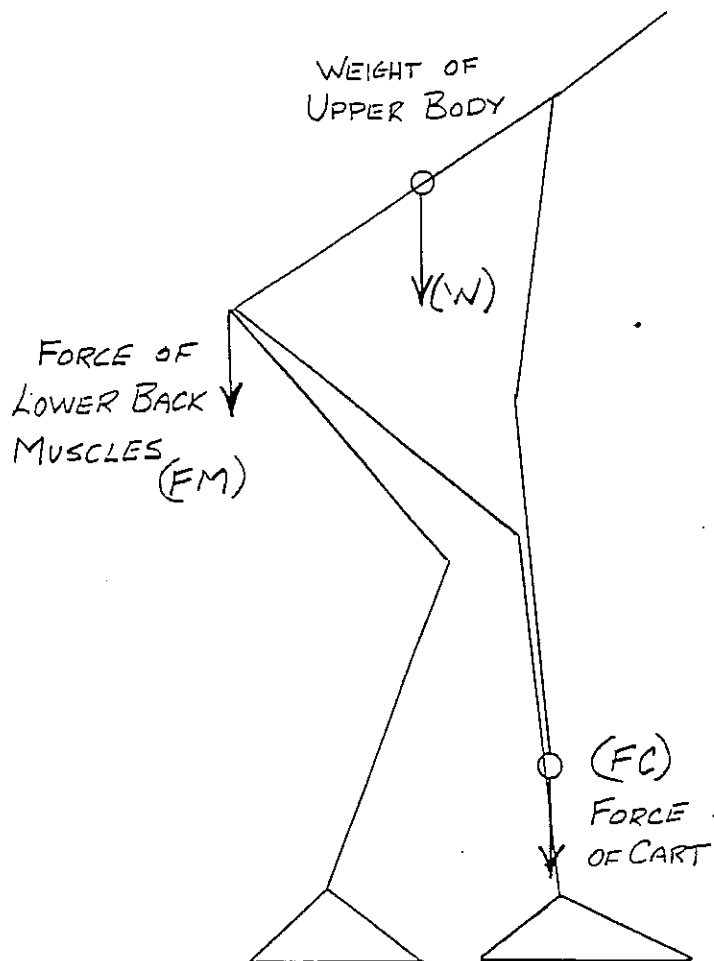
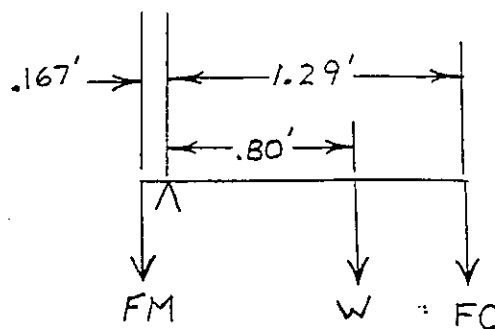


Figure 1. Worker descending steps with cart in front of the body.



Forces acting on body.

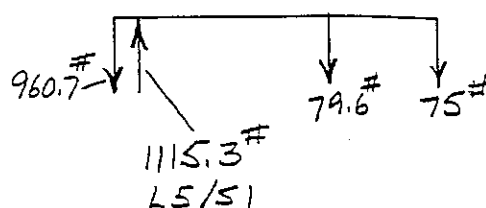


Free body diagram of forces.

$$FM(.167) = W(.80) + FC(1.24)$$

$$FM(.167) = 79.6(.80) + 75(1.24)$$

$$FM = 960.7 \text{ lbs.}$$



Compressive force diagram.

The compressive force on the lumbar intervertebral discs = 1,115.3 lbs.

NIOSH compressive force limit = 770 lbs.

Figure 2. Diagram of the compressive force acting on the lumbar intervertebral discs for the cart lowering method shown in Figure 1.

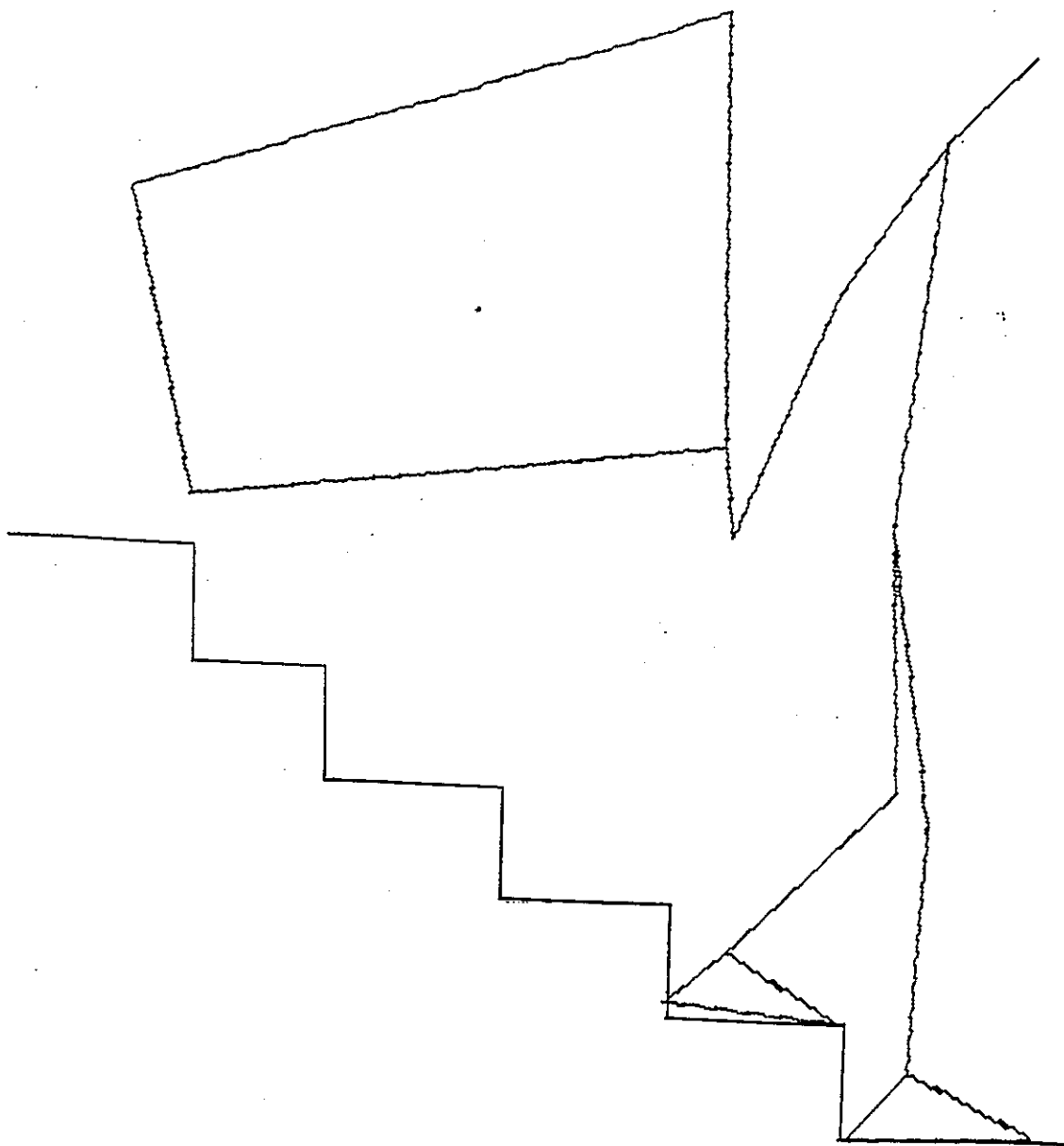
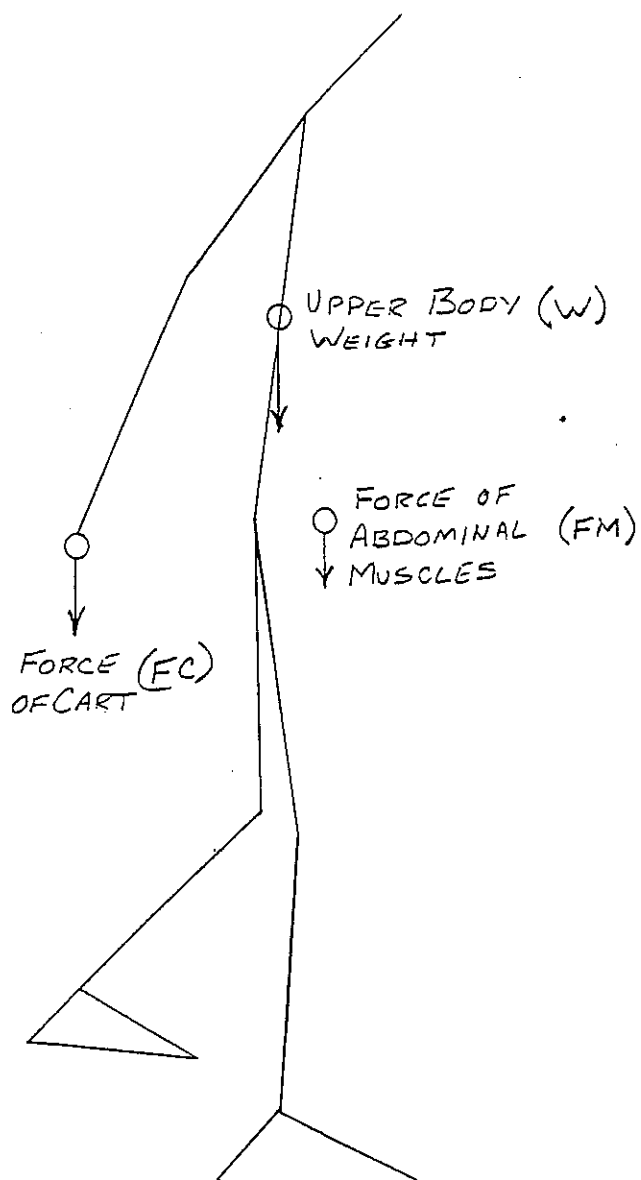
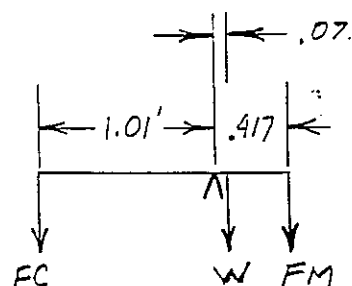


Figure 3. Worker descending steps with body in front of cart, facing downhill.



Forces acting on body.

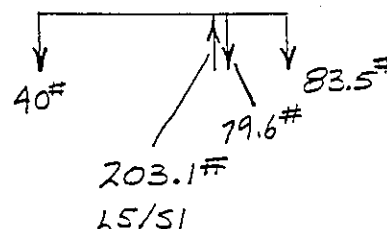


Free body diagram of forces.

$$FM(.417) + W(.07) = FC(1.01)$$

$$FM(.417) = 40(1.01) - 79.6(.07)$$

$$FM = 83.5 \text{ lbs.}$$



Compressive force diagram.

The compressive force on the lumbar intervertebral discs = 203.1 lbs.

NIOSH compressive force limit = 770 lbs.

Figure 4. Diagram of the compressive force acting on the lumbar intervertebral discs for the cart lowering method shown in Figure 3.

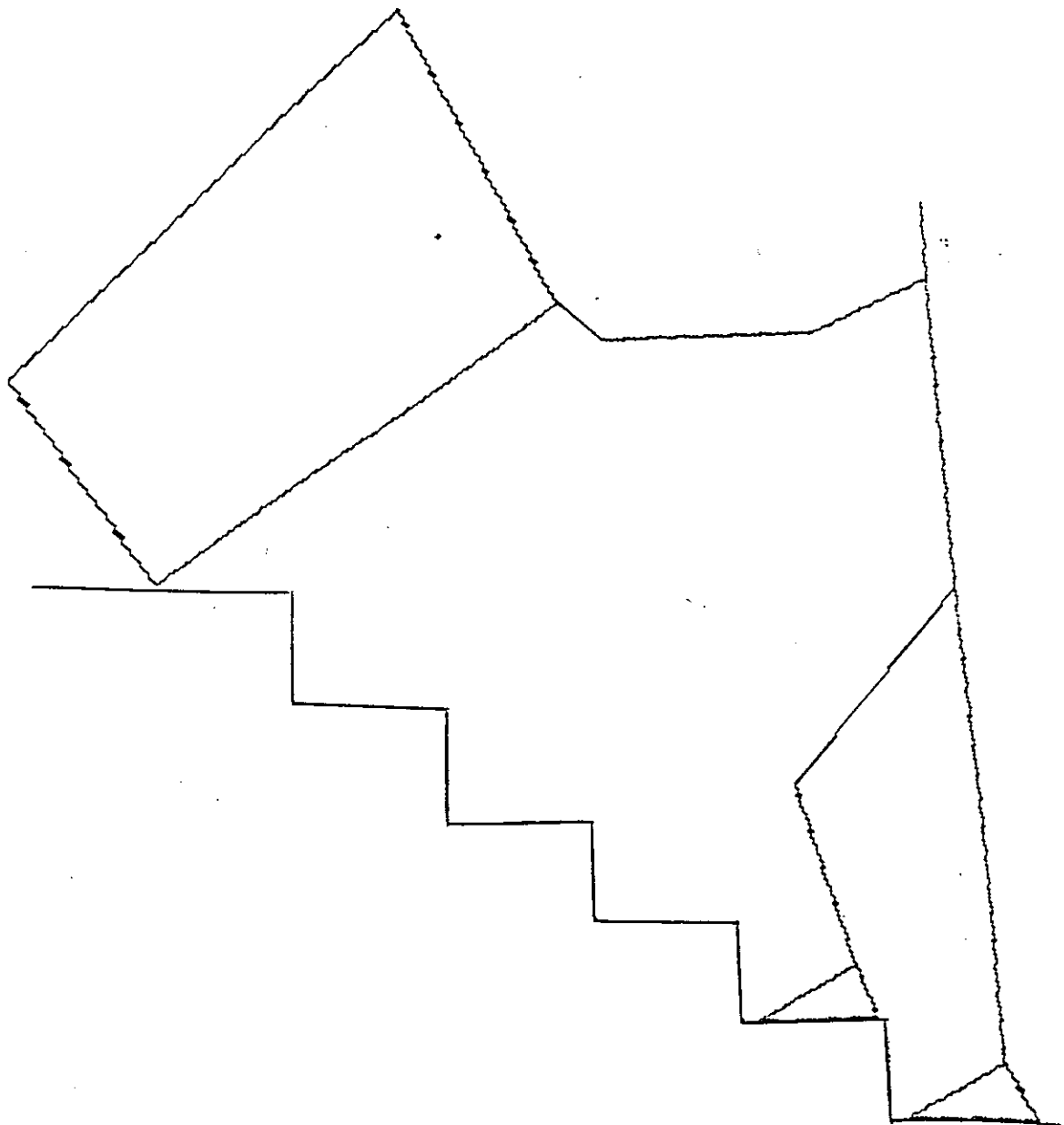
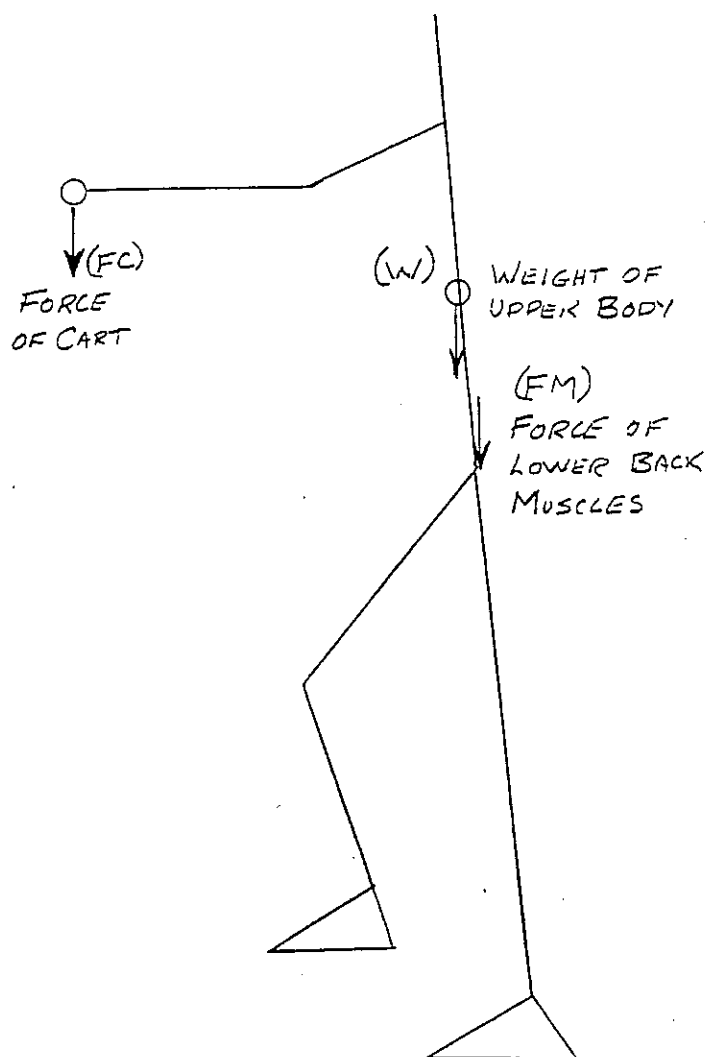
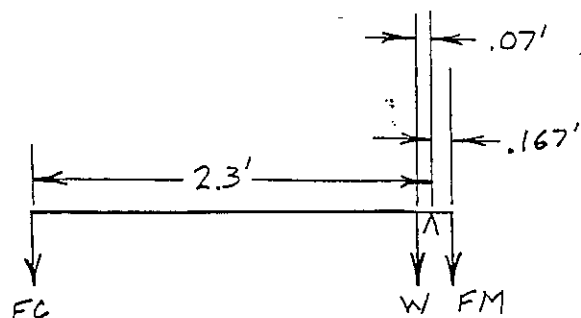


Figure 5. Worker descending steps with body in front of cart, facing uphill.



Forces acting on body.

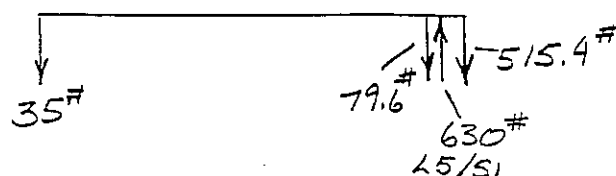


Free body diagram of forces.

$$FM(.167) = W(.07) + FC(2.3)$$

$$FM(.167) = 79.6(.07) + 35(2.3)$$

$$FM = 515.4 \text{ lbs.}$$



Compressive force diagram.

The compressive force on the lumbar intervertebral discs = 630 lbs.

NIOSH compressive force limit = 770 lbs.

Figure 6. Diagram of the compressive force acting on the lumbar intervertebral discs for the cart lowering method shown in Figure 5.

4. Workers lifting recycling bins often laterally flex and twist at the waist to lift a bin from ground level to the dump bin on the recycling truck. This lifting position increases the compressive forces on the lumbar intervertebral discs and increases the tension in the lower back muscles, thus increasing the risk of low back pain.
5. Workers lifting recycling bins often bend forward at the waist and reach away from the body at arms length, to lift a bin from ground level to the dump bin on the recycling truck. This lifting position increases the compressive forces on the lumbar intervertebral discs and increases the tension in the lower back muscles, thus increasing the risk of low back pain.
6. During the winter when carts are stuck in the snow with the wheels and handle against a wall, the Workers will grab the metal handle (34" high) on the front of the cart and pull on the cart to free it from the snow. This pulling position increases the compressive forces on the lumbar intervertebral discs and increases the tension in the lower back muscles, thus increasing the risk of low back pain. In addition, pulling on the cart in this manner increases the stress on the shoulders.
7. When placing carts on the flipper, Workers usually push or pull the cart up to the flipper, then grab the front metal handle in one hand and lift the cart onto the flipper. When lifting the cart, the Worker reaches to the side of the body or behind the back to lift the cart. Lifting a cart in this manner increases stress to the shoulder girdle.
8. When lifting loose bags of trash, the Workers frequently bend forward at the waist and reach forward, away from the body, to lift the bag. This lifting position increases the compressive forces on the lumbar intervertebral discs and increases the tension in the lower back muscles, thus increasing the risk of low back pain.
9. Entering and exiting the left side of the truck cab can result in knee and ankle injuries if performed improperly. Normally Workers grab the steering wheel with the left hand, place the left foot on the door step and pull themselves or hop into the cab. There is little room to maneuver around the steering column, thus the right knee can easily hit the column when entering and exiting. In addition, the door step is bare metal and becomes slippery, especially in the winter. If a Worker slips on the step when entering the truck, an ankle

injury can occur.

II. Forceful Exertions

1. Newspaper bins, lifted from recycling carts may weigh up over 60 pounds (average weight ranges from 20 - 30 pounds), and are lifted from a height of 43 inches to 60 inches to remove the bin from the cart. Each Worker lifts 250 to 300 bins per day (observed rate). Lifting heavy bins of paper increases the risk of an overexertion injury to the shoulders and the lower back.
2. Workers lift recycling bins loaded with glass, plastic, and paper, that may weigh over 65 pounds (average weight is 20 - 40 pounds). A Worker may lift up to 800 bins per day (observed rate). Lifting heavy bins of glass, plastic, and paper increases the risk of an overexertion injury to the lower back.
3. During the winter when carts are stuck in the snow with the wheels and handle against a wall, the Workers will grab the metal handle (34" high) on the front of the cart and pull on the cart to free it from the snow. Pulling and jerking on the cart in this manner may result in an overexertion injury to the shoulders and the lower back.
4. When placing carts on the flipper, Workers often grab the front metal handle in one hand and lift the cart onto the flipper. When lifting the cart, the Worker reaches to the side of the body or behind the back to lift the cart. To lift a cart in this manner, the Worker may exert up to 100 pounds of force, with one arm, to lift the cart onto the flipper. Lifting in this manner, may result in an overexertion injury to the shoulder or lower back.
5. Workers occasionally encounter carts loaded with concrete, plaster, or other building materials. This type of material overloads the cart and makes it difficult to handle. Workers who handle overloaded carts increase their risk of an overexertion injury, by handling more than they are physically capable.
6. Workers occasionally encounter household items such as mattresses, chairs, couches, etc., and load these items into the packer. These items are heavy and awkward to handle, even when two workers lift the items. Lifting heavy household items increases the Worker's risk of incurring an overexertion injury.

HAZARD CONTROL RECOMMENDATIONS

I. Engineering Controls

1. The Bureau of Sanitation is exploring the use of a divided cart to be used for recycling. One side of the cart is for paper and the other side for glass and plastic. The cart will be placed on a flipper and dumped into a truck. This type of cart will eliminate lifting the paper bin currently used with the recycling carts, thus reducing the potential for shoulder and lower back injuries. In addition, if this cart is used city wide, it will eliminate lifting and handling the recycling bins that are currently used. Again, the potential for shoulder and lower back injuries would be reduced.
2. The handles on the "Toter" carts cannot be used with a gloved hand. The handles should be replaced with larger handles that fit a gloved hand.
3. The carts currently in use are supposed to be placed with the handles and wheels facing the alley, street, or away from a wall. This placement enables the Worker to grasp the cart handle, tip the cart back and move the cart. However, most residents place the cart with the wheels facing away from the alley, street, or against a wall. The reason for this is the manner in which the lid opens. It is easier to open the lid with the wheels against a wall. A new cart design that lets the resident open the lid easily with the handles and wheels away from a wall may eliminate or reduce overexertion injuries that occur when moving carts stuck in snow, against a wall. Figure 7. illustrates a possible cart design that allows the resident to open the lid with the cart wheels away from a wall.
4. An out side handle attached to the rear of the cab door opening will give the Workers a handle to grab with the right hand, when entering the left side of the cab. When entering the cab, the Worker can grab the steering wheel with the left hand, the cab handle with the right hand, and step onto the door step with the left foot. Using a three-point entry and good entry techniques should reduce injuries that occur when entering the cab.
5. Increasing the friction on the door step will help reduce injuries that occur when entering and exiting the cab. Some steps are currently covered with abrasive strips that have an adhesive backing. However, these strips wear away quickly. Some alternative methods of increasing the friction on the step are rubber treads, wear-resistant adhesive strips, or non-slip safety

coatings. Some examples of these are listed in Appendix B.

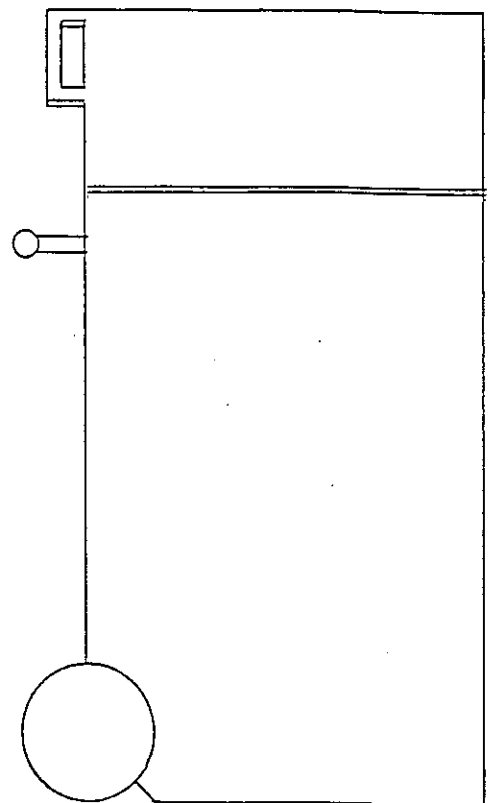
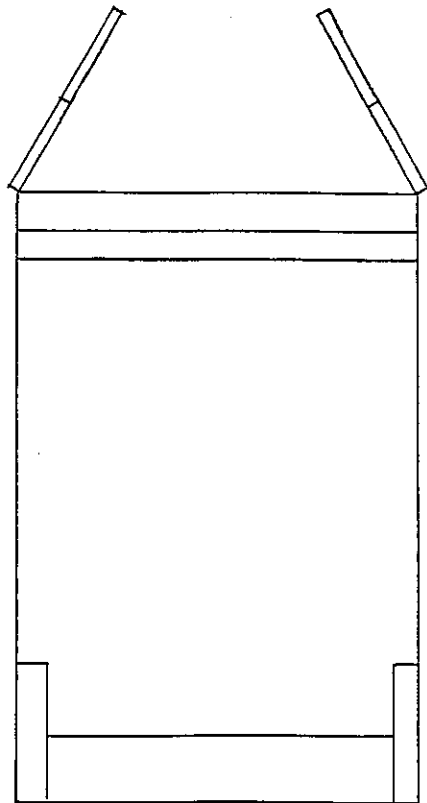
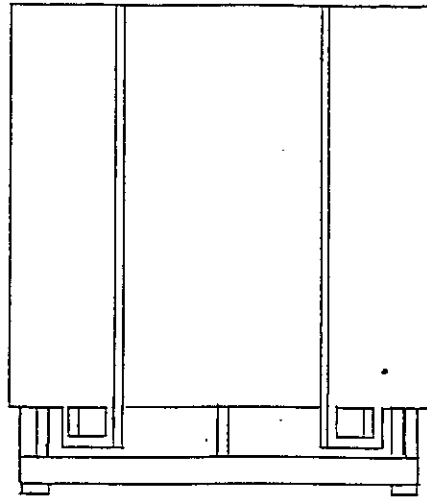


Figure 7. Cart design to accommodate Worker handling and access, and Resident access.

II. Work Practice Controls

1. Cart Handling

- A. The Workers should push carts and not pull them. Pushing a cart is less stressful on the lower back and shoulders. Pushing a cart allows the Worker to push the cart up to the flipper and place it on the fixture. To initiate movement of a cart, the Worker should grasp the cart handles, place one foot against the base of the cart or a wheel, and step back, pulling on the handle to pivot the cart onto the wheels. The cart can then be pushed to the truck.
- B. To lower a cart down a set of steps, the Worker should stay behind the cart while descending the steps. Remaining behind the cart is safer than in front of the cart, if the Worker should lose control. Behind the cart, the Worker can release the cart and not be struck by the cart. In front, the Worker could be struck by the cart if he loses control of the cart. To correctly lower the cart, the Worker should lower the cart down one step, keeping the back straight and using the legs to control the lowering. When lowering the cart, the Worker's feet should be one or two steps above the cart (Figure 8).

This method of lowering the cart still places stress on the lower back (Figure 9.), although not as much as the method shown in Figure 1. However, keeping the body behind the cart is safer in regards to slipping/tripping hazards when lowering the cart down the steps. If slipping/tripping hazards are not an issue, then lowering the cart, facing downhill with the cart behind the back, is the least stressful on the lower back. The best ergonomic solution is have the Workers retrieve the carts at curbside and eliminate lowering the carts down steps.

- C. To remove carts that are placed against a wall with the handle and wheels against the wall, the Worker should stand at the side of the cart and spin the cart 90° with the arms. The cart will now be in position for the Worker to correctly handle the cart. During winter months when carts are stuck in the snow, the Worker should stand at the side of the cart, feet planted firmly, and push against the top of the cart to rock it loose from the snow. Pushing on the top of the cart provides the Worker

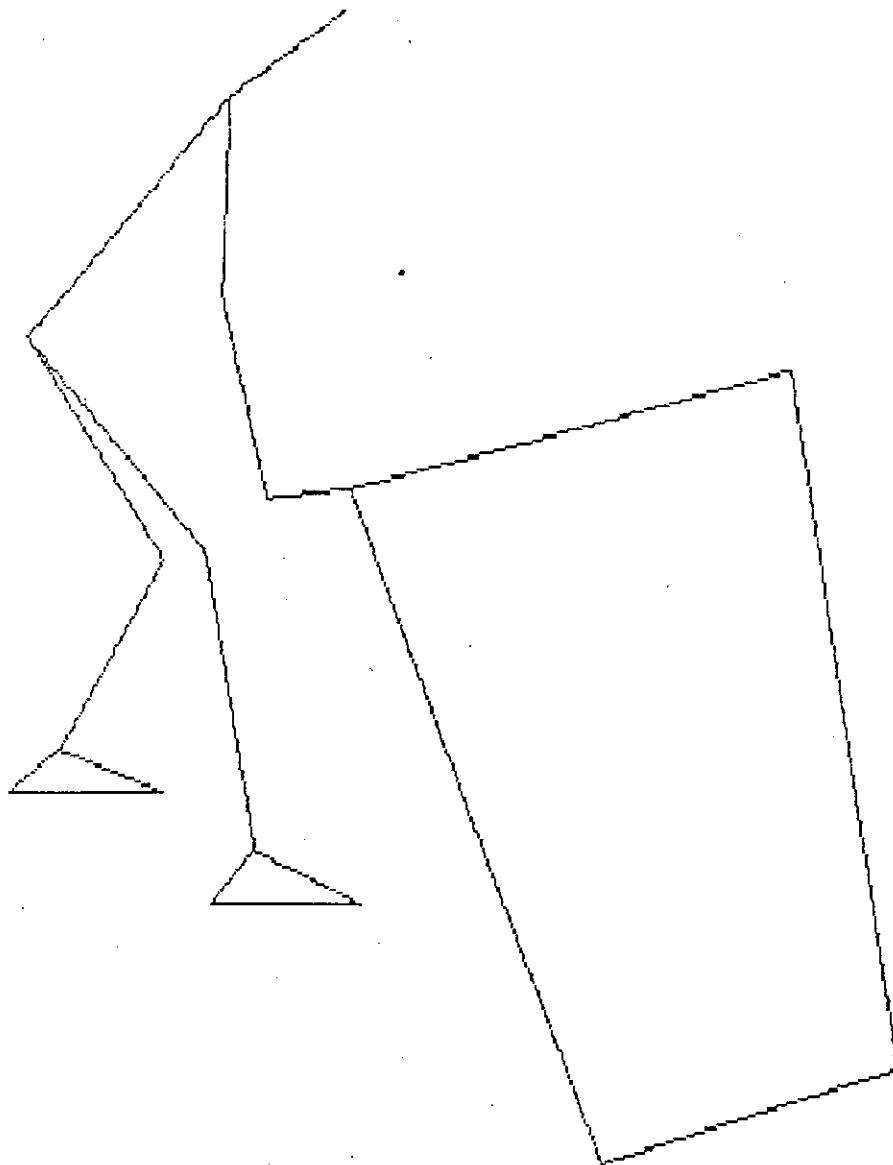
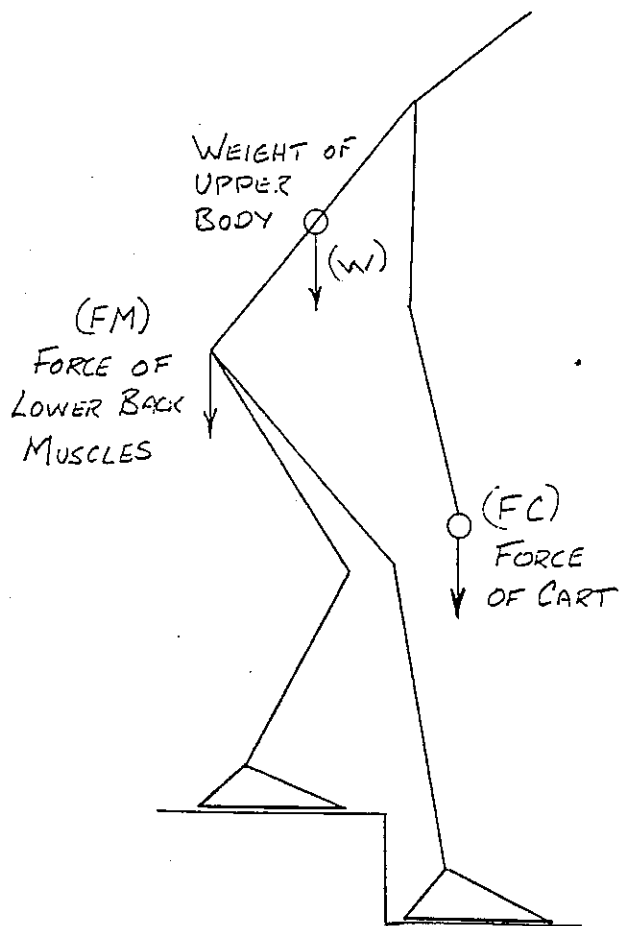
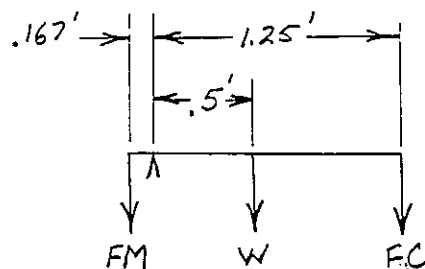


Figure 8. Worker descending steps with cart in front of the body.



Forces acting on body.

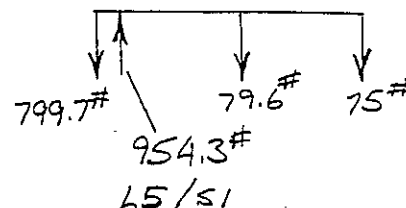


Free body diagram of forces.

$$FM(.167) = W(.50) + FC(1.25)$$

$$FM(.167) = 79.6(.50) + 75(1.29)$$

$$FM = 799.7 \text{ lbs.}$$



Compressive force diagram.

The compressive force on the lumbar intervertebral discs = 954.3 lbs.

NIOSH compressive force limit = 770 lbs.

Figure 9. Diagram of the compressive force acting on the lumbar intervertebral discs for the cart lowering method shown in Figure 8.

with greater leverage than pulling on the front bar. Once the cart is freed, the Worker can spin the cart 90° and correctly handle the cart.

- D. To remove a cart from a ledge in an alley the Worker should lower the cart down the ledge in the same manner as described above for lowering the cart down steps. If this is not possible or the ledge is too high, then two Workers should lower the cart. The Workers should stand on either side of the cart, grab the front bar, pull the cart forward, grab the handle, and lower the cart down the ledge. While lowering, the Workers should stay close to the cart, keep the back straight and use the legs to lower the cart.
- E. Carts that are overloaded with building materials should not be moved. The Workers should inform their supervisor and let him/her discuss the overloading problem with the resident.

2. Handling of Recycling Bins

- A. To remove a newspaper bin from a recycling cart the Worker should stand directly behind or in front of the cart, as close as possible, slide the bin to the body and then lift it from the cart. The Worker can then pivot on the feet, keeping the bin close to the body, and dump the bin into the recycling truck. Another method would be to move the cart next to the truck and remove the newspapers by hand instead of lifting the bin. If the bin is heavy the Worker should remove the newspapers by hand until he can safely handle the bin.
- B. When handling the red recycling bins, the Worker should lift the bags or bundles of newspapers separately from the bin and place them in the truck. This will reduce the amount of weight lifted by the Worker. To lift the newspapers and bins, the Worker should stand as close to them as possible, even squat over the load if possible, bend at the knees and waist, keep the back straight, grasp the load, and lift it, keeping the load as close to the body as possible at all times. Once the load is lifted the Worker can carry it to the truck and dump it in.
- C. A summary of proper lifting techniques is listed below:

- a. Always position the body so the load is as close to the body as possible.
- b. Lift with the legs and not with the back as often as possible.
- c. Do not lean to one side or twist at the trunk when lifting. Always face the load and pivot with the feet.
- d. Test the load before lifting so you know what you are lifting. Do not jerk on a load to lift it..

3. Handling Loose Bags & Household Items

- A. To properly lift loose bags the Worker should straddle the bag, bend at the knees and waist, grasp the top of the bag with both hands, test the weight to make sure it can be safely lifted, then lift the bag keeping the back straight and using the legs. One bag should be lifted at a time.
- B. Household items should only be lifted if one or both Workers are positive they can lift and carry the item safely. To reduce overexertion injuries from lifting household items, they should be lifted by equipment and not by Workers. Most household items are heavy and awkward to lift and carry. A front-end loader with a bucket or set of jaws should be used to lift and place these items in a truck.

4. Entering & Exiting the Cab

- A. When entering the left side of the cab, the Worker should grasp the steering wheel with both hands, place the left foot on the door step, and step into the cab leading with the right foot. While stepping into the cab the Worker should be aware of his right leg in relation to the steering column, to avoid hitting the column. Exiting the cab should be performed in the reverse manner of entering the cab. The Workers should be reminded to enter and exit the cab in a controlled manner, and not jump in and out of the cab.

III. Administrative Controls

- 1. Starting in the summer of 1993, City of Milwaukee residents will be required to place their carts curbside for trash collection. This policy will make handling of

the carts easier for the Workers, as they can correctly grasp the cart and initiate movement. Extending the curbside collection policy to year round will reduce the potential of overexertion injuries encountered when the Workers handle carts frozen in snow with the wheels and handle against a wall. In addition, a year round curbside collection policy will eliminate the practice of Workers lowering carts down a set of steps.

2. Provide training for the Workers regarding proper cart handling, bin handling, and cab entry/exit. Occupational Medical Clinic can establish and present a training program for the Sanitation Workers and Supervisors. The training program should be presented twice a year to reinforce proper material handling procedures and cab entry/exit procedures.

The training program should include the following:

- (1) A brief anatomy and biomechanics lesson to educate the Workers how the human body works, and what the capabilities and limitations of the body are.
 - (2) What the major causes of musculoskeletal injuries are (overexertion, improper body mechanics, and repetitiveness) and how they result in an injury.
 - (3) How to reduce the potential for musculoskeletal injuries through proper cart handling, bin handling, household item handling, and cab entry/exit.
 - (4) Demonstrations of proper cart handling, bin handling, household item handling, and cab entry/exit.
3. Supervisors should enforce proper cart and bin handling techniques when needed. Positive reinforcement is the best approach. However, if a Worker continues to use improper handling techniques, then disciplinary action should be taken.

ERGONOMIC PROGRAM PLAN

1. Review the Ergonomic Analysis with Bureau of Sanitation management and labor union, and discuss Hazard Control Recommendations.
2. Occupational Medical Clinic will develop an Ergonomic Training Program for the Sanitation Workers in conjunction with the Bureau of Sanitation management and the labor union.
3. Occupational Medical Clinic will implement the Ergonomic Training Program in a pilot study to examine the program's effectiveness.
 - A. Select a pilot district or area to implement the program.
 - B. Obtain data on employee injuries for the pilot area for the past three years (OSHA 200 logs, insurance records, etc.).
 - C. Present the Ergonomic Training Program to the pilot area supervisors and employees.
 - D. Put the program into affect for 3 - 6 months and monitor impact on employee injuries.
 - E. Re-evaluate the Ergonomic Training Program with management and employees to determine its effectiveness.
4. After the pilot study is completed, Occupational Medical Clinic will make changes as necessary to the Ergonomic Training Program and begin implementation in all districts.
5. Occupational Medical Clinic will meet with management and employees 3 - 4 times per year to re-evaluate program. The program should be a topic at all monthly safety meetings. Management and employee feedback is very critical for the success of the Ergonomic Training Program.
6. Occupational Medical Clinic will collect data on employee injuries every three months for 1 - 2 years and compare the incidence of injuries pre and post Ergonomic Training Program.
7. Occupational Medical Clinic will review the Ergonomic Training Program quarterly and provide report updates.

APPENDIX A

STRAINS

<u>CAUSES</u>	<u>MOST FREQ. PART INJURED</u>	
1. LIFTING BINS/BAGS/ETC.	BACK - SHOULDER	35
2. PULLING/PUSHING CARTS	BACK - SHOULDER	28
3. GETTING IN/OUT OF TRUCK	KNEE - ANKLE	15
4. SLIPS		14
5. DRIVING FLEET ACCIDENTS		8
6. WALKING/STEPPED ON STONE/GRAVEL		6
7. PULLING ON PACKING CYCLE HANDLE		5
8. DUMPING RECYCLING BINS		5
9. BENDING TO PICK UP MATERIAL		2
10. BANGED KNEE/FINGER		3
11. LOST CONTROL OF CART		3
12. GRABBED CART		2
13. THROWING MATERIAL IN CART		2
14. CARRYING MATERIAL		2
15. NUMBNESS & COLD FINGERS		1
16. UNHOOKING PLOW BLADE		1
	TOTAL	132

TYPE OF INJURIES

1. STRAINS	132
2. CONTUSIONS	71
3. LACERATIONS	21
4. PUNCTURE	12
5. MISCELLANEOUS	16
	TOTAL
	252

PART OF THE BODY INJURED

BACK	40
SHOULDER	23
KNEE	18
ANKLE	10
WRIST	7
GROIN	6
ARM	6
FINGER	5
ELBOW	4
LEG	4
CHEST	3
ABDOMEN	2
HAND	2
FOOT	1
NECK	1
	TOTAL
	132