HETA 98-0291-2750
Safelite Auto Glass
Cincinnati, Ohio

Elena H. Page, M.D., M.P.H.
Thomas R. Waters, Ph.D., C.P.E.

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Elena Page of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies and Thomas Waters of the Applied Psychology and Ergonomics Branch, Division of Biomedical and Behavioral Science. Field assistance was provided by Brian Lowe of the Applied Psychology and Ergonomics Branch, Division of Biomedical and Behavioral Science. Desktop publishing was performed by Elaine Moore and Patricia McGraw. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Safelite and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Safelite Auto Glass
Cincinnati, Ohio
August 1999

Elena H. Page, M.D., M.P.H.
Thomas R. Waters, Ph.D., C.P.E.

SUMMARY

On July 27, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) from employees of Safelite Auto Glass in California. This request stated that employees were lifting excessive weights and using awkward positions when removing and installing windshields, and this had resulted in neck and back disorders. In response to this request, NIOSH investigators conducted two site visits at Safelite facilities in Cincinnati, Ohio, on September 22, 1998, and on September 30, 1998.

The NIOSH investigation consisted of observation and videotaping of the removal and installation process both in the shop and with a mobile operator. Workers Compensation (WC) data was reviewed for Safelite employees in Ohio from March 1, 1997, to December 31, 1998.

To assess the potential risks to the low back associated with the removal and installation of the windshield, we used the revised NIOSH lifting equation[1] to determine the physical demands associated with the lifting component of the job. We found that lifting a 25-pound windshield yielded a lifting index (LI) of 1.2 and a 50-pound windshield yielded a LI of 2.3, indicating an increased risk for low back pain.

To estimate the strength requirements and forces developed about the low back, shoulders, and arms during the lifting activity, we used the University of Michigan three-dimensional static strength prediction program (3DSSPP) to model the lifting activity. Only 3% of the male worker population would have the shoulder strength needed to lift the 50-pound windshield, and only 51% of the male worker population would have the necessary elbow strength. The L5/S1 disc compression force for this lift would be 650 pounds, a value slightly below the 770 pounds (3,400 Newtons) disc compression force that is considered to be hazardous for infrequent lifting.

To estimate the physical demands of using the cold knife, we used the Strain Index (SI), a mathematical equation for estimating the potential risk of distal upper extremity musculoskeletal disorder for a repetitive upper extremity task. Applying the SI equation to these data yields an SI value of 5.1 for cutting the seal between the old windshield and the window. Jobs with SI values above 5 have been shown to have significantly increased risk of distal upper extremity musculoskeletal.

Review of WC data for installing technicians reveals a rate of 125.8 back disorders/10,000 employees from March 1, 1997, to December 31, 1997, and 322/10,000 employees from January 1, 1997, to December 31, 1998, compared to 0/10,000 and 54.5/10,000 for employees other than installing technicians. Rates of neck disorders in installing technicians were 377.4/10,000 and 322.6/10,000 employees in 1997 and 1998, respectively, compared to 26.8/10,000 and 18.2/10,000 in other employees.

The task of installing a new windshield poses a risk of back, shoulder, elbow, and distal upper extremity disorders. The risk increases as the weight of the windshield increases. Recommendations include: (1) providing an assistive lift device for lifting the old windshield from the vehicle and for lifting and positioning the new windshield in the window frame, or providing two workers to lift and position the windshield in place during the installation; (2) developing better tools for raising the windshield while the worker is cutting the seal from inside the car; (3) wearing eye protection during glass removal; (4) establishing regular safety and health meetings at the corporate, district, and local levels; and (5) forwarding all OSHA 200 logs to corporate level for analysis and action.

KEYWORDS: SIC 7536; auto glass installation and removal, neck, back, ergonomics, lifting

National Institute for Occupational Safety and Health (NIOSH) Evaluation of Musculoskeletal Hazards in Safelite Auto Glass Installing Technicians

NIOSH conducted this health hazard evaluation (HHE) in September 1998 at the request of Safelite employees who were concerned they may be at risk of neck and back disorders from the task of windshield replacement.

What NIOSH Did

- Observed and videotaped workers removing and installing front window glass
- Performed an ergonomic analysis and calculated physical stresses to the shoulder, arm, and back
- Reviewed Workers' Compensation data for neck, back, and shoulder injuries in Ohio employees from March 1, 1997, through December 31, 1998

What NIOSH Found

- The task of replacing a windshield poses a risk of back, shoulder, and elbow disorders
- The risk increases as the weight of the windshield increases
- Installing technicians had higher rates of neck, back, and shoulder disorders than other employees

What Safelite Auto Glass Managers Can Do

- Provide a lifting device for windshield installation or have two workers lift and position the windshield
- Adjust incentive pay to account for the added time needed to do the job safely
- Develop better tools for raising the windshield while the worker is cutting the seal from inside the car
- Establish regular safety and health meetings at the corporate, district, and local levels
- Forward all OSHA 200 logs to the corporate level for analysis and action

What the Safelite Auto Glass Employees Can Do

- Use lifting devices if available when installing a windshield, otherwise, ask a co-worker to help with windshield installation
- Report possible job-related neck, back, shoulder, or arm pain to your supervisor as soon you notice it

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841- 4252 and ask for HETA Report # 98-0291-2750

NIOSH National Institute for Occupational Safety and Health

TABLE OF CONTENTS

INTRODUCTION

On July 27, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) from employees of Safelite Auto Glass in California. This request stated that employees were lifting excessive weights and using awkward positions when removing and installing windshields, and this had resulted in neck and back disorders. In response to this request, NIOSH investigators conducted two site visits in Cincinnati, Ohio, on September 22, 1998, and on September 30, 1998. This evaluation at a different facility was acceptable to the requestor, as both the requestor and management agreed that the work was similar at all Safelite facilities.

BACKGROUND

Safelite Auto Glass is a nationwide supplier of auto glass replacement services with corporate headquarters in Columbus, Ohio. There are approximately 6,900 employees at over 800 locations nationwide, organized into 40-45 districts. Approximately 50% of these employees are installers. There are approximately 1200 employees in Ohio. In 1997-1998, the average number of installers in Ohio was 86; the rest of the employees mostly were administrative, with some warehouse workers. Since installers perform the same duties in all locations, any site should be representative of work done in all sites. This investigation focused on employees in Ohio.

Each shop has between one and six installers. Some work in a fixed location (shop), and some work from a mobile van. In the Cincinnati area, 68% of installations are mobile. Installers receive on-the-job training, and are paid a base salary plus an incentive based on number of installations done. Incentive pay is forfeited if the windshield is not properly installed. The majority of jobs are done by one installer. It is left to the discretion of the installer to determine if assistance is needed on a large job. If the installer is mobile, then he/she must wait for help to arrive, and this decreases the number of jobs completed that day. The average number of installations per installer is 1,200 annually.

Safelite does not have a corporate safety and health committee nor does it have periodic safety meetings. The Occupational Safety and Health Administration Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs) are maintained at each shop, and the logs are not forwarded to the district or to the corporate level. Safelite has a contract with a loss control agent to formulate a plan to decrease injury rates and Worker's Compensation costs.

The replacement of a windshield begins with removing the trim around the window, then cutting the old seal between the windshield and the frame, using a long knife and a cold-cut knife. Considerable force is required to cut through the existing sealant that holds the glass in place. Then the glass has to be pushed out of the car, often requiring the installer to push with his head and both hands. The area of the vehicle where the glass sits, the pinchweld, must be cleaned, and rust must be removed. To prevent corrosion, a solvent-based polyisocyanate primer is applied to areas where the metal is bare. The replacement glass is then cleaned using an alcohol-based cleaner. A solvent-based activator is applied to the band of paint along the edge of the glass (frit band). A polyurethane adhesive is then heated to 175^{o} F and applied in a triangular bead along the pinchweld, using a battery-powered caulking gun. The new glass is placed in position and pressed into place. This is done manually by the installer, who has to reach across the hood of the vehicle to position the glass accurately because it will not slide once it has been set. Finally, the trim is reinstalled.

METHODS

Ergonomic Assessment

During two separate visits, we observed and videotaped workers removing and installing the front window glass in a number of different vehicles. During our first visit, we observed an installer replacing the front window glass in cars at a branch service shop. During our second visit, we observed an installer replacing the front window glass in a full-size van at a field location.

Revised NIOSH Lifting Equation

To assess the potential risks to the low back associated with the removal and installation of the windshield, we used the revised NIOSH lifting equation[1] to determine the physical demands associated with the lifting component of the job. The revised NIOSH lifting equation is a mathematical formula for determining the recommended weight limit (RWL) for a two-handed manual lifting task. The RWL is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g., up to 8 hours) without an increased risk of developing lifting-related low back pain (LBP). The equation considers the geometry of the lifting activity (where the load starts and ends), the frequency rate of lifting, and the quality of the hand-to-object coupling. The lifting index (LI), a term that provides a relative estimate of the physical stress associated with a particular manual lifting task, can then be determined for the lift by dividing the actual weight lifted (L) by the RWL for the job. The details of the equation are presented in Appendix A. According to NIOSH, it is likely that lifting tasks with an LI > 1.0 pose an increased risk for lifting-related LBP for some fraction of the workforce, and that lifting tasks with an LI > 3.0 pose an increased risk of LBP for many workers. Thus, as the LI of a job increases, the risk of LBP for a population of workers likely increases.

Biomechanical Analysis

To estimate the strength requirements and forces developed about the low back, shoulders, and arms during the lifting activity, we used the University of Michigan three-dimensional static strength prediction program (3DSSPP) to model the lifting activity. The University of Michigan 3DSSPP model is a computer program that provides estimates of static lumbar disc compression force and moments at the L5/S1 disc, as well as estimates of the muscle strength requirements needed to perform a specified material handling activity.[2] The model requires input of 15 joint angles to define body posture, three anthropometric measures that define body characteristics, and six measurements that define the magnitude and direction of externally applied forces at the two hands. The model computes axial disc compression force and anterio-posterior and lateral shear forces at the L5/S1 joint, as well as the moments and muscle forces acting at each of the major joints. The estimated biomechanical loads can then be compared to baseline values that define various levels of physical stress or risk.

Strain Index

To estimate the physical demands of using the cold knife, we used the Strain Index (SI), a mathematical equation for estimating the potential risk of distal upper extremity musculoskeletal disorder for a repetitive upper extremity task.[3] The SI is a semi-quantitative job analysis methodology that results in a numerical score that the authors believe correlates with the risk of developing distal upper extremity disorders. The SI represents the product of six multipliers that correspond to six task variables. The six task variables include: (1) intensity of exertion, (2) duration of exertion, (3) exertions per minute, (4) hand/wrist posture, (5) speed of work, and (6) duration of the task per day. Each of the six variables are rated according to five levels as shown in Appendix B. The SI is then calculated using multipliers that are derived from the ratings, using the multiplier table shown in Appendix B. The SI equation is shown below:

Strain Index (SI) = (Intensity of Exertion Multiplier) X (Duration of Exertion Multiplier) X (Exertions per Minute Multiplier) X (Posture Multiplier) X (Speed of Work Multiplier) X (Duration per Day Multiplier).

Although the SI has not yet been widely validated, its authors have reported that it is an effective tool for distinguishing a safe from a hazardous job with regard to distal upper extremity musculoskeletal disorders such as tendinitis, peritendinitis, delayed-onset muscular soreness, muscle strains, localized muscle fatigue, stenosing tenosynovitis, and carpal tunnel syndrome. Jobs with SI values above 5 have been shown to have significantly increased risk of distal upper extremity musculoskeletal disorders.

Medical

Workers Compensation data for Safelite employees in Ohio from March 1, 1997, to December 31, 1998, were reviewed. These dates were chosen because computerized data were available only from March 1, 1997. The following International Classification of Disease 9th Revision (ICD9) codes were the focus of the review: 722.0 (cervical disc), 722.10 (thoracic or lumbar disc), 722.4 (cervical disc degeneration), 722.5 (thoracic or lumbar disc degeneration), 722.71 (cervical disc and myelopathy), 722.72 (thoracic disc and myelopathy), 722.73 (lumbar disc with myelopathy), 723.1 (cervicalgia), 723.4 (cervical radiculitis), 724.2 (lumbago), 724.3 (sciatica), 724.4 (thoracic or lumbosacral radiculitis), 724.5 (backache not otherwise specified), 846.0 (lumbosacral sprain), 846.1 (sacroiliac strain), 847.0 (cervical strain), 847.1 (thoracic strain), 847.2 (lumbar strain), 847.9 (back not otherwise specified), and 840.0-9 (sprains and strains of the shoulder and upper arm).

One employee was interviewed by telephone and one employee in a shop was interviewed in person.

RESULTS

Ergonomic Assessment

In order to assess the physical demands associated with these tasks we evaluated the videotapes of the workers installing the glass and conducted an ergonomic analysis of the three task elements. The primary musculoskeletal stressors associated with these tasks are shown in Table 1. While there are potential stressors associated with nearly all of the task elements we observed, the level of musculoskeletal stressors appeared highest for the seal-cutting, window removal, and window placement tasks.

Static Back Postures

During our visit we observed that workers often had to adopt awkward trunk postures during the windshield replacement process. Awkward trunk postures, such as those we observed, can create large static forces on the musculoskeletal components of the back that can increase the workers risk of developing a back disorder. Therefore, to the extent feasible, the work should be designed so that awkward trunk postures can be avoided.

Revised NIOSH Lifting Equation

We assumed that the loading on the spine would be the greatest at two points during the windshield replacement process: (1) the lift-off point during the removal of the old windshield, and (2) the set-down point during installation of the new windshield. We also assumed that the worker would grasp and lift the load in the same manner at those two points. Therefore, the lifting equation value would be the same for both points. We analyzed the lift using two windshield weights, 25 and 50 pounds. The input values and results for our analysis of this lift are shown in Tables 2 and 3. We found that lifting a 25-pound windshield yielded a LI of 1.2, and a 50-pound

windshield yielded a LI of 2.3, indicating an increased risk for LBP.

Biomechanical Analysis

The same assumptions about the location of greatest musculoskeletal loading was assumed for our analysis with the University of Michigan 3DSSPP. The results of our biomechanical analysis are shown in Table 4. As can be seen in the table, only 3% of the male worker population would have the shoulder strength needed to lift the 50 pound windshield, and only 51% of the male worker population would have the necessary elbow strength. Safelite installers are mostly males. Females working in this job generally would have less strength capacity and may be at higher risk performing the same job. The L5/S1 disc compression force for this lift would be 650 pounds, a value slightly below the 770 pounds (3400 Newtons) disc compression force that is considered to be hazardous for infrequent lifting.

Strain Index

In observing the workers cutting the old seal between the window and the frame, it was apparent that the use of the cold knife required the workers to use a significant amount of hand, arm, and shoulder force to separate the glass from the frame. Moreover, the cutting operation sometimes required the worker to work in an awkward posture (trunk twisted and flexed and arms raised), which reduces the efficiency of the muscular exertions. Excessive muscle exertion may place the worker at an increased risk of developing an upper extremity musculoskeletal disorder. Based on our observations of the seal cutting activity in a full sized van where the technician stood on the rocker panel while performing the task, we rated the six factors needed to use the strain index for estimating the stress to the distal upper extremities for this task. The input parameters and corresponding multipliers for determining the strain index for this task are shown in Table 5. Applying the SI equation to these data yields an SI value of 5.1 for cutting the seal between the old windshield and the window. This value may be lower while performing the task in other vehicles or under different circumstances, for example, standing on a step stool instead of the rocker panel. According to the developers of the strain index, a value greater than 5.0 was associated with a significant risk of upper extremity musculoskeletal disorders. We concluded that the seal cutting task may pose a risk for distal upper extremity musculoskeletal disorder. A recent NIOSH HHE found the use of the cold knife preferable to the use of power tools for cutting the seal.[4]

Medical

The number of neck, back, and shoulder disorders for which Workers Compensation claims were accepted among Safelite employees in Ohio are listed in Table 6. These figures can represent more than one diagnosis per individual. For example, one individual filed one claim for 2 diagnoses, and another for 3 diagnoses. Both claims and all 5 diagnoses involved lost work-time. The rates by year, job category, and body part are listed in Tables 7 and 8. The rates of back disorders were approximately 8 times higher in installing technicians than in other employees over the time periods analyzed. Rates of neck disorders were approximately 15 times higher, and rates of shoulder disorders were 36 times higher.

The employee interviewed by telephone reported having a work-related back injury that resulted in a surgical procedure. The employee interviewed in person did not report any health concerns related to the process of removing and installing glass other than exposure to the chemicals used.

DISCUSSION

Our ergonomic assessment found an increased risk of low back injuries, with a LI of 1.2 for a 25-pound windshield, and 2.3 for a 50-pound windshield. Biomechanical analysis found an L5/S1 disc compression force for this lift of

650 pounds, a value slightly below the 770 pounds (3400 Newtons) disc compression force that is considered to be hazardous for infrequent lifting (i.e., less than 12 lifts per hour). Review of WC data for installing technicians reveals a rate of 125.8 back disorders/10,000 employees from March 1, 1997 to December 31, 1997, and 322/10,000 employees from January 1, 1998, to December 31, 1998, compared to 0/10,000 and 54.5/10,000 for employees other than installing technicians. This rate is for both lumbosacral and thoracic strains (See Tables 7 and 8). None of these claims resulted in lost-time, making the rate for lost-time back injuries 0/10,000 employees. This is lower than rates reported by the Bureau of Labor Statistics (BLS) for back injuries involving lost work-time in the auto repair industry (SIC 753), which ranged from 50.2 to 57.0 per 10,000 full-time workers in the years 1992-1995 (See Table 9). The installers receive incentive pay based on the number of installations completed. Workers' Compensation reimburses a percentage of base pay if there is a lost work-time injury, but employees do not receive their incentive pay. This may lead to increased motivation to stay on the job despite an injury, and may also result in under-reporting of injuries. Because assistive devices may increase the amount of time to install a windshield, incentive pay may also reduce employees willingness to use these assistive devices.

Rates of neck disorders in installing technicians were 377.4/10,000 and 322.6/10,000 employees in 1997 and 1998, respectively, compared to 26.8/10,000 and 18.2/10,000 in other employees. Lost work-time rates in the same years were 125.8/10,000 and 0/10,000 (Tables 7 and 8). BLS reported rates of neck disorders involving lost work-time ranged from 2.9 to 5.8 per 10,000 full-time workers in the years 1992-1995 (Table 9). The lost work-time rates in installers in 1997 exceed the BLS reported rates, but the company rates are based on a single lost work-time claim. Biomechanical analysis found that only 3% of the male population would have the shoulder strength necessary for lifting the windshield. The overall rates of shoulder disorders in installing technicians were 0/10,000 in 1997 and 322.6/10,000 in 1998. Rates of disorders involving lost work-time were 0/10,000 and 107.5/10,000 in 1997 and 1998, respectively. Rates reported by BLS ranged from 6.9 to 10 per 10,000 full-time workers for the years 1992 -1995 (Table 9). Therefore the rates of shoulder disorders resulting in time away from work in 1998 exceeded rates reported by BLS in the auto repair industry. However, this is the result of a single lost work-time claim.

The strain index indicates a moderate risk for distal upper extremity disorders. Workers' Compensation rates were not reviewed for these diagnoses, as the HHE request primarily concerned neck and back injuries.

The injury rates in installers are based on small numbers, both in the claims accepted and in the denominator. There was an average of 86 installers in the time frame studied, and a total of 13 accepted claims in the ICD codes studied. Only 2 of these resulted in lost work-time. While the rates in the installers were higher than in the other employees at Safelite (Tables 7 and 8), 16.7% of claims in installers resulted in lost work-time, compared to 63% of claims in other employees.

It may be misleading to directly compare the Safelite rates to those of BLS for the auto repair industry because the Safelite rates are based on accepted WC claims, while BLS data are derived from OSHA 200 logs, which include all injuries and illnesses reported by workers. It is highly likely that all injuries logged do not result in an accepted WC claim. Safelite keeps OSHA 200 logs at each shop, but they are not forwarded to district or corporate offices. Thus, we were unable to analyze these data.

CONCLUSIONS

Based on the ergonomic analysis, the task of installing a new windshield poses a risk of back, shoulder, elbow, and distal upper extremity injury. The risk would increase as the weight of the windshield increases and as the frequency of installations increases. Rates of neck, shoulder, and back disorders were much higher in installing technicians than in other employees of Safelite in the state of Ohio, but a higher percent of disorders in non-installing employees resulted in lost work-time. Because the installers receive incentive pay, they may be less inclined to miss work than employees who do not receive incentive pay.

RECOMMENDATIONS

1. Provide an assistive lift device for lifting the old windshield from the vehicle and for lifting and positioning the new windshield in the window frame. Devices are available both for use in the shop and on a mobile unit that will assist with the lifting of the glass into place. These devices consist of an electronically controlled arm, which can lift and lower the glass into place. The glass is attached to the arm via suction devices. The device may be suspended above the workspace in the shop, or for a mobile installation, attached to the worker's van. Alternatively, or as an interim measure, provide two workers to lift and position the windshield in place during the installation. This may effect the number of installations completed and incentive pay should be adjusted accordingly so as not to adversely affect the employees. Otherwise, workers will have less incentive to ask for help lifting the windshield or to take the time to use the lifting device.

2. Develop better tools for raising the windshield while the worker is cutting the seal from inside the car so the worker does not have to lift the glass with his head. Air bladders are available at Safelite but are not generally used. Research is needed to develop tools that are more acceptable to the workers.

3. Wear eye protection during glass removal.

4. Establish regular safety and health meetings at the corporate, district, and local levels.

5. Wear appropriate gloves when applying primer or handling broken glass.

6. Ensure adequate ventilation when utilizing chemicals.

7. Forward all OSHA 200 logs to corporate level for analysis and action.

REFERENCES

1. Waters TR, Anderson VP, Garg A. [1994] Applications manual for the revised NIOSH lifting equation, DHHS (NIOSH) Pub. No. 94-110, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, Ohio.

2. Chaffin D., Andersson G., Martin B. [1999] Occupational Biomechanics, Third Edition, John Wiley & Sons, Inc. New York.

3. Moore and Garg, [1995] The strain index: A proposed method to analyze jobs for risk of distal upper extremity disorders. American Industrial Hygiene Association Journal 56:443-458.

4. NIOSH [1999]. Hazard Evaluation and Technical Assistance Report: Oakes and Parkhurst Glass, Winslow, Maine. Cincinnati, OH:U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. NIOSH Report No. HHE 99-0029.

Table 1. Primary Musculoskeletal Hazards for Auto Glass Installers

Body Part at Risk	Physical Exposure Hazard	Cause of Hazard
Low Back	Awkward Back Postures Heavy Manual Lifting	Sustained bending and reaching Lifting Glass (install and removal)
Shoulders	Awkward Arm Postures Heavy Manual Lifting Excessive Force Application	Excessive reaching Lifting glass Use of cutting tools
Hand and Wrist	Awkward Wrist Postures Excessive Force Application Vibration	Use of cutting tools Use of cold knife Use of electric cutting saw
Head and Neck	Excessive Force Application	Lifting glass with head

Table 2. Input measurements for the Revised NIOSH Lifting Equation for the windshield lifting task (See Appendix A for definition of terms)

Hand Location (in)				Vertical	Asymmetry		Lift	Duration	Coupling
Origin		Destination		Distance	Angle (deg)		Frequency		
H	V	H	V	(in)	Orig	Dest	(lifts/minute)		
20	50	25	50	0	0	0	<.2	1 hour	Fair

Table 3. Revised NIOSH Lifting Equation calculations for the windshield lifting task (See Appendix A for definition of terms)

Task	LC	HM	VM	DM	AM	CM	FM	RWL	LI
Lift 25 lbs	51	.50	.85	1.0	1.0	1.0	1.0	21.7	1.2
Lift 50 lbs	51	.50	.85	1.0	1.0	1.0	1.0	21.7	2.3

Table 4. Biomechanical analysis of windshield lifting task

Task	Disc Compression Force (lbs)	Percentage of Population with Sufficient Strength Capability						Estimated Ligament Strain (%)
		Elbow	Shoulder	Torso	Hip	Knee	Ankle	
50 lb lift	650 ± 47	51	3	85	77	91	66	6.98
25 lb lift	451 ± 31	97	80	96	88	99	86	6.98

Table 5. Strain Index for seal cutting operation

	Intensity of Exertion	Duration of Exertion	Efforts per minute	Hand/Wrist posture	Speed of Work	Duration per day (hrs)
Rating	Very Hard	10-29	9-14	Fair	Fair	≤ 1
Multiplier	9	1.0	1.5	1.5	1.0	.25

SI = 9 x 1.0 x 1.5 x 1.5 x 1.0 x .25 = 5.1

Table 6. Number of Neck, Back, and Shoulder Disorders,* by Body Part and Job Title, Safelite Auto Glass, Ohio, March 1, 1997, - December 31, 1998

Body Part	**Installing Technicians**	**Other Employees**	**Total**
	Total # Disorders (Lost time)	Total # Disorders (Lost time)	Total # Disorders (Lost time)
Neck	6 (1)	5 (4)	11 (5)
Back	4 (0)	6 (3)	10 (3)
Lumbosacral	2 (0)	4 (2)	6 (2)
Thoracic	2 (0)	2(1)	4 (1)
Shoulder	3 (1)	1 (1)	4 (2)

* only disorders for which Worker's Compensation claims were accepted are included

Table 7. Neck, Back, and Shoulder Disorder Rates per 10,000 employees of Safelite Auto Glass in Ohio*, by Job Title, March 1, 1997, - December 31, 1997

Body Part	Installing Technicians	Other Employees	Total
	Overall Rate (Lost time)	Overall Rate (Lost time)	Overall Rate (Lost time)
Neck	377.4 (125.8)	26.8 (26.8)	50 (33.3)
Back (lumbosacral and thoracic)	125.8 (0)	0 (0)	8.3 (8.3)
Shoulder	0 (0)	8.9 (8.9)	8.3 (8.3)

* only disorders for which Workers Compensation claims were accepted are included

Table 8. Neck, Back, and Shoulder Disorder Rates per 10,000 employees of Safelite Auto Glass in Ohio*, by Job Title, January 1, 1998, - December 31, 1998

Body Part	Installing Technicians	Other Employees	Total
	Overall Rate (Lost time)	Overall Rate (Lost time)	Overall Rate (Lost time)
Neck	322.6 (0)	18.2 (9.1)	41.7 (8.3)
Back (lumbosacral and thoracic)	322.6 (0)	54.5 (27.3)	75 (25)
Shoulder	322.6 (107.5)	0 (0)	25 (8.3)

* only disorders for which Workers Compensation Claims were accepted are included

Table 9. Incidence Rates Involving Days Away From Work per 10,000 Full-time Workers for the Automotive Repair Industry, SIC Code 753. (BLS)

Body Part	1992	1993	1994	1995
Neck	5.3	5.8	2.9	2.9
Back	56.9	52.4	57.0	50.2
Shoulder	8.7	6.9	9.5	10.0

FIGURE 1. Installation of windshield

Appendix A

NIOSH Lifting Equation Calculations
Safelite Auto Glass
HETA 98-0291-2750

A. Calculation for Recommended Weight Limit

RWL = LC * HM * VM * DM * AM * FM * CM
(* indicates multiplication)

Recommended Weight Limit

COMPONENT	METRIC	U.S. CUSTOMARY
LC = Load Constant	23 kg	51 lbs
HM = Horizontal Multiplier	(25/H)	(10/H)
VM = Vertical Multiplier	(1-(.003|V-75|))	(1-(.0075|V-30|))
DM = Distance Multiplier	(.82+(4.5/D))	(.82+(1.8/D))
AM = Asymmetric Multiplier	(1-(.0032A))	(1-(.0032A))
FM = Frequency Multiplier	(from Table 1)	(from Table 1)
CM = Coupling Multiplier	(from Table 2)	(from Table 2)

Where:

H = Horizontal location of hands from midpoint between the ankles. Measure at the origin and the destination of the lift (cm or in).

V = Vertical location of the hands from the floor. Measure at the origin and destination of the lift (cm or in).

D = Vertical travel distance between the origin and the destination of the lift (cm or in).

A = Angle of asymmetry - angular displacement of the load from the sagittal plane. Measure at the origin and destination of the lift (degrees).

F = Average frequency rate of lifting measured in lifts/min.
Duration is defined to be: $\leq$ 1 hour; $\leq$ 2 hours; or $\leq$ 8 hours assuming appropriate recovery allowances (See Table 1)

Appendix A
Table 1

Frequency Multiplier (FM)
NIOSH Lifting Equation

Frequency Lifts/min	Work Duration					
	≤ 1 Hour		≤ 2 Hours		≤ 8 Hours	
	V † < 75	V ≥ 75	V < 75	V ≥ 75	V < 75	V ≥ 75
0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in cm; 75 cm = 30 in.

Appendix A
Table 2
Coupling Multiplier
NIOSH Lifting Equation

Couplings	V< 75 cm (30 in)	V ≥ 75 cm (30 in)
	Coupling Multipliers	
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Appendix B
Strain Index Calculations
Safelite Auto Glass
HETA 98-0291-2750

A. Rating Criteria

Rating	Intensity of exertion	Duration of Exertion	Efforts/Minute	Hand/Wrist Posture	Speed of Work	Duration per Day
1	light	< 10	< 4	very good	very slow	≤ 1
2	somewhat hard	10-29	4-8	good	slow	1-2
3	hard	30-39	9-14	fair	fair	2-4
4	very hard	50-79	15-19	bad	fast	4-8
5	near maximal	≥ 80	≥ 20	very bad	very fast	≥ 8

B. Multiplier Table

Rating	Intensity of Exertion	Duration of Exertion (% of cycle)	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration per Day (hrs)
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.50
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.00
5	13	3.0	3.0	3.0	2.0	1.50

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
www.cdc.gov/niosh

National Institute for Occupational Safety and Health
NIOSH

Delivering on the Nation's promise:
! Safety and health at work for all people through research and prevention