U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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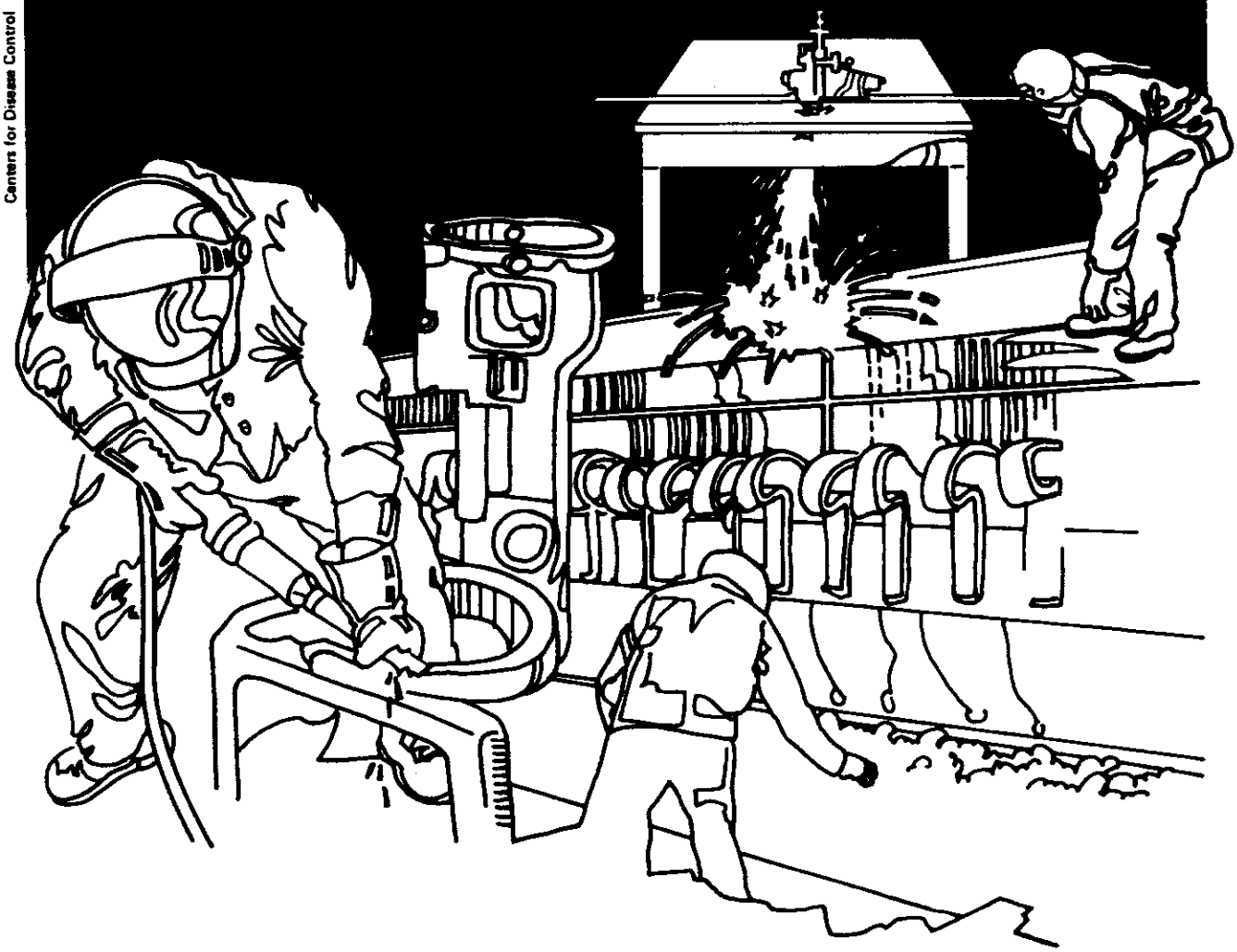
NIOSH



Health Hazard Evaluation Report

HETA 87-428-2063
ANCHOR SWAN DIVISION
HARVARD INDUSTRIES, INC.
BUCYRUS, OHIO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

HETA 87-428-2063
AUGUST 1990
ANCHOR SWAN DIVISION
HARVARD INDUSTRIES, INC.
BUCYRUS, OHIO

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I. SUMMARY

In September 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from the management of Anchor Swan Division, Harvard Industries, Inc., Bucyrus, Ohio. NIOSH was asked to investigate a "Carpal Tunnel Syndrome (CTS) problem" prevalent in certain departments of the plant. The plant employs approximately 600 workers, and manufactures a variety of automotive, industrial, and garden hoses.

The initial site visit was made in August 1987, at which time representatives of the management and the labor union were interviewed and workers' compensation (WC) claims and OSHA 200 logs reviewed. These reviews indicated that employees involved with pin and cure (P & C) jobs in the formed hose department filed workers' compensation claims for hand/wrist cumulative trauma disorders (CTDs) 5.8 times more frequently during the period 1980-84, and were recorded in OSHA 200 logs as "repetitive trauma" 10.5 times more frequently during the period 1984-86, compared to other employees of the plant.

In early 1988, a self-administered musculoskeletal questionnaire for the upper extremity was mailed to all employees. Employees in the formed hose department reported "hand/wrist pain and other related problems lasting for at least 4 days" approximately twice as frequently as workers in all other manufacturing departments, and 10 times more often as the office and sales employees.

In July 1989, an ergonomic evaluation of pin and cure job and other potentially high exposure jobs was conducted, including braiding in the industrial hose department, coupling in the plastic hose department, and cut, trim, pack and assemble (CTPA) in the formed hose department. These jobs had been perceived to be at risk of developing CTDs by both management and labor union representatives. The ergonomic analyses indicated that the P & C and braiding jobs involved high exposures to musculoskeletal stressors, the coupling job had medium exposures, and the CTPA job which had a history of increased numbers of WC claims and OSHA log entries, had low to moderate exposures.

On the basis of these evaluations, NIOSH investigators determined that potential musculoskeletal hazards, resulting in the risk of cumulative trauma disorders (CTDs) existed at Anchor Swan Division, Harvard Industries, Inc., Bucyrus, Ohio. Recommendations to reduce such hazards are included in this report.

KEYWORDS: SIC 3079 (Industrial, automotive and garden hoses), cumulative trauma disorders (CTDs), carpal tunnel syndrome (CTS), upper extremity musculoskeletal disorders, ergonomics.

II. INTRODUCTION

In cooperation with the Industrial Commission of Ohio, NIOSH analyzed the workers' compensation (WC) claims data for the period 1980 through 1984 that met the following criteria: 1) nature of illness (tenosynovitis, etc.), 2) body parts affected (wrist), 3) type of exposure (over-exertion), and 4) time of occurrence (over a long period of time or unknown). During this five year period, 3,316 WC claims met these criteria. Crude incidence rates of wrist CTDs were calculated by company and rank ordered (1).

Seven of the top 20 companies with highest rates of such disorders were contacted. The crude annual rate of the defined CTDs per 10,000 workers ranged from 100.0 at the highest to 34.7 in the group compared to a rate of 1.1 for all workers in Ohio. Anchor Swan, Division of Harvard Industries, Inc., Bucyrus, Ohio, initially ranked second with a rate of 75.0. After a preliminary contact, management invited NIOSH investigators to make an on-site visit for further evaluation and assistance. After the opening conference and a walk-through inspection on August 26, 1987, the management submitted a request for a health hazard evaluation on September 14. When the rate was recalculated using the actual employee population (rather than the figure listed in an industrial directory), this company's rank fell to the 19th in Ohio with a crude annual rate of 36.0 per 10,000 workers.

This plant manufactures a variety of industrial, automotive, and garden hoses with a capacity of 1.8 million feet of hose per day. The number of employees in various departments are listed in Table 1. In brief, the ingredients of industrial and automotive hoses are mixed in a Banbury mixer, extruded to a cylindrical shape, cured by heat, reinforced by nylon or aluminum, and cut to size. Many automotive hoses need to be formed to certain shapes which require considerable amounts of manual work. Garden hoses are made mostly with vinyl, some with rubber, but both are reinforced with nylon mesh. Detailed descriptions of the work methods relevant to the CTD hazard are presented in the following:

1. Pin & Cure. During this operation, workers slide lengths of rubber hose onto steel forming molds (pins). The hoses can be of various lengths and diameters, and the molds can be of various shapes. A lubricant is poured onto the pins and the hoses are dipped into the lubricant to facilitate the sliding of the hoses. Racks of the molds are placed on a cart which, when filled, is pushed into a pressurized oven which vulcanizes (cures) the hoses and causes them to retain the shape of the mold. When the cart is withdrawn from the oven, the workers rapidly remove the hoses from the pins while they are still hot. A crew of 3 workers typically loads 11 carts per shift, each containing 600-700 hoses of various sizes.

2. CTPA job. After curing, the hoses are sent to the Cut, Trim, Pack and Assemble (CTPA) section, where final sizing takes place. The worker stands at a press machine, loads the hoses onto a wood mold, and activates a pneumatic cutting press which trims the hose to the correct length. An identifying marker is stamped by hand at each end of the hose to complete the trimming operation. About 1500 hoses are trimmed and stamped per shift per worker.

3. Braiding. During this operation, strands of reinforcing thread are wound over the inner layer of a hose. The winding is performed by a machine, but an operator must keep the machine supplied with spools of thread. The spools are slid onto a spindle and then placed onto the braiding machine. Each machine is comprised of two levels of spindles, 18 spindles per level. The operator holds a small pair of scissors in the right hand continuously while maintaining the braiding machines. One operator is assigned to as many as 20 machines, which require up to 6 changes of thread per shift.

4. Coupling. During this operation, brass couplings and plastic sleeves are attached to the ends of garden hoses. A standing operator receives wound 50-foot hoses from a conveyor located directly in front of the workplace. Four bins of parts are positioned to the right of the worker. These bins are tilted towards the work area, with three aligned vertically and one aligned horizontally below the three. Coupling materials are taken from the bins with the right hand, placed on one end of the hose, and crimped into place using a vertically oriented mandril located in front of the worker. The worker releases the hose from the winding machine by pressing a button with the right hand. Couplings are then attached to the other end of the hose using the same mandril, and the hose is slid to the left side of the work area to a machine that winds tie-wraps around the hose. The button-control for this machine is activated by the operator's left hand. During a typical day, a worker will perform this operation 1300-1400 times.

III. BACKGROUND

Cumulative trauma disorders (CTDs) of the musculoskeletal system occur in workers whose jobs require repetitive exertion, most often of the upper extremities (UE-CTDs). These disorders are usually diagnosed as tendonitis, synovitis, tenosynovitis, bursitis, ganglionic cysts, strain, or other specifically described disorders, such as carpal tunnel syndrome (CTS) and DeQuervain's disease. CTDs affect the tendons, tendon sheaths, and nerves of the involved area. Studies have shown that these disorders can be precipitated or aggravated by activities associated with repetitive exertion, particularly if the tasks require application of force in an awkward posture (2-14). The postures most often associated with upper extremity CTDs are extension, flexion, and ulnar and radial deviation of the wrist, open-hand pinching, twisting movements of the wrist and elbow,

and shoulder abduction. These types of postures and movements are frequently necessitated in many manufacturing and assembly jobs in industry. Occupations with a high incidence of CTDs include electronic components assembly, garment manufacturing, small appliance manufacturing and assembling, meat processing and packing, fish filleting, and buffing and filing of metal or plastics parts. As many as 41.7 cases per 100 workers per year have been reported in a meat packing plant (15).

Motion-related but non-occupational risks for CTDs include hobbies and recreational activities, such as woodworking, tennis, weight lifting, knitting, and sewing. All of these pastimes could impose physical demands on the musculotendinous system similar to those of the jobs mentioned above.

One of the most disabling CTDs is carpal tunnel syndrome (CTS). It was reported as a clinical entity as early as 1854. However, not until 1927 was this median nerve disorder fully described and recognized as a syndrome in medical literature (16). It is caused by compression of (the small arteries going to) the median nerve inside the carpal tunnel at the wrist. Its clinical manifestation includes (17-20) pain and paresthesias (numbness, burning and tingling sensation) in the hand and fingers along the distribution of the median nerve, which frequently awake persons from sleep, and possible radiation of pain to other portions of the involved arm/hand. In the advanced stage, atrophy (wasting) of the thenar muscle (at the base of the thumb) may occur.

CTS may be associated with non-exertional conditions such as diabetes mellitus, hormonal factors (use of oral contraceptives, pregnancy, and gynecological surgery), rheumatoid arthritis, acromegaly, and gout (21). Since many of these conditions are unique to women, their risk of CTS may be elevated. Previously, it was thought that women were at higher risk than men for work-related CTS (12), although such a study did not compare the rate of CTS between men and women performing similar jobs. Based on a series of studies encompassing several different manufacturing plants, women and men were found to be at essentially the same risk for CTS if performing identical job activities (22, 23).

There are several factors which precipitate occupational CTDs. Among these are excessive muscular force, high frequency of movements (short length of task cycles), and awkward hand/wrist postures. One study found that workers performing jobs with force levels of 4 kilograms or more were four times as likely to develop hand/wrist CTDs as those workers whose jobs required muscular exertions of 1 kilogram or less (24). Job tasks with cycle times lasting 30 seconds or less were found to be associated with an incidence of UE-CTDs three times greater than those jobs where the cycle time was greater than 30 seconds (24). In studies reporting an increased incidence of CTDs, where the number of hand movements were recorded, the range was from 5000 to 50,000 repetitions per day (5, 25-31). The work activities were varied and included cutting poultry, keystroking, hand sanding/filing, and packing tea.

Because of the complexity of repetitive motion patterns, it has been difficult to establish a critical frequency factor for a CTD risk. Recently, however, guidelines for using frequency of movement as a method for assigning risk to a repetitive task were developed and applied in a study of a meat processing and packing plant (15). Low risk was defined as fewer than 10,000 movements per day, medium risk as 10,000 to 20,000 movements per day, and high risk as 20,000 or more movements per day. These frequency of movement criteria are intended merely as guidelines for judging the relative risk of a hand intensive job task. It is also important to note that other factors associated with the performance of a work activity such as levels of muscular force exerted, and awkward upper extremity postures, would reduce the number of movements defining each of the above risk factors (32).

IV. EVALUATION METHODS

The potential CTD hazard at this plant was evaluated by the following methods:

A. Perception of CTD hazard by management and labor representatives was assessed by conferences and walk-through inspection of the plant focusing on workers' musculoskeletal involvement in their tasks.

B. Workers' compensation claims were reviewed for the 5-year period 1980-84, and OSHA-200 logs were examined for the 3-year period 1984-86, counting entries indicating or suggestive of hand/wrist CTDs.

C. Questionnaire - A self-administered questionnaire inquiring about shoulder, arm, hand and wrist problems was mailed by NIOSH to all 611 employees using address labels provided by the company. The questionnaire was accompanied by a cover letter signed by the plant manager, union president, and the NIOSH project officer. It assured confidentiality of information under the Privacy Act, and the return envelope was addressed to the project officer at NIOSH. Two weeks later, a second copy of the same questionnaire was mailed to the non-respondents.

D. Evaluation of ergonomic stresses was conducted by observation and video taping of workers performing those tasks which had been identified or suspected as "stressful or high risk" to the upper extremity based on WC claims, OSHA-200 log entries, and management and labor perceptions. Several jobs which have been associated with hand/wrist CTDs were videotaped for detailed analysis. As described in the Introduction section, these were "P & C" and "CTPA" in the formed hose department, "braiding" in the industrial hose department, and "coupling" in the plastics hose department. A protocol established by ergonomists at the Division of Biomedical and Behavioral Sciences (DBBS), NIOSH, was followed for the evaluation and analysis (33). The videotapes for each of the jobs evaluated were

analyzed to determine cycle time, number of movements per cycle, presence of awkward postures, and estimated muscular force requirements. For repetition of manual tasks, low risk was defined as fewer than 10,000 movements per day, medium risk as 10,000 to 20,000 movements/shift, and high risk as greater than 20,000 movements/shift.

V. RESULTS

A. Risk Perception by Management and Labor Union Representatives

Both management and labor representatives felt that the P & C job which was performed exclusively by men would pose the highest exposure potential for developing UE-CTDs. They reported that the CTPA job, performed mostly by women, used to be of high exposure in the past when the hoses were manually cut with a knife. However, this problem has been mostly eliminated after the introduction of pneumatic cutters in about 1985-86. The braiding job (one to two female operators per shift) and coupling job (about five to six hose assembly men per shift) were also perceived to pose certain degree of exposure hazards, which were described in the Introduction section.

B. Review of Records

1. Workers' Compensation (WC) Claims

Based on the Ohio WC data, there were eleven claims related to UE-CTDs over a 5-year period (1980-1984); 5 cases of tendinitis or tenosynovitis, 3 cases of carpal tunnel syndrome, and 2 cases of pinched nerve of the hand/wrist. (One claim could not be retrieved.) The claim rate in P & C job and CTPA job was about 5.8 and 11.6 times higher than the plant wide rate of 36 per 10,000 workers per year, respectively (Table 1). The majority of claims were filed in 1984. This was prior to the introduction of the pneumatic hose cutters for CTPA.

2. OSHA-200 Logs

OSHA-200 logs were reviewed for a 3-year period (1984-86). All OSHA-200 log entries suggestive of hand/wrist CTDs were counted, including sprains and strains. (These were excluded from the review of WC claims data.) The OSHA logs showed a similar pattern to the WC claim records in that P & C and CTPA jobs had 10.5 and 6.3 times the plant-wide rate for CTS, respectively; and 12 and 4.1 times for sprains/strains, respectively (Table 2).

C. Questionnaire

The results are summarized in Table 3. After two mailings, the response rate was just below 50%. In this table, the departments are assigned to one of three groups according to the estimated degree of ergonomic stress, to which their workers are exposed based on the above assessments A and B. Department 1 (formed hose) is designated as "high" exposure, departments 2 through 10 are combined as "low/medium" exposure, and department 11 (office and other) as "no" exposure. Prevalence rates for each department were calculated using the assumption that non-respondents had no musculoskeletal complaints. This is unlikely but would result in a more conservative estimate. Although no significance tests were conducted due to the low response rate, a clear pattern can be observed.

Table 3 shows that the high-exposure group and low/medium-exposure group had about 3 and 2 times, respectively, as many "pain or other problems lasting for at least 4 days in the neck, shoulder, arm or forearm during the past 12 months" as the no-exposure group. With regard to the "pain or other problems lasting for at least 4 days in the hand, wrist or finger during the last 12 months," the high-exposure group reported such symptoms almost 10 times, and the low/medium-exposure group about 5 times, that of the no-exposure group.

The last column relates to the question, "Did it (the pain or other problem) ever awaken you from sleep?" Since no diagnostic tests were conducted, this question was included as a simple probe for CTS. Further, in consideration of the effect of job changes within the company, the individuals reporting "nocturnal hand pain, etc" were reclassified into the department in which they were working when they first experienced such a symptom. This resulted in reassigning eight workers out of the low/medium exposure to the high-exposure and one worker to the no-exposure group. As a result, the high-exposure group had nocturnal hand pain 16.4 times, and the low/medium-exposure group 3.0 times, that of no-exposure group. It has been reported that nocturnal symptoms have a sensitivity of 0.77 for CTS, a specificity of 0.28 and a positive predictive value of 0.42 (34).

D. Ergonomics Evaluation

1. Pin and Cure

The results of the job analysis indicated that work in this department is very unstructured, and the number of movements needed to load and unload hoses from the molds or "pins" is highly dependent on the type of hose. The short and/or thin hoses could usually be removed from the pins with one movement, and loaded onto the pins with about 4 movements per hose, which included movements required to lubricate the pins. Sometimes these motions would be evenly distributed between the

two hands, and at other times, concentrated mainly on the dominant hand. This variability in motion patterns occurred among workers and within individual workers. The larger hoses (which were often more serpentine in shape) on average required 2 or 3 movements per hose to unload, and 5 or 6 movements per hose to load. Even with lubrication, the loading and unloading of hoses required very high force. A demonstration of the amount of force that is needed to slide the hoses onto the pins could be seen by how dramatically a worker "overshot" when a hose was incorrectly aligned with one of the pin molds.

While performing the pin and cure job, a 3-member crew processing 600-700 hoses per cart on 11 carts yields a movement per shift ranging from 11,000 to 21,000 per worker. This figure is only an estimate because factors such as the mix of hose types on any given day, the number of ovens in operation, and the number of workers per crew can increase or decrease this range. At the time of the evaluation, there were either 3 or 4 workers assigned to a cart at any one time.

There are other factors, in addition to the loading and unloading of hoses, which add to the biomechanical stress of this job. These are the lifting and handling of the racks while performing the job, the bending over to retrieve hoses from storage bins and to place racks on the low shelves of the cart, and working on extremely slippery metal grates.

One of the less stressful aspects of the job is the 20-minute period of rest that often occurs if there is no cart to load while another is in the oven. Some of this time, however, is used to remove finished hoses from the work area, and to restock storage bins with uncured hoses.

An unusual aspect of the job is how a departure from a basic ergonomic principle actually facilitates the work task. In highly repetitive work, it is usually beneficial to reduce the pace of work and/or spread the work evenly throughout the day. In this job, however, it is easiest to remove the hoses immediately after the cart is withdrawn from the oven, and easiest to load hoses on the pins while they are still warm. This results in the crews working at a feverish pace to remove hoses promptly, and as quickly as possible to load new hoses on the same molds if another rack of that type of hose is scheduled for the next curing cycle.

In summary, the analysis yielded that pin and cure is a job which combines medium to high repetitiveness with very high muscular force, making it a high exposure job with respect to developing CTDs.

2. CTPA Job

Only the trimming portion of this job was observed and videotaped during the evaluation. Trimming requires 3 movements per hand to perform, one of which is the activation of the press machine. At 1500

hoses per shift, the motion requirement is 4500 per hand. There were no observed deviated hand/wrist postures, and no excessive muscular forces. The movements required to further handle the hoses to stamp them, and to place them in a bin for shipment, would probably add 3 or 4 movements per hand. This number of movements places the press job in the medium range for repetition, and thus, makes it low/medium exposure job. Muscular force level is estimated to be low.

3. Braiding

This job was not observed under actual working conditions; it was demonstrated by one of the workers in the department. The main task, which is to keep the braiding machines filled with thread, requires the operator to slide spools of thread onto and off of the spindles. The spools fit very tightly on the spindles and must be "pounded" on and "yanked" off, both of which require high levels of muscular force. The job analysis indicated that about 15 movements are needed to attach a spool of thread to a spindle, 5 of which are forceful impacts. For 20 machines, with 18 spindles, and six changes per day, this aspect of the job would require 32,400 movements (10,800 forceful movements). The biomechanical stress of the task to the hand is increased by the scissors which are held in the hand while the impacts are made. Added to this stress is the above-shoulder-height reaching required to remove and place spindles on the top level of the braiding machine, which seemed to be the most common level in use. Removing the spools from the spindles requires one forceful movement per spindle. This is accomplished by attaching the base of the spindle to a fixture mounted on the side of the braiding machine and pulling off the empty spool. This aspect of the job adds 960 forceful movements to the job, totalling 33,360 movements per day, 11,760 of which require excessively high muscular force. It is important to note that not all winding machines were equipped with the fixture needed to remove empty spools.

There is a lever device available to the worker which can be used to attach and remove spools from the spindle. It helps to reduce the manual force needed to do the job but is very awkward and ungainly to use and requires a lot of time. Since use of this device is not accounted for in the production standard for the job, it is seldom used.

In summary, this job combines high repetition and high force, and overall is judged to be high exposure with respect to CTDs.

4. Coupling

The time and motion analysis of this job task indicated that each cycle requires 10 movements of the right hand and 6 for the left. According to the rate that the operator was working while the videotapes were taken, the total number of pieces produced per 8-hour

shift would be 1655, yielding a movement total of 16550 for the right hand and 9930 for the left. However, average production per day is 1300-1400 pieces, so actual movement frequency would be in the range of 13000-14000 for the right hand and 7800- 8400 for the left. According to the evaluation criteria, this job task is in the medium frequency range for the right hand and low for the left hand. Wrist extension, ulnar deviation of the wrist, pinching, and forearm pronation (rotation of the palm downward) were observed in the right hand, while left hand postures were mostly neutral. The most stressful part of the job was judged to be the attachment of the brass coupling to the hose. It appeared to require high force and was performed with the wrist extended. The worker verified that this was the case and added that attaching the brass coupling to smaller diameter hoses was the most difficult.

Other ergonomic stressors included the improper height of the work surface, the long reach required to retrieve parts from the bins, and the location of the hand controls. While the work surface height seemed to be ideally located at waist height, it must be noted that the actual working height was increased by the thickness of the wound hose, or about 8 inches. This added height caused the shoulders to be slightly abducted. The reach to the parts bins was longer than it needed to be, because the worker had to reach over the horizontally positioned bin to get to the three bins that were vertically oriented. The edge of the horizontal bin was also sharp, which presents an impact hazard to the hand/wrist. The height of the button activated by the right hand not only appeared too high for safety reasons, but also caused the worker to take his eyes away from the center of the work area and to flex the shoulder needlessly. The button controlled by the left hand, in contrast, was too low and too small, causing the worker to reach down and search for it. A foot pedal or large button that could be activated by the knee would simplify this aspect of the job task.

In summary, this is a poorly designed job with medium exposure to CTD hazards, which could be improved with some simple modifications to the workplace.

VI. DISCUSSION

Based on the analysis of WC claims data, this company was identified as being at potential "high risk" for CTD hazards. A site evaluation lead to the identificaion of additional cases not noted in the analysis of WC claims. The perception of CTD hazards by management and labor, the review of WC claims and OSHA-200 logs, the analysis of the questionnaire responses, and the ergonomics evaluation all yielded agreement on the job with the highest potential ergonomic hazard, the P & C job. However, this agreement did not hold up for other jobs. For example, the ergonomics evaluation determined that CTPA job was not as hazardous as it was perceived to be by management and labor.

Similarly, although braiders and coupling operators were involved in an ergonomically stressful job, they did not appear to have correspondingly high departmental rates of CTD cases. This discrepancy may be accounted for by the fact that only a small number of workers in these job categories within their corresponding department were available to be evaluated (4 braiders in industrial hose dept. and 10 to 12 hose assembly men in plastic hose dept.). Thus, data analysis by department alone may miss some hazardous job categories. In general, however, labor and management's perception of ergonomic hazards were confirmed.

The rate of response to the questionnaire was low. Reasons for this may include: (a) indifference to mailed questionnaires particularly among asymptomatic individuals, and (b) fears that positive responses could adversely affect their employment or jeopardize their future claim for WC, despite assurance of confidentiality. These factors would bias the result in opposite directions. If asymptomatic individuals did not respond, then the calculated CTD rates would be falsely elevated. If individuals with CTD problems did not participate, then a falsely lower CTD rate would be result. Thus it is impossible to determine the true incidence rate. By treating non-respondents as negatives (no-CTD) as was done in this evaluation, a more conservative result or an under-estimate of CTD rate was calculated.

In view of recent report of epidemics of CTS among office workers, a question was raised as to whether it was appropriate or not to classify office workers as no-exposure. Casual observation of the offices of this company indicated that the work methods were of a more conventional type (unlike those observed in insurance companies or airline reservation offices, where workers are bound to video display terminals with high speed repetition of finger movements).

VII. RECOMMENDATIONS

The current strategy for reducing the risk of CTDs for a certain task is to minimize exposure to the previously mentioned stress factors. This is most effectively achieved through the modification of work pace, redesign of work stations, tools, or work methods that were identified through job analysis as CTD exposure hazards. The following recommendations are offered as possible means to reduce the observed ergonomic stress factors in the jobs evaluated.

A. Pin and Cure

1. Continue experimenting with the "cell concept," whereby workers rotate out of the pin and cure area every 2 or 3 hours. Limiting the time spent performing this job is the single most effective intervention that can easily be implemented. Development of a tool (or set of tools) to aid in removing or attaching hoses to the pins would be desirable, but may not be easy to implement because of the many different sizes and shapes of hoses.

2. Add workers to the line to reduce the number and types of ergonomic stresses currently imposed on each worker. These added workers could be material handlers who keep the bins filled with uncured hoses, and who remove filled bins of hoses from the work area. These workers could also be added to, and rotated with, the crew of workers who remove and replace hoses when a cart is removed from the oven. The added workers could also be used to allow crew members to "sit out" every second or third rack of hoses so that proper recovery from the stresses of the task could take place.

3. Work with the auto industry design engineers in developing a hose which can be more easily produced. These design engineers may not know that hoses with multiple bends are much more difficult to manufacture than straight hoses. If more flexible hoses were used, they could be manufactured and installed more easily, and fewer different kinds would be needed. Figures 1 and 2 are presented merely as an example of possible changes which can be implemented in the "under-the-hood" layout of the engine cooling fluid circuit. Such a change would eliminate most of the bends in the hose, which would reduce worker's musculoskeletal stress in making it. It is also possible that such a simplification would result in cost reduction in automobile manufacturing and repair.

B. CTPA Job

The addition of the press to clip the ends of the hoses pneumatically, instead of by hand, has eliminated the major ergonomic stress of this job. Continuing attention should be paid to reducing stress in this job.

C. Braiding

Reconfigure the manner in which new spools of thread are placed on the braiding machine. This can be accomplished in a number of ways. The following are possibilities (listed in decreasing order of ergonomic desirability):

a) Add a worker to the department whose main responsibility is to supply "respooled" spindles to the production area. This worker, or perhaps the current operator in the department, could deliver empty spindles to a designated area. In this area, empty spindles would be removed and filled ones attached. These refilled spindles would then be delivered back to the production area. This approach would require a number of spare "spooled" spindles, but would eliminate the pounding (at above shoulder level) and yanking currently required to attach and remove spindles. A more simple, upright lever tool, much like a bottle capping tool, would be suitable for removing and attaching spindles if this approach were adopted.

b) Purchase or develop a spindle that requires little effort to attach and remove spools of thread. This approach would allow the job to be conducted as it currently is, but would require many new spindles.

c) Conduct another time study of the job which includes use of the company- made lever device for attaching and removing spools from the spindles. For this approach to be successful, additional (possibly better designed) devices would be needed to service all of the machines in the department.

D. Coupling

1. Redesign the parts delivery system so that there are four vertically oriented bins in the workplace instead of the current arrangement of 3 vertical and 1 horizontal. These should be gravity-feed bins with an opening only at the bottom. This would control the point at which parts are retrieved, which should be within easy reach of the worker. The current arrangement of long, fully-opened bins results in the possibility of long reaches for parts, depending on where they are in the bin.

2. Relocate the button activated with the right hand to a position within easy reach of the worker. The worker should not have to reach up to activate the button. There seemed to be enough room on the work surface for a horizontally located button. A foot control or a large, well-padded knee-operated button could also be considered.

3. Either enlarge or relocate the button activated with the left hand. Location of the button on the work surface, or knee- or foot-activated controls are also possibilities which could be considered.

4. Lower the height of the work surface so that the shoulders are not abducted while handling the hose. Proper relocation of the hand controls would diminish the need to implement this work station modification, but it is nonetheless important to note that the current work height is too high. A stool would not suffice because it would also increase the level of the worker's eyes, which is currently proper at the height of the mandril. A reduction in work surface height would also enable the worker to more easily attach the couplings to the hose without extending the wrist.

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The authors acknowledge the management of Anchor Swan Division, Harvard Industries Incorporated, and the members and representatives of Local 673, United Rubber Workers Union, for their cooperation. James McGlothlin, Ph.D., Research Industrial Hygienist, Engineering Control Technology Branch, Division of Physical Sciences and Engineering, participated in the early phase of this evaluation. Dorothy Lowe, Health Statistician, Support Services Branch, assisted in data analysis of the questionnaire.

X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati address. Copies of this report have been sent to:

A. Anchor Swan, Division of Harvard Industries, Bucyrus, Ohio
B. United Rubber Workers Union Local 673, Bucyrus, Ohio
C. Occupational Safety and Health Administration - Region V
D. Division of Safety and Hygiene, Industrial Commision of Ohio
E. Division of Occupational Health, Ohio Department of Health
F. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

Table 1.
Incidence Rate of Filing Workers' Compensation Claims by Department
Based on Anchor Swan's Records for the 5-year
Period 1980 through 1984.

Dept. Code	Dept. Name	Number* of Employees (as of 1988)	Number of Claims** (1980-84)	Rate per 10,000 per year	Rate Ratio among Departments
01	Formed Hose	67	8	239	6.6
	Pin & Cure	29	3	207	5.8
	C.T.P.A.	24	5	417	11.6
	Other	14	0		
02	Hydraulic	28			
03	Industrial	123	2	33	0.9
04	Janitors	12			
05	Maintenance	42			
06	Plastic	104			
07	Quality Control	17			
08	Receiving	8			
09	Reclaim	39	1	51	1.4
10	Shipping	15			
	All Manufacturing	455	11	48	1.3
11	Office & Other	156			
	OVERALL	611	11***	36	1.0

* Employee population used here are from a 1988 data.

** Limited to those claims accompanied by diagnosis of carpal tunnel syndrome, pinched nerve or tendonitis of the hand/wrist.

*** Detailed information was available for 10 of these 11 claims. There were 5 men (mean age: 29) and 5 women (mean age: 32); 8 claims were filed in 1984 and one each in 1982 and 1983.

Table 2.

Incidence Rate of CTD-like Disorders by Department Based on Anchor Swan's OSHA 200 Logs for the 3-year Period 1984 through 1986.

Dept. Code	Dept. Name	Carpal Tun. Synd & Like			Sprains, Strains, etc.		
		Number	Rate per 10,000 per year	Rate Ratio	Number	Rate per 10,000 per year	Rate Ratio
01	Formed Hose	3	149	6.8	27	1343	6.6
	Pin & Cure	2	230	10.5	21	2414	12.0
	C.T.P.A.	1	139	6.3	6	833	4.1
	Other	0					
02	Hydraulic	0					
03	Industrial	1	27	1.2	7	190	0.9
04	Janitors	0			1	278	1.4
05	Maintenance	0					
06	Plastic	0			1	32	0.2
07	Quality Control	0					
08	Receiving	0					
09	Reclaim	0			1	85	0.4
10	Shipping	0					
	All Manufacturing	4	29	1.3	37	271	1.3
11	Office & Other	0					
	OVERALL	4	22	1.0	37	202	1.0

Table 3.

Questionnaire Response for Upper Extremity Musculoskeletal Disorders by Department Grouped by Estimated Exposure Risk*

Estimated Exposure Risk for MS Disorder	Number of Workers	Response Rate %**	Q-7 Positive %**	Q-11 Positive %**	Q-16 Positive %***
High Exposure (Formed Hose Dept.)	67	56.7	31.3	31.3	32.0
Low - Medium Exposure (Dpts. 2 to 10)	388	51.3	21.9	16.8	6.1
No Exposure (Office & Other)	156	38.5	10.3	3.2	1.9
Overall	611	48.6	20.0	14.9	7.9

* Estimated exposure risk was basesd on the perception and review of workers' compensation records and OSHA-200 logs, but prior to the ergonomics evaluation.

** Percentage of the number of workers answering positive within the department(s), assuming non-respondents are symptom-free.

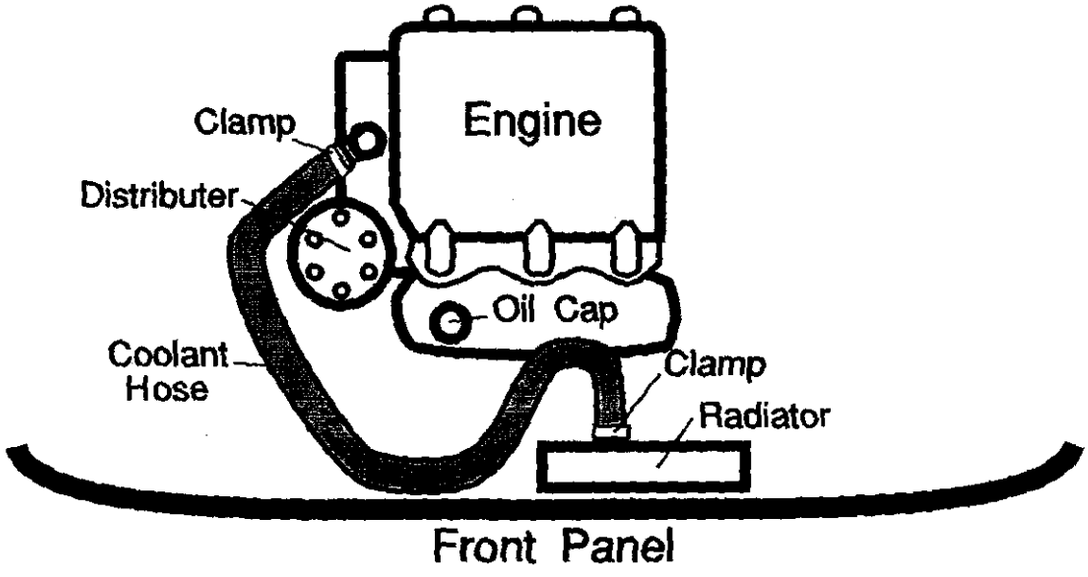
*** Among those answering positive to Q-11, workers who had experienced the nocturnal hand pain (positive response to Q-16) were recounted into the department in which they were working when they first had symptom. This resulted in reassigning eight workers from low/medium to high exposure group, and one from low/medium to no exposure group.

Q-7: During the past 12 months, have you had pain or other problems lasting for at least 4 days in your neck, shoulder, arm or forearm?

Q-11: During the past 12 months, have you had pain or other problems lasting for at least 4 days in your hand, wrist or finger?

Q-16: Did it (the pain or other problems) ever awaken you from sleep?

Figure 1. A currently used configuration of an engine coolant hose in a mini-van. Note that these bends are needed because of the location of an orifice of the radiator.



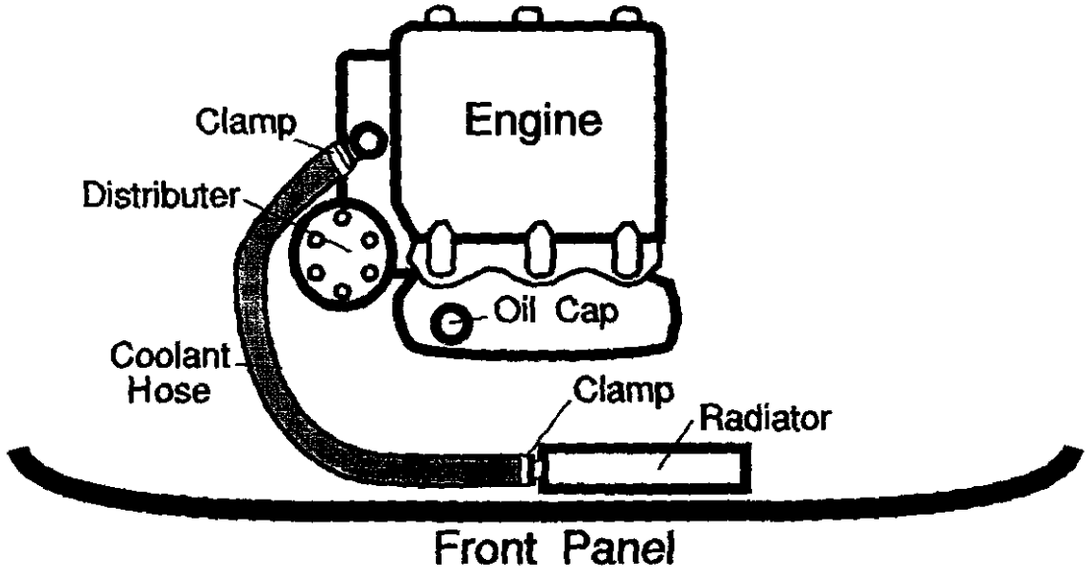


Figure 2. The above shape of the coolant hose can be much simplified, if the orifice of the radiator is relocated as shown here. A reinforced flexible hose may do the job as well, and perhaps more economically.