Evaluation of Ergonomic Risk Factors, Thermal Exposures, and Job Stress at an Airline Catering Facility

Jessica Ramsey, MS, CPE
Kristin Musolin, DO, MS
Diana Ceballos, PhD, CIH
Douglas M. Wiegand, PhD
Kenneth Mead, MS, PE

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from a union to evaluate an airline catering facility. The union was concerned about ergonomic risk factors, heat and cold exposure, and job stress. We evaluated the facility in September 2012.

We evaluated ergonomic, environmental temperature, and job stress concerns among employees at an airline catering facility. Employees used awkward postures and repetitive motions, stayed inside cold rooms for their entire shift, and experienced time pressure. We recommend redesigning workstations, rotating employees out of the cold rooms for part of their shift, and increasing teamwork and social support.

What We Did

- We measured workstation heights and reach distances. We used this information and observations to determine work-related musculoskeletal disorder risk.
- We looked at logs of work-related injuries and illnesses.
- We measured air temperature and air flow inside cold rooms.
- We measured carbon monoxide at loading docks.
- We interviewed employees about their work, medical history, symptoms, job stress, personal protective equipment, and health and safety concerns.

What We Found

- Some employees used awkward postures and repetitive motions while doing their jobs. These factors increased their risk for work-related musculoskeletal disorders of the shoulders, back, and arms.
- The most common injuries reported on the logs were musculoskeletal strain, sprain, or pain.
- Employees reported diesel exhaust entering the loading docks during winter days.
- Employees reported health concerns from hot and cold temperatures.
- No confined space entry procedures were in place for cleaning the autoclave.
- Employees reported time pressure, high workload, lack of social support, and limited access to resources as common sources of job stress.

What the Employer Can Do

- Develop a written autoclave cleaning procedure. Follow guidelines and standards for confined space, lockout/tagout, and personal protective equipment.
- Design work areas to have a working height of 27–62 inches.
- Provide work tables that have adjustable heights.

- Rotate employees to different job tasks after every break.
- Present all information such as training, messages to employees, and hazard communication materials in a manner that employees can understand. This may include languages other than English.
- Train employees on the health effects of exposure to hot and cold temperatures and ways to be more comfortable at work.
- Provide glove alternatives for employees inside cold rooms.
- Provide warm water or dry air heaters outside of the cold rooms for the employees to warm up their hands.
- Install horizontal baffle deflectors on all refrigerator fans located near workstations inside the cold rooms.
- Develop and implement a heat stress prevention program. Establish mandatory breaks for employees exposed to heat, including drivers.
- Ensure new trucks have air conditioning.
- Perform preventative maintenance and repair trucks promptly if heating systems are not working.
- Seal loading docks so diesel truck exhaust does not enter the building.
- Educate employees on musculoskeletal disorders and ergonomics.
- Explore and address issues of job stress.

What Employees Can Do

- Keep heavy loads close to your body when lifting and carrying.
- Do not wear wet clothes inside the cold room.
- Drink plenty of fluids when exposed to heat.
- Take regular breaks to recover from extreme temperatures.
- Take part in safety and ergonomic committees.
- Report symptoms and injuries to supervisors and medical staff as soon as they occur.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
MSD	Musculoskeletal disorder
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PPE	Personal protective equipment
SOP	Standard operating procedure
TLV®	Threshold limit value
WBGT	Wet bulb globe temperature

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Introduction

The Health Hazard Evaluation Program received a request from a union representing airline catering employees. The union was concerned about musculoskeletal disorders (MSDs), extreme hot and cold temperatures, job stress, and employees being injured while working in the kitchen and loading docks. In September 2011, we evaluated a facility in Michigan. We provided an interim letter detailing our evaluation and preliminary recommendations in November 2012. In January 2013, we evaluated a second facility in New York with employees represented by the same union. The concerns at the second facility were similar to those at the first. Additionally, concerns were raised about language barriers because most employees spoke a primary language other than English. This report covers the 2011 evaluation of the Michigan facility. The results from the evaluation at the New York facility will be reported separately.

At the time of our September 2011 visit to the Michigan facility, production took place in a 213,000-square foot building that was constructed in 1981 and renovated in 1991. The facility had approximately 500 employees and operated two shifts. The company catered for one major airline at the airport and serviced 16 international flights and 220–260 domestic flights per day. Employees prepared food, beverages, and nonfood amenities (e.g., napkins, sugar packets, and stir sticks) and placed them in drawers. The drawer content varied by aircraft type and capacity. The drawers were then placed on food service carts. The carts were loaded onto trucks and delivered to the plane. Employees typically worked 8-hour shifts with a 30-minute lunch break and an additional 20-minute break. This work schedule covered most employees except drivers whose breaks varied depending on delivery schedules. Occasionally, employees worked voluntary overtime.

Methods

Ergonomics

We observed workplace conditions, processes, and practices. We measured workstation heights and reach distances and noted the availability of antifatigue mats and personal protective equipment (PPE). A full description of the criteria we used to determine risk factors for work-related MSDs is provided in Appendix A. We reviewed a report prepared by the company's insurance provider in 2009 on their evaluation of musculoskeletal risk factors for employees pushing airline service carts. We reviewed training materials and standard operating procedures (SOPs) provided to employees upon hire.

Cold Exposure

We evaluated cold exposures by sampling two cold rooms where employees routinely worked for varying periods throughout the day (3 to 8 hours per 8-hour shift). We collected information on factors that can influence an employee's response to cold, including air temperature, air velocity, humidity, physical activity, work/rest schedule, and type of protective clothing worn [Canadian Centre for Occupational Health and Safety 2008]. We measured temperature and relative humidity with a HOBO H08-032-IS Pro Series Relative

Humidity/Temperature Data Logger. The temperature and relative humidity measurements were taken simultaneously in different locations within the cold rooms to determine variability. We estimated air velocities inside the cold rooms with a TSI VelociCalc® Plus with articulated arm (model 8386A). Air velocities were measured at a typical standing chest height to capture what employees were experiencing at their workstations. We reviewed the company's daily temperature records for the cold room, and obtained temperature records for one summer month and one winter month for each of the past 2 years. This information was compared to available guidelines for working in cold environments [ACGIH 2014].

Heat Stress

We evaluated hot environmental conditions in the autoclave and hot food area by measuring temperature and wet bulb globe temperature (WBGT) with a QUESTemp°36 instrument. In the autoclave area, we placed the WBGT monitor on the autoclave controls near the operator. In the hot food area, we placed the monitor by one of the cutting workstations near the ovens. The WBGT data from the hot food area was not used because of instrument failure during sampling. Metabolic rates were estimated on the basis of observation of work load by job task. The WBGT measurements and metabolic rate estimates were compared to the National Institute for Occupational Safety and Health (NIOSH) heat stress recommended exposure limit [NIOSH 1986] and the American Conference of Governmental Industrial Hygienists (ACGIH®) screening criteria [ACGIH 2014]. Food delivery trucks and flight line operations were not evaluated for heat stress because of mild environmental temperatures during our visit (approximately 75°F).

Carbon Monoxide

We measured carbon monoxide concentrations in the loading and unloading docks with a BW Technologies direct-reading GasAlert Extreme meter to assess whether exhaust from diesel powered vehicles was entering the docks. After performing spot checks around the loading and unloading docks, we positioned the meters approximately 5 feet above the floor in several locations throughout the docks for the reminder of the workday. We talked to managers and employees about the operation of powered vehicles and any problems they may have encountered with exhaust from powered vehicles.

Employee Interviews and Document Review

Prior to our visit, we requested the following information: SOPs for different departments, an employee roster, and copies of the Occupational Safety and Health Administration (OSHA) Form 300 Log of Work-Related Injuries and Illnesses for years 2007–2011. We used the employee roster to select every third or fourth employee for an interview. This selection process continued until we believed we had a representative sample of the workplace population on the basis of sex, job title, length of employment with the company, and work shift. While on site, we held confidential, voluntary interviews with selected employees to discuss their workplace practices, medical history, job stress, psychosocial factors at work, and health and safety concerns. The interviews included scaled items (e.g., a job stress scale from Clark et al. 2011), open-ended questions, and forced choice (i.e., yes/no) response options.

Results and Discussion

Ergonomics

We observed employees in the assembly areas as they prepared liquor and beverage drawers, food drawers, nonfood amenities drawers, and first class snack trays. Assembly tables throughout the facility varied in height from 29″–34″. Each assembly area had shelves that contained bulk materials for stocking the drawers. These shelves varied in height from 26″–67″. The employee safety audit had documented that the soda assembly items were too high and awkward for the employee to reach, which was included in the audit item labeled, "Equipment/materials at workstation are at or below shoulder level. Heavier items kept lower." We also documented several assembly workstations where the work required outstretched arms in an extended reach. These kinds of tasks place stress on the shoulders, elbows, and back when reaching. The food production SOP recommended an "efficient" work area, where the employee's "work envelope" (the maximum overall area where the employee works) is reduced in size to increase overall efficiency by minimizing the employee's movements. However, if the work envelope is reduced too much, then reconfiguring the work area may require shelves that are higher or lower than recommended to prevent musculoskeletal problems. Because the workstations are not adjustable, higher and lower shelving could cause extended reaches and awkward postures for some employees.

After learning that the "lean team" was responsible for designing workstations, we spoke with a lean team member who clarified that its purpose was to "optimize flow and decrease waste." The lean team had designed workstations for the "average" employee, which is not recommended because it excludes approximately 67% of the working population [Humantech 2009].

After the trays were assembled they were placed on flow racks used by other employees to complete a cart. These flow racks varied in height from 26″–66″ on the replenish side and 24″–60″ on the retrieval side.

Canned and bottled beverages were stored on pallets in another area of the facility. The pallets were stacked next to each other directly on the floor. Employees could access the pallets on only one or two sides, resulting in extended reaches and the need to lift materials from floor level to above shoulder level. This item had been noted on a recent employee safety audit as an area that needed improvement; the audit recommends that "boxes, cartons, and equipment stored on pallets are in orderly stacks and no higher than 60″ from the floor." The lifting and moving water SOP included only water, not soda or other items stored on pallets. The SOP stated that "pallets should have access from all sides, and cases should not be stacked above waist level." This procedure was not being followed with other palletized material, such as soda.

We observed employees in the food prep cold room preparing and packaging food for first class meals. The tables in the food prep cold room were 35″ in height and had a supporting shelf for materials that was 48″ in height. Some employees did not rotate to different job tasks and stood at the workstations all day without an antifatigue mat. Prolonged standing had been documented on the recent employee safety audit as an area that needed improvement; the audit recommends that "antifatigue mats are used in work areas that employees must stand all day. Fatigue mats are in good condition and have beveled edges so as not to cause a tripping hazard and for ease of cart movement."

We observed employees preparing "napkin roll-ups" by wrapping napkins around silverware and then securing the napkin with an adhesive sticker. Two employees were sitting while performing the task; a third employee alternated between sitting and standing. Each employee performed a different step in the process. Employees rotated between the three different tasks at their discretion. The table height was 36″ and the reach distances for the napkins, silverware, and stickers ranged from 13″–18″. The table height is within the range for both seated and standing workstations. Reach distances should be within 16″ and should not exceed 22″.

We reviewed a 2009 report from the company's insurance provider on their evaluation of employees pushing airline carts. We verified some of the cart push forces reported by the provider. We agreed with the insurance provider's recommendation that employees push a maximum of four loaded carts strapped together or six empty carts strapped together. We also reviewed the dish room SOP and the cart pushing SOP. Although the company revised their procedures to reflect the insurance provider's recommendation, both SOPs still contained the higher maximum number of carts (four loaded carts and ten empty carts). These documents should be modified to reflect the existing procedures. The cart pushing SOP was also missing a section addressing a schedule for inspection and maintenance of cart wheels and floor surfaces, both of which are important to prevent injuries when pushing carts.

Assembly employees placed carts on the dock on the basis of plane type. The procedure, as we observed, seemed to cause confusion among the drivers and loaders, and carts were moved around the dock because employees had trouble finding the correct cart for the particular driver. Drivers and loaders placed carts onto trucks on the basis of flight departure times.

It is important to ensure that employees understand the potential hazards in the food service industry and how to protect themselves. Work-related MSDs comprise most of the injuries in food service industries [Cal/OSHA 2003]. Most injuries, according to the OSHA Logs we reviewed, were work-related MSDs. Engineering, work practice, and administrative improvements should be made to reduce risk factors for MSDs. In the short term, repositioning placement of items, such as cases of water, beer, and soda, could have a big impact on employee injury risk. Placement should eliminate reaching overhead, eliminate extreme bending of the back and twisting of the trunk, and reduce the amount of lifting of water, soda, and beer cases.

The new hire orientation materials we reviewed had a suggestion for stretching exercises. We did not see any employees performing the stretches. Stretching exercise programs should be part of a comprehensive ergonomic program. The Washington State Department of Labor and Industries has an online guide with information on how to set up an ergonomic program [Washington State Department of Labor and Industries 2005].

Cold Exposure

The facility had two cold rooms, "food prep" (where food was prepared for trays) and "cold food" (where full carts were stored before being loaded onto the plane). The cold food room was further divided into an international section and a domestic section that were separated by a door. The international section was approximately six times larger than the domestic section.

Both cold rooms were climate conditioned to approximately 40°F, a temperature required by food safety standards. The air temperature was maintained by roof-mounted refrigerator units (heat pumps) located around the upper perimeter of the rooms. No outdoor air was introduced into the cold rooms by the heat pumps. Each refrigerator unit had two to four fans and a temperature control unit with no visual display. Each cold room had a thermometer displaying the temperature inside the cold room. The temperature was also displayed outside the room. Air temperature was documented daily for both shifts and the thermometer was checked against a primary standard once a month for accuracy.

We estimated the activity level for most cold room employees as light to moderate, depending on the job tasks for the day. The company provided mandatory PPE to protect the food from contamination (e.g., lab coat, hairnet, plastic sleeve guards, plastic or polyvinyl chloride gloves, and apron) and optional PPE for warmth (e.g., coat, hat, and liner gloves). Employees also reported wearing additional personal clothing for comfort.

Some employees were concerned about drafts inside the cold rooms and believed that some areas were colder than others. Metal deflectors were installed on some of the refrigerator units several years ago because of employees' concerns with drafts at their workstations. The deflector design (Figure 1) seemed to have decreased some of the drafts in the cold rooms but we noticed condensation from the cold air striking the metal deflector. The condensate water collected inside the deflector; creating the potential for microbial growth.

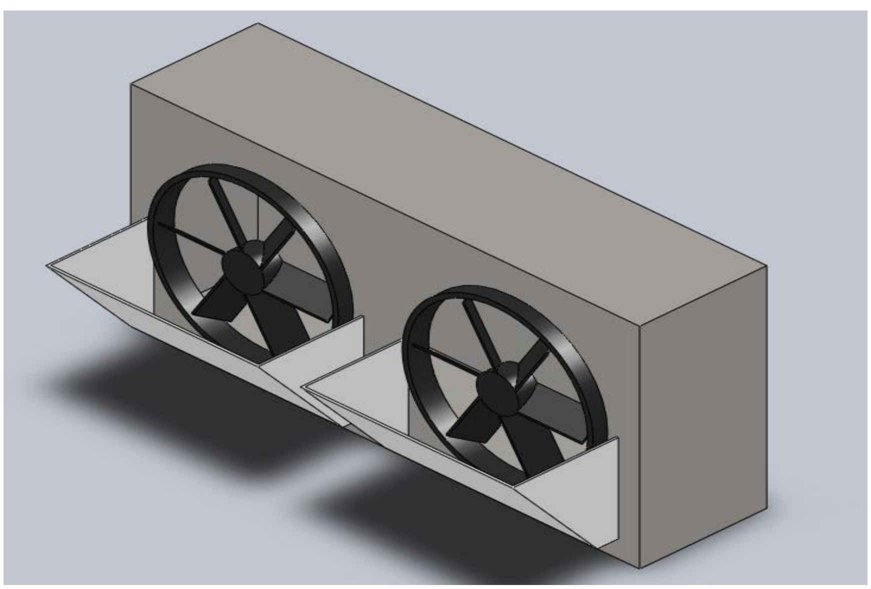

Figure 1. Fan refrigerator unit assembly with deflectors. Figure by NIOSH.

The food prep cold room had food storage areas containing shelves, carts, and tables. The room had 12–16 workstations, three strip curtain doors, one solid door, and six refrigerator units with a total of 12 fans. Depending on the production demands, 7–25 employees worked in the room and the workstations varied depending on the type of task performed at each table. Some of these employees went in and out to retrieve supplies; therefore, they spent 4–6 hours inside the cold room per shift. Food prep employees assembled meals individually or in teams of two or three.

Some of the assembled meals required fine motor skills (e.g., decorating with small garnishes, picking shrimp with toothpicks, cutting very thin slices of fish). Employees performing these tasks stated that they could only wear plastic gloves as additional layers would limit dexterity. In some instances, the food they were handling was frozen, and employees reported that their hands were cold and numb.

The cold room temperatures, relative humidity, and air velocities we measured are presented in Tables 1 and 2. The three food prep workstations we evaluated included two in opposite corners and a middle workstation near a door. The temperatures averaged 43.1°F. At any given time, the three workstations had a maximum temperature difference of +/−2°F.

Table 1. Temperatures and relative humidity measured inside cold rooms on September 21, 2011

Work area	Sampling time	%RH	Temperature at workstations (°F)				
				#1	#2	#3	Average
Food prep	9:06 a.m.–5:04 p.m.	67–95	Average	41.6	43.8	43.9	43.1
			Minimum	40.2	42.5	43.2	
			Maximum	43.9	45.4	46.8	
International cold food	9:06 a.m.–4:45 p.m.	59–89	Average	40.4	39.4	NS	40.8
			Minimum	38.0	37.2	NS	
			Maximum	44.6	41.0	NS	

NS = not sampled

RH = relative humidity

In contrast, we measured a wide range of air velocities inside the food prep cold room. All job sites had room average air velocities below the ACGIH cold stress threshold limit value (TLV®) of 200 feet per minute for job sites inside refrigerated rooms [ACGIH 2014]. Cold room temperatures approached the 40°F lower operating limit of the air velocity instrument. It is possible that instrument limitations could have contributed to the fluctuations in the air velocity readings.

Table 2. Air velocities measured inside cold rooms on September 21, 2011

Work area	Shift	Number of samples	Air velocity* (feet per minute average and range)
Food prep	Day	7	59.3 (14–116)
	Night	7	53.3 (24–105)
International cold food	Day	6	146.3 (30–240)
	Night	6	103.4 (25–259)
Domestic cold food	Day	2	89.5 (70–109)
	Night	2	33.8 (2–51)

*A range of air velocities was noted instead of a single value when the instrument displayed unstable readings due to turbulent flow conditions. We used the average of the minimum and maximum from several readings within the cold room to calculate the reported average.

We analyzed the company's daily air temperature records for 2 months each in 2010 and 2011 (Table 3). Air temperatures were fairly uniform between the months and work shifts and were similar to our September 2011 measurements (Table 1).

Table 3. Cold rooms air temperature records

	Air temperature averages (°F)					
	Food prep*		International†		Domestic†	
Month and year	Day shift	Night shift	Day shift	Night shift	Day shift	Night shift
February 2010	40.6	40.7	40.8	40.3	40.0	40.2
February 2011	41.7	40.9	42.2	41.8	41.3	40.5
July 2010	40.8	40.9	40.5	38.1	37.5	36.9
August 2011	42.9	42.3	43.4	37.7	34.7	36.6

*Data from company records. Some temperature data (< 5%) were illegible and were not included in the data analysis.

†Data from company records. Some temperature data (< 20%) were illegible and were not included in the data analysis.

International Cold Food

Up to three employees worked in the international cold food room. The room had food shelves and carts, two strip curtain doors, two solid doors, and eight refrigerator units with a total of 24 refrigerator fans. Four of the refrigerator fans did not have deflectors. We observed employees prepping food; job tasks required mobility and included stocking food and organizing or checking food carts. Employees remained inside the room for most of their shift (up to 6 hours) but in some instances left to transport carts. Temperatures around two workstations at opposite ends of the room averaged 40.8°F (Table 1). The maximum temperature variability between the two measurement locations at a given time was 5°F.

We analyzed the company's daily temperature records from the international cold food room for 2 months each in 2010 and 2011 (Table 3). No difference was noted between the average recorded temperatures for the day and night shift. Temperatures were less variable in the international cold food room than in food prep cold room.

Air velocities measured during the day and night shifts in the international cold food room are listed in Table 2. The average air velocities, 146 feet per minute during the day shift and 103.4 feet per minute during the night shift, were below the cold stress ACGIH TLV of 200 feet per minute [ACGIH 2014]. However, some of the maximum air velocities in the international cold food room were above the guideline. The higher air velocities in the international cold food room could be due to the lack of deflectors on some of the refrigerator units.

Domestic Cold Food

The domestic cold food room had three solid doors and two refrigerator units with a total of six refrigerator fans. None of the refrigerator fans had deflectors. Employees only entered the domestic cold room briefly to leave carts in storage.

We analyzed the company's daily temperature records for the domestic cold food room for 2 months each in 2010 and 2011 (Table 3). Temperatures were slightly more variable than in the food prep cold room (< 8% coefficient of variation for domestic cold food room compared to < 3.5% coefficient of variation for food prep, Table 3). Differences in the recorded temperatures for the day and night shift were minimal.

Air velocity measurements taken during the day and night shifts in the domestic cold room are listed in Table 2. The average air velocities, 89.5 feet per minute during the day shift and 33.8 feet per minute during the night shift, were below the cold stress ACGIH TLV of 200 feet per minute [ACGIH 2014].

The food prep cold room employees were exposed to cold temperatures and drafts from vents and fans blowing directly on them. Approximately 130 employees worked in the cold food department as food preparers at the time of our evaluation. Cold exposure has a negative impact on human performance, particularly for those with certain pre-existing medical conditions such as certain infectious diseases, cardiovascular and metabolic disorders, or musculoskeletal problems [Holmer et al. 1998]. A cold environment may also increase the chances of an injury or aggravate an existing injury [Cal/OSHA 2003]. Cold storage work is an artificial cold exposure that is characterized by a controlled climate. Employees can preserve body heat, particularly in their hands, by wearing appropriate protective clothing such as thin cotton gloves worn underneath metal gloves when cutting meat. In many cool workplaces, preservation of manual dexterity poses challenges for the employees [Holmer et al. 1998]. Some cold room employees reported cold fingers and reported that putting on gloves reduced dexterity. The ACGIH recommends establishing special provisions to keep hands warm for employees doing fine work with bare hands for more than 10–20 minutes in an environment below 60.8°F [ACGIH 2014]. The company provided gloves and long insulated coats and allowed employees to wear hats but lacked a written cold room safety policy or SOP.

Heat Stress

Autoclave Operators

The highest air temperature measured in the autoclave area was 87.0°F (average 80.1°F), and the highest calculated indoor WBGT reading in the autoclave department was 79.4°F with an average of 74.8°F. The WBGT results indicate that most surfaces in the autoclave department were warm and served as radiant heat sources.

The autoclave operators' activities included pulling large carts of trash, loading and unloading the autoclave, operating the autoclave, moving trash, and cleaning the autoclave. We estimated the operators' metabolic rate as moderate, defined as "sustained moderate hand and arm work, moderate arm and leg work, moderate arm and trunk work, or light pushing and pulling and normal walking" [ACGIH 2014]. No clothing adjustment factor [ACGIH 2014] was needed because the employee was lightly clothed in an undershirt, short sleeve shirt, and pants. Leather protective gloves were worn for handling trash and working with hot surfaces. No safety glasses were worn.

We compared the WBGT results and metabolic rate estimates to those listed in the NIOSH recommended exposure limits to determine a work/rest schedule [NIOSH 1986]. The comparison yielded a recommendation of continuous work for employees when environmental conditions are similar to those on the day we evaluated.

We also compared our WBGT measurements and metabolic rate estimates to the ACGIH screening criteria [ACGIH 2014] to determine a work/rest schedule. These criteria suggest a continuous work schedule is acceptable for acclimatized employees with moderate workloads in environments with a WBGT between 77°F and 82.4°F. The maximum WBGT (79.4°F) we measured in the autoclave department was within this range, but was above the ACGIH action level (77°F) for a moderate workload and without a clothing factor adjustment [ACGIH 2014]. When WBGT values are above the action level, ACGIH recommends implementing precautionary general controls to avoid heat strain, especially in the summer months when outside temperatures are expected to rise significantly above those we measured. ACGIH recommends a heat stress management program including monitoring of the environmental temperature in the area of concern [ACGIH 2014].

The NIOSH recommended exposure limit and ACGIH TLV assume a 5-day workweek and an 8-hour workday with short morning and afternoon breaks (approximately 15 minutes each) and a longer lunch break (approximately 30 minutes).

Truck Drivers

Although we did not evaluate heat stress conditions in the food delivery trucks, we talked to several employees and management representatives about temperatures in the trucks. Employees reported that the trucks were poorly maintained (e.g., some trucks had no air conditioning or had windows that did not open or close). Employees reported that the heating system in some of the trucks could not be turned off so it operated throughout the year.

Managers reported that a typical delivery job took about 2 hours and included loading the truck at the dock, driving approximately 25 minutes to the airport, going through airport security, driving to the plane parked on the tarmac, unloading carts from the truck to the plane, and then driving back to the dock. The delivery could take longer if the plane was not ready to receive the carts. Employees were expected to do three or four deliveries during their shift. Employees could take a break between deliveries in an air conditioned room at the airline catering facility. However, managers said that on busy days employees sometimes skipped these breaks to keep up with job demands. Some employees also reported that they skipped breaks to shorten their shift so they could leave work early.

Drivers, loaders, and sanitation (i.e., autoclave operators, dishwashers) employees were potentially exposed to hot temperatures. Although conditions were cool during our visit, the potential exists for delivery truck drivers and the autoclave operator to work in hot conditions during the summer months. Heat measurements in the autoclave area suggest a continuous work schedule is acceptable for acclimatized employees with moderate workloads when outdoor temperatures are in the mid-70s. For the temperatures we measured in these work areas, acclimatization for most people occurs in 4 days by exposing them to progressively longer periods in a hot work environment [NIOSH 1986]. We reviewed the heat-related disorders training materials provided by the company. The training included sources of heat, symptoms of heat-related disorders, and recommendations for preventing heat stress, such as taking breaks in a cool area and drinking one glass of water every 20 minutes. However, breaks were limited to two per 8-hour shift, and beverages were prohibited in most work areas.

Carbon Monoxide

We did not detect carbon monoxide in the loading and unloading docks (limit of detection was 1 part per million), which together with field observations during our visit suggests that truck exhaust was negligible in these areas during our evaluation. However, employees reported diesel odors in the docks, especially in the winter months. Appendix A provides a brief description of occupational exposure limits (OELs) and provides specific health information about diesel exhaust and carbon monoxide.

Although the employer required delivery trucks to be turned off during loading and unloading, company policy required trucks to be left running at other times during the winter months to avoid difficult startups. During a typical winter day trucks were warmed up and kept idling for several hours in a parking lot adjacent to the loading and unloading docks. Depending on the prevailing wind direction, truck exhaust may enter the building. Employees mentioned that truck exhaust sometimes entered the building through the open dock doors. Employees reported transient eye and throat irritation and headaches that were possibly associated with truck exhaust. Because of the transient irritation experienced by employees and the potential risk of cancer from occupational exposure to diesel exhaust emissions [NIOSH 1988; IARC 1989; Garshick et al. 2004; Attfield et al. 2012; Silverman et al. 2012] efforts to reduce exposure to truck emissions are needed. During our visit, the employer communicated to us plans to address truck exhaust concerns in the near future.

Other Observed Hazards

The autoclave operator cleaned the approximately 5 × 20 foot autoclave weekly. To remove debris, the employee had to physically enter into the autoclave after it cooled. The company had no written procedures for entering and cleaning the autoclave, and no lockout/tagout or confined space program. The autoclave operator usually worked alone, even when cleaning the autoclave.

Entering the autoclave without proper precautions regarding work in a hot environment or in an oxygen deficient atmosphere poses serious risks to employees. The water vapor used during autoclaving can displace oxygen inside the autoclave, possibly leading to asphyxiation. Entrapment is also a possible hazard. The autoclave might be considered a permit-required confined space on the basis of the OSHA confined space standard (29 CFR 1910.146), because it had "limited entry and exit" through the 5-foot-wide door [OSHA 2007].

The company could best manage entry into the autoclave by following the OSHA standard for permit-required confined spaces (29 CFR 1910.146) [OSHA 2007] or the NIOSH recommendation to treat all confined spaces as permit-required confined spaces [NIOSH 1979]. An autoclave operator, at a minimum, would need to follow lockout/tagout procedures and verify safe oxygen levels before entry. If the atmosphere was oxygen depleted (< 19.5% by volume), proper ventilation would be needed to eliminate the hazard. Alternatively, cleaning procedures could be developed that would not require the operator to enter, such as cleaning the autoclave from the outside with a large rake or high-pressure water.

Employee Interviews

We confidentially interviewed 55 of approximately 500 employees using a structured interview form. Of the 55 employees who completed interviews, 64% were male; the average age was 26 years (range: 20–62 years). Seventy-seven percent of interviewed employees spoke English as their primary language. Some interviews were not completed due to language barriers which prevented us from effectively communicating with the employee. Job titles included 23 liquor beverage assemblers, 11 cold room food preparation employees, 11 drivers, 7 sanitation employees, and 3 others. Most interviewed employees reported working approximately 40 hours a week. About half of the participants responded that they rotated job tasks daily. The average time employed at the facility was 9 years (range: 1–23 years).

Not all employees interviewed answered all questions. Thirteen of 55 employees (24%) reported having one or more health problems they believed were work-related. These included mostly musculoskeletal problems such as tendonitis, foot pain, arthritis, carpal tunnel syndrome, and back and shoulder pain. Thirty-two of 54 employees (59%) reported discomfort with temperatures at work. Of these employees, 14 (44%) reported that extreme temperatures made them experience symptoms such as migraines, heat rash, fever, nausea, dizziness, lightheadedness, or other symptoms (e.g., sore throat, cough, runny nose) in the dishwashing area, on the dock, or in cold rooms.

Employees were asked to respond "yes" or "no" to a question regarding injury or illness. Twenty-one of the 55 employees (38%) reported they had missed work, required treatment, or been reassigned to other duties because of an injury or illness.

Health and Safety Concerns

We asked employees an open-ended question regarding what, if any, health and safety concerns they had about their job or how it was performed. Thirty-three of 55 employees (60%) reported health and safety concerns. The most frequently reported concerns were about injuries due to repetitive motions (n = 7), unsafe or unsanitary behaviors of coworkers (n = 5), truck maintenance issues (n = 5), and exposure to truck exhaust (n = 4). The remaining concerns were reported by three or fewer employees and are not listed.

Job Stress and Psychosocial Factors

NIOSH defines job stress as the harmful physical and emotional responses that occur when job demands do not match the capabilities, resources, or needs of employees [NIOSH 2009]. We asked employees to rate their level of job stress over the past week on a scale from 0 (as good as it can be) to 10 (as bad as it can be) [Clark et al. 2011]. Fifty-three employees answered this question, with the average response being 4.2. Figure 2 shows the distribution of responses to this question. Forty-nine percent of scores were between 0–3 (low job stress), 19% were between 4–6 (moderate job stress), and 32% were between 7–10 (high job stress) [Clark et al. 2011].

Figure 2. Reported job stress level over the past week (N = 53).

We asked employees an open-ended question regarding what, if any, stressors were present on the job. Forty (74%) employees reported one or more job stressors. Job stressors reported by five or more employees are listed in Table 4.

Table 4. Reported job stressors among employees (N = 54)

Job stressor	Number of employees (%)
No stressors reported	14 (26)
Time pressure	12 (22)
High work load	9 (17)
Equipment missing or unavailable	8 (15)
Understaffed/No help when needed (e.g., from runners)	8 (15)
Lack of respect from management	5 (9)

Interviewed employees were also asked to rate their level of perceived personal control in how they do their jobs on a scale from 0 (none) to 10 (very much). Fifty-three employees answered this question; the median response was 6.8. Figure 3 shows the distribution of responses to this question. Twenty-one percent of scores were between 0–3 (low perceived personal control), 21% were between 4–6 (moderate perceived personal control), and 58% were between 7–10 (high perceived personal control) [Clark et al. 2011].

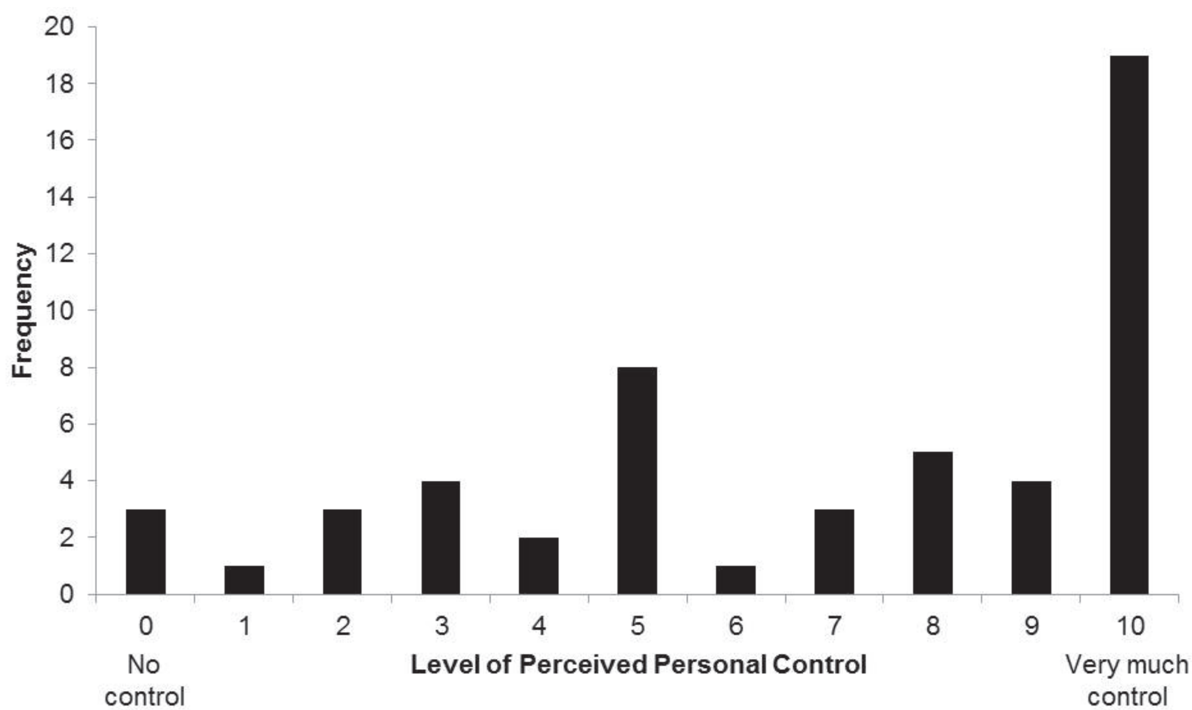

Figure 3. Reported perceived personal control in completing one's job (N = 53).

We also asked about the following psychosocial factors during the interviews: time pressure, being yelled or cursed at by managers, social support among coworkers, and whether managers were perceived as approachable for reporting health and safety concerns. Employees were asked to respond "yes" or "no" to each question, and to explain their answer. Table 5 describes the results of the yes/no portion of these questions.

Table 5. Responses to yes/no questions about psychosocial factors

Question	Number (%) of "yes" responses
Do you have enough time to do your job? (N = 53)	37 (70)
Do you feel your coworkers are supportive of one another? (N = 55)	39 (71)
Do you believe management is easy to talk to when it comes to reporting health concerns? (N = 50)	36 (72)
Has your supervisor ever yelled at you? (N = 55)	25 (45)
Has your supervisor ever sworn at you or cursed you? (N = 51)	5 (10)

Most interviewed employees (70%) indicated they had enough time to complete their job. The most frequently reported reasons for not having enough time to do one's job included equipment not being ready, busy flight schedules, being understaffed or without necessary help (e.g., runners), or being "held up" by the actions (or lack thereof) of coworkers. Some employees reported that, sometimes, common resources were not shared or were "stolen" (e.g., someone takes my supplies then I have to find new ones), which interfered with their ability to perform job tasks efficiently.

We asked for more detail regarding the approachability of managers for reporting health concerns. The most frequent response from those who said their manager was not approachable was that the concern would not be addressed. Some employees noted that they felt more comfortable talking to upper managers than their direct supervisor, and several reported that upper managers were very empathic and helpful regarding their concern or issue.

Many of those who indicated a supervisor had yelled or cursed at them also noted that it was not a common practice. Several individuals said they accept the yelling as part of their relationship with their supervisor and are not particularly bothered by it (e.g., "we yell at each other").

Our interviews revealed the most common sources of job stress included time pressure, high workload, and limited access to resources. Interviewed employees noted that these issues are not constant, which may be why the ratings of job stress were varied and low overall, with most employees' ratings falling at the bottom end of the job stress scale. Nonetheless, 17 (32%) employees rated their job stress level at 7 or greater, indicating these employees may benefit from changes in work organization to decrease time pressure and workload and to improve access to resources to complete their tasks.

Perceived personal control was explained to employees as how much choice or control they have over their jobs, including things such as how to complete their tasks and in what order. Ratings of perceived personal control varied; most responses reported a high level of perceived control (rating > 7). Eleven individuals (21%) reported feeling a low sense of personal control (rating 0–3). Most of these individuals mentioned time pressure, high work load, and inconsistency in procedures as major job stressors, which may be tied to their feelings of low control.

A recurring theme in the interviews included the behavior of one's coworkers impeding efficiency and a lack of sense of teamwork. Some individuals thought more help would improve their feelings of job stress, either in increased staff or willingness of others to assist during periods of high time pressure and workload. Social support from coworkers and supervisors is integral to a successful work environment, and improves organizational outcomes such as reduced turnover and burnout, and increased work engagement and productivity [Leiter and Stight 2009].

Research supports a strong association between psychosocial factors and work-related MSDs [NIOSH 1997; Warren 2001]. Psychosocial factors may cause chronic increased muscle tension, thus making soft tissues more susceptible to the effects of physical stressors. Psychosocial factors may also raise awareness of MSD symptoms and affect reporting behavior [NIOSH 1997]. For example, the interactive effects of psychosocial factors (e.g., high workload, low social support, and low job satisfaction) and physical stressors are related to the development of musculoskeletal pain in the lower back [De Beeck and Hermans 2000; World Health Organization 2010]. A combination of ergonomic, job design (e.g., rotation of tasks), and psychosocial interventions may result in a decrease in job stress and musculoskeletal pain.

Work Practices Reported During Interviews

Most of the interviewed employees reported taking two scheduled breaks per shift, 30 minutes for lunch and another break for 20 minutes. Some employees reported having problems with access to fluids on hot days because drinks were permitted only in the cafeteria and on the dock. Employees reported that hand washing behavior varied depending on the job task, but for the most part, employees washed their hands before and after shifts and during breaks. The company provided PPE; however, some employees brought their own shoes for comfort reasons and gloves because of limited availability of some glove types/sizes. Employees reported wearing many types of gloves for all duties including cloth, latex, cloth and latex, autoclave (heat resistant), leather, and cut-resistant gloves. The company provided the cold room employees with lab coats and winter coats. All interviewed employees reported that they wore slip-resistant shoes per company policy; the drivers wore steel-toed shoes. In addition, four employees reported wearing some type of hearing protection and safety glasses.

Review of OSHA Logs

The OSHA Logs for the previous 5 years, 2007–2011, contained reports of 200 injuries and 2 skin disorders. Musculoskeletal strain, sprain, or pain entries were the most common type of injury with 112 cases (56% of injuries). The number and type of injury for 2007–2011 are described in Figure 4. Musculoskeletal strain, sprain, or pain injuries most commonly affected the back and shoulder and the most common causes of injuries were lifting and pulling/pushing equipment and falling. Other types of injuries included contusion/abrasion, laceration, burn, fracture, foreign object, and insect stings.

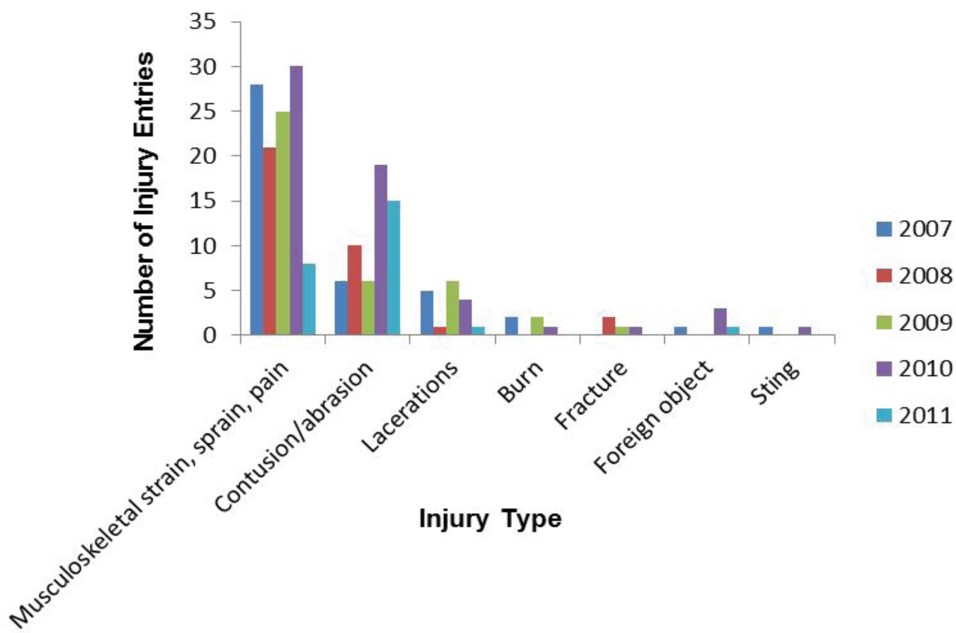

Figure 4. OSHA Log injuries by type for years 2007–2011.

Conclusions

Employees were exposed to a combination of risk factors for work-related MSDs including awkward postures, forceful exertions, and repetitive motions. Musculoskeletal strain, sprain, or pain entries were the most common type of injury according to the OSHA Logs. The potential exists for autoclave operators and delivery truck drivers to work in hot conditions during the summer months. Measures to reduce the potential for heat strain and confined space hazards in the autoclave should be implemented. Potential exposure to diesel exhaust for loading and unloading dock employees should be reduced. Most employees reported low to moderate job stress. The most common sources of job stress included time pressure, high workload, and limited access to resources. A lack of social support and teamwork among employees was also a common theme reported during interviews.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the airline catering facility to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the airline catering facility.

Ergonomics

Many of the recommendations listed below were obtained from *The Handbook of Ergonomic Design Guidelines* [Humantech 2009].

1. Design for adjustability when possible. When designing reaches, design for the smallest or shortest people in the working population (5th percentile female). Do not design for the average; it excludes most of the working population.
   a. Create a standing hand working height that is adjustable at 38″–47″ or fixed at 42″.
   b. Place part bins in front of the employee with less than 16″ reaching distance at a vertical height of 24″–70″.
   c. Locate more frequently used items or heavy items 38″–49″ above standing surface.
   d. Do all work within 22″ of the edge of the workstation (horizontal work distance guideline) to eliminate extended reaches.
2. Provide tools to aid in reaching, such as a hook to pull material closer to the employee.
3. Ensure that flow racks have the following dimensions: 38″–49″ retrieval height (frequent), 38″–62″ replenish height (infrequent), rack angles of 0°–30°, and a minimum 5″ clearance from the top of the bin to the bottom of the next shelf.
4. Cross-train employees for different jobs, and rotate employees through jobs with different physical demands to reduce the stress on limbs and body regions. Rotate every 2 hours to increase job variability.

5. Provide lift tables or load levelers for palletized materials such as soda, beer, or water. A rotating top will help reduce reach distances when access is not available on three sides of a pallet.
6. Keep heavy loads close to the body when lifting and carrying.
7. Provide industrial mats for employees who stand for 90% or more of their working hours. Mats should be ≥ 0.5″ thick, have an optimal compressibility of 3%–4%, have beveled edges to minimize trip hazards, and be placed at least 8″ under a workstation to prevent uneven standing surfaces. Mats should cover the entire area over which the employee moves while performing work tasks and be replaced when they appear worn out or are damaged.
8. Evaluate the effectiveness of the new engineering and administrative controls. Develop a system for employees to provide information and feedback on work equipment and procedure modifications.

Cold Rooms

1. Install deflectors in all refrigerator fans in the international cold room. A horizontal deflector design with spacers (Figure 5) should improve the volumetric flow and efficiency of the refrigerator unit (the less restrictive design should improve airflow through the cooling coils). Nonmetal spacers that create an air gap between the refrigeration unit and the edge of the deflector will create a thermal break, enhance airflow, and eliminate the condensation collection point inherent in the current deflector design.
2. Replace old deflectors (Figure 1) with horizontal baffle deflectors (Figure 5).

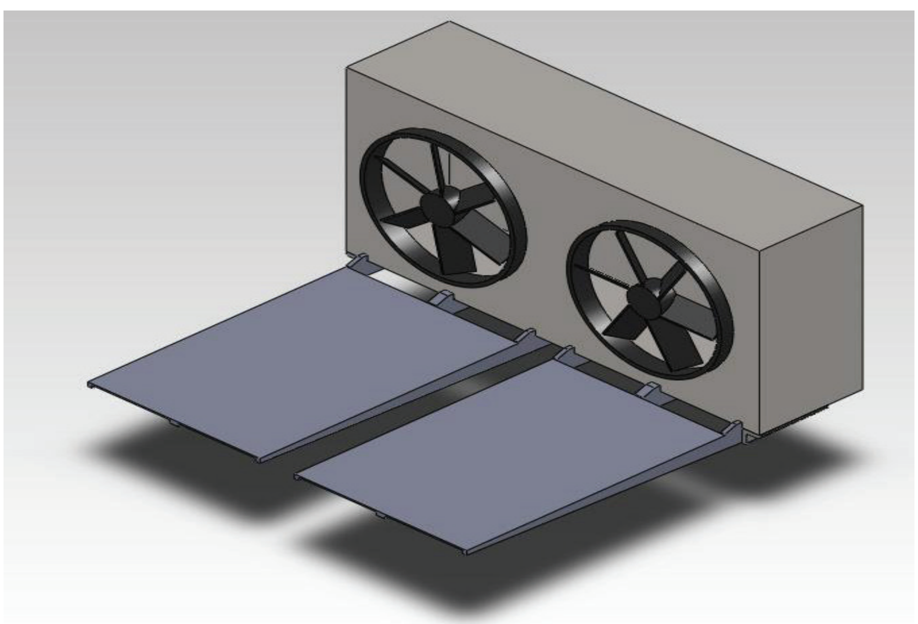

Figure 5. Suggested fan assembly horizontal deflector design with spacer. Figure by NIOSH.

3. Install ceiling baffles in cold rooms where employees spend more than a few hours a day to decrease drafts without overly restricting room airflow. These baffles are horizontally suspended panels (free hanging nonporous surfaces) intermittently spaced throughout the ceiling. A trial-and-error approach can be used for determining baffle placement that reduces drafts in fixed work locations.
4. Evaluate using thinner, fingertip-less, or fingerless liner gloves for employees to wear under the required plastic gloves when performing work requiring fine manual dexterity. We do not recommend natural rubber latex gloves because they can cause Type I allergy, such as hives, rhinitis, asthma, and anaphylaxis.
5. Do not wear wet clothes inside the cold room. Dry clothes are essential to achieve thermal comfort.
6. Rotate employees performing work requiring fine manual dexterity between warmer and colder areas throughout the workday. Rotating every 2 hours will also allow for breaks from cold temperatures.
7. Minimize work requiring fine manual dexterity during the food preparation stage, when feasible.
8. Implement a replacement schedule for gloves and other nondisposable PPE that includes checking for degradation of the materials, excessive wear, tears, or other factors that may impede its effectiveness.
9. Provide hand warmers (e.g., warm air hand dryer) outside of the cold rooms so that employees can warm their hands periodically.

Heat

1. Establish a written heat stress prevention program that includes regular breaks and access to fluids.
2. Inform employees and supervisors of OSHA heat safety tools found at http://www.osha.gov/SLTC/heatillness/heat_index/heat_app.html. The website provides information on protective measures they can take on the basis of the heat index at the worksite.
3. Ensure that new trucks have air conditioning and repair systems in existing vehicles.

Carbon Monoxide

1. Maintain and inspect trucks following Environmental Protection Agency guidelines found at http://www.epa.gov/otaq/im.html to identify high emission vehicles that need repair.
2. Implement plans to minimize diesel exhaust entering the building during the winter season by installing dock-to-truck seals and rerouting truck exhaust.
3. Use air extraction fans, filters attached to tailpipes, and catalytic converters as recommended in the Health and Safety Executive guidance document (http://www.hse.gov.uk/pubns/indg286.html) to reduce diesel exhaust in the workplace.

4. Park trucks at the alternative location away from the building, especially during the morning start-up activities in the winter. Make sure that dock doors remain closed while trucks are not docked to avoid diesel exhaust entering the building.

Policies and Procedures

1. Classify the autoclave as a confined space. The OSHA standard on confined spaces is found at http://www.osha.gov/SLTC/confinedspaces/index.html.
2. Establish a written autoclave cleaning procedure. If entry is required for cleaning, address confined space requirements including lockout/tagout procedures, air monitoring prior to entry, and use of PPE and rescue procedures in accordance with the applicable OSHA standards and NIOSH recommendations.
3. Ensure good housekeeping to reduce slips, trips, and falls. The Washington State Department of Labor and Industries has restaurant safety materials that provide information on footwear, housekeeping, and general awareness tips to prevent slips, trips, and falls [Washington State Department of Labor and Industries 2008].
4. Replace or repair uneven floors as well as wheels on carts to reduce injuries caused by cart accidents.
5. Modify the lifting water SOP to also include soda and other palletized materials. Remind employees to keep heavy loads close to the body when lifting and carrying.
6. Present all information (e.g., training, messages to employees, hazard communication materials, etc.) in a manner that employees are able to understand, which may include languages other than English.
7. Educate employees on the symptoms of cold and heat stress, as well as the importance of using the appropriate protective clothing and staying hydrated. Train employees in how to appropriately reduce heat (e.g., reacclimatization, and work/rest and hydration schedules) and cold stress (e.g., appropriately using PPE, changing wet clothing immediately, and taking short breaks to warm hands).
8. Provide drinkable water and cups. Water containers must be cleaned and refilled daily and kept in a shaded area. Reevaluate the policy prohibiting water and other drinks in the trucks if employees do not have access to a break area every 30 minutes.
9. Educate employees on MSDs and ergonomics, covering specific operations that have been identified by NIOSH or the company as causing or likely to cause MSDs.
10. Explore and address issues of job stress, particularly the importance of increasing teamwork/social support and personal control and decreasing time pressure. An open discussion with employees may help identify and address barriers to these issues. Otherwise, hiring a consultant with expertise in organizational psychology or a related field may be beneficial. The Society for Industrial and Organizational Psychology maintains a consultant locator at http://www.siop.org/consultantlocator/search.aspx. The American Society of Safety Engineers also maintains directories of qualified consultants at http://www.asse.org/practicespecialties/consultants/. Evaluate whether increasing staff during peak hours would improve efficiency and lower job stress.

11. Encourage employees to report work-related symptoms (e.g., musculoskeletal, cold, and heat stress) to their supervisor. Employees with work-related symptoms should promptly seek medical attention from their healthcare provider.
12. Encourage employees to seek services from their healthcare provider or a mental health professional if they are experiencing significant stress-related symptoms that are impairing their occupational, social, or other important areas of functioning (e.g., engagement in day-to-day tasks, hygiene, etc.). This should be communicated to all employees so no individuals feel singled out.
13. Improve communication between managers and employees regarding employee health and safety concerns. Employees should feel that managers are interested in knowing about their concerns and take them seriously. Employees should be informed what actions have been or will be taken regarding their concerns, and concerns should be addressed in a timely manner.
14. Encourage employees to participate in safety and ergonomics committees. These committees should consist of management, union, and employee representatives.
15. Use injury and illness cases recorded on OSHA Logs and other incident reporting systems to look for trends in type of injury or job title to target interventions. This may be especially helpful for MSDs since they constituted the majority of OSHA Log entries. Information on using OSHA Logs to improve safety and health programs can be found at https://www.osha.gov/recordkeeping/handbook/.

Appendix A: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time weighted average exposure. A time weighted average refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits or ceiling values. Unless otherwise noted, the short-term exposure limit is a 15-minute time weighted average exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- The U.S. Department of Labor OSHA permissible exposure limits (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH recommended exposure limits are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Other OELs commonly used and cited in the United States include the TLVs, which are recommended by ACGIH, a professional organization, and the workplace environmental exposure levels™, which are recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and workplace environmental exposure levels are developed by committee members of these associations from a review of the published, peer-reviewed literature. These OELs are

not consensus standards. TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2014]. Workplace environmental exposure levels have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2014].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/Gefahrstoffdatenbanken/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 1,500 hazardous substances and is updated periodically.

OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at http://www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement existing OELs.

Ergonomic Evaluation Criteria

Musculoskeletal disorders are those conditions that involve the nerves, tendons, ligaments, muscles, spinal discs, and soft tissues of the body. They can be characterized by symptoms of pain, aching, numbness, or tingling that may come and go. MSDs can range in severity from mild and intermittent to debilitating and chronic. They are not typically the result of any instantaneous or acute event (such as a slip, trip, or fall) but reflect a more gradual or chronic development. MSDs are diagnosed by a medical history, physical examination or other medical tests. Work-related MSDs refer to (1) MSDs in which the work environment and the performance of work contribute significantly, or (2) MSDs that are made worse or longer lasting by work conditions. A substantial body of data provides strong evidence of an association between MSDs and certain work-related factors (physical, work organizational, psychosocial, individual, and sociocultural). The multifactorial nature of musculoskeletal disorders requires a discussion of individual factors and how they are associated with work-related musculoskeletal disorders. Strong evidence shows that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs [NIOSH 1997]. Further strong evidence shows job tasks that require a combination of risk factors (highly repetitious, forceful hand/wrist exertions) increase risk for hand/wrist tendonitis [NIOSH 1997]. Finally, strong evidence shows that low-back disorders are associated with work-related lifting and forceful movements [NIOSH 1997]. A number of personal factors can also influence the response to risk factors for MSDs: age, sex, smoking, physical activity, strength, and body measurements. Although personal factors may affect an individual's susceptibility to overexertion injuries/disorders, studies conducted in high-risk industries show that the risk associated with personal factors is small compared to that associated with occupational exposures [NIOSH 1997].

In all cases, the preferred method for preventing and controlling work-related MSDs is to design jobs, workstations, tools, and other equipment to match the physiological, anatomical, and psychological characteristics and capabilities of the employee. Under these conditions, exposures to risk factors considered potentially hazardous are reduced or eliminated.

Carbon Monoxide

Carbon monoxide is produced by incomplete burning of carbon-containing materials such as diesel fuel. In previous evaluations of employees' exposures to diesel exhaust, NIOSH investigators have concluded that a potential health hazard exists when employees are experiencing occupational exposures that exceed ambient background levels – such as when diesel engines are operated close to work areas – and have recommended adopting measures to reduce exposures whenever feasible [NIOSH 1992, 1999]. Although these evaluations often have included measuring employees' exposures to a variety of airborne contaminants, the basic conclusions and recommendations have applied regardless of the exposure levels measured. Therefore, exposure measurements may be more useful for comparing exposures before and after controls are established than in establishing that a potential hazard exists.

Diesel Exhaust

Diesel exhaust is a complex mixture of thousands of gases and fine particles (commonly known as soot) that contains more than 40 potentially toxic compounds [Environmental Protection Agency 2002]. The particulate fraction of diesel exhaust is composed of microscopic cores of elemental carbon onto which are adsorbed thousands of substances [NIOSH 1988; OSHA 1988]. The adsorbed material contributes 15% to 65% of the total particulate mass and includes compounds such as polycyclic aromatic hydrocarbons, many of which are possibly carcinogenic [NIOSH 1988; OSHA 1988; Air Resources Board 1998]. Because of their small size (< 2.5 micrometers in aerodynamic diameter) [Wichmann 2007], diesel exhaust particles can be inhaled deeply into the lungs where they are more difficult to clear [Hinds 1999]. Some of the main toxic gases in diesel exhaust are oxides of nitrogen, sulfur, and carbon [NIOSH 1988; OSHA 1988].

Acute health effects of diesel exhaust exposure include irritation of the eyes, nose, throat, and lungs, and it can cause cough, headache, lightheadedness, and nausea [Reger and Hancock 1980; Gamble et al. 1987; Sydbom et al. 2001]. Exposure to diesel exhaust can also cause inflammation in the lungs, which may aggravate chronic respiratory symptoms and asthma. Chronic exposures are associated with cough, increased sputum production, and lung function changes [Ulfvarson and Alexandersson 1990; Sydbom et al. 2001]. Whether a person experiences these acute or chronic health effects depends on the magnitude of their exposures and on individual susceptibility.

Diesel exhaust is considered a probable human carcinogen [IARC 1989]. On the basis of the results of laboratory animal and human epidemiology studies, NIOSH considers whole diesel exhaust emissions a potential occupational carcinogen [NIOSH 1988]. Human epidemiology studies suggest an association between occupational exposure to whole diesel exhaust emissions and lung cancer [NIOSH 1988; Air Resources Board 1998; Garshick et al. 2004; Attfield et al. 2012; Silverman et al. 2012], while studies of rats and mice exposed to whole diesel exhaust, and especially to the particulate portion, confirm an association with lung tumors [NIOSH 1988; OSHA 1988; Air Resources Board 1998]. NIOSH has stated that "excess cancer risk for workers exposed to diesel exhaust has not yet been quantified, but the probability of developing cancer should be reduced by minimizing exposure" [NIOSH 1988]. Federally mandated OELs exist for nitrogen monoxide, nitrogen dioxide, sulfur dioxide, and carbon monoxide; however, at the present time, no federally mandated OELs exist for diesel exhaust.

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