Ergonomic Evaluation of Frank Hangers at a Turkey Processing Plant

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Health Hazard Evaluation Report
HETA 2007-0098-3061
Foster Farms
Livingston, California
May 2008

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
NIOSH *National Institute for Occupational Safety and Health*

The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

Contents

Abbreviations

CLIs	Cumulative lifting indices
HHE	Health hazard evaluation
LI	Lifting index
MSD	Musculoskeletal disorder
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RNLE	Revised NIOSH lifting equation
RWL	Recommended weight limit
WMSD	Work-related musculoskeletal disorder

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a union request for a health hazard evaluation at Foster Farms in Livingston, California. NIOSH investigators performed an ergonomics evaluation there in March 2007. The investigators evaluated potential workplace hazards and explored ways to decrease risks for musculoskeletal injuries.

What NIOSH Did

- We talked with workers about their work and medical history. We also talked to them about work-related musculoskeletal disorders.
- We watched and took videos of jobs in the raw and cooked frank areas. We also recorded weights, heights, and distances to calculate injury risk.

What NIOSH Found

- We found that hanging and unloading franks increases the risk of musculoskeletal injury due to awkward postures, repetitive motions, and heavy lifting.
- We found that workers reported musculoskeletal pain and discomfort in their back and shoulders when hanging and removing franks.

What Foster Farm Managers Can Do

- Managers should provide workers with taller platforms in both the raw and cooked production areas. They should raise the floor in both production areas, or lower the conveyor so that lifting is performed between 28"–60" from the floor.
- Managers should rotate workers from lifting to non-lifting jobs so that lifting tasks are limited to less than two hours per rotation.
- Managers should provide workers' training so they can identify unsafe work practices, and early warning signs of musculoskeletal disorders.

What Foster Farm Employees Can Do

- Employees should not lift while standing behind the platform; this reduces the horizontal reach distance.
- Employees should step as close as possible to racks when hanging and removing franks to minimize horizontal reach.
- Employees should take time to work safely and lift properly.

Summary

Workers hanging and removing franks from racks in the deli plant are at increased risk for musculoskeletal injury. Risk factors include repetitive motions, awkward postures, and heavy lifting. Recommendations include job redesign and/or job rotation.

On January 19, 2007, NIOSH received an HHE request from the International Association of Machinists and Aerospace Workers to evaluate potential ergonomic hazards among workers at the Foster Farm deli plant in Livingston, California. Complaints from employees who were not able to perform the frank hanging job in the deli plant prompted the request.

On March 15–16, 2007, NIOSH investigators visited the Foster Farms deli plant. NIOSH ergonomic specialists walked through the plant to observe tasks in both the raw and cooked frank production areas. A NIOSH epidemiologist conducted voluntary medical interviews with workers.

The ergonomics evaluation indicated that workers are exposed to risk factors for developing MSDs due to awkward postures (lifting overhead) and repetitive motions. Five of 10 (50%) workers who performed frank hanging tasks at the time of their interviews reported work-related musculoskeletal pain or discomfort in the back and/or shoulder in the previous year. Pain was reported as minor with no missed work; however, two workers had sought medical care from their personal physician.

Recommendations for reducing the risk of injury include reducing the heights and horizontal reach distances of the lifts and/or providing platforms that reduce overhead reaching in both the raw and cooked production areas.

Keywords: NAICS 311615 (Poultry Processing), hanging franks, repetitive motions, work-related musculoskeletal disorders, ergonomics, shoulder pain

On January 19, 2007, NIOSH received an HHE request from the International Association of Machinists and Aerospace Workers to evaluate potential ergonomic hazards among frank hangers at the Foster Farms deli plant in Livingston, California. Reports from some employees who were not able to perform frank hanging, a specific job on the production line, prompted the request.

On March 15–16, 2007, NIOSH investigators visited the deli plant in Livingston, California. On March 15, 2007, NIOSH investigators held an opening conference with management, union officials, and the company's contracted ergonomist. NIOSH ergonomic specialists observed frank hanging tasks in both the raw and cooked production areas and a NIOSH epidemiologist held voluntary medical interviews with the workers. Translators (union representatives and management) were used to assist Spanish-speaking participants. On March 16, 2007, NIOSH investigators conducted a closing conference and provided preliminary recommendations to union officials and company representatives.

Process Description

The Livingston, California processing plant was added to Foster Farms in 1959. In 1960, Foster Farms corporate headquarters moved to Livingston. The current deli plant was built in 1979 and the current frank process began in 1989. According to company representatives, no process changes have been made since 1989. The entire plant (including the kill plant) has approximately 2400 employees; approximately 24 employees hang or remove franks in the deli-cook division. Hangers in the deli plant work first and second shift; third shift is reserved for cleaning and sanitation. Each shift is 8 hours; however, workers are subject to seasonal compulsory overtime with a maximum of 48 hours worked per week.

Job Descriptions

Raw Production

Six stuffer/linker machines produce links of franks that are used for hot dogs or corn dogs. These machines automatically stuff casings and form a continuous link of franks. A worker at the end of each machine positions a rod through the loop of draped links, lifts the rod off the conveyor system, and hangs the rod onto a rack that moves through the oven. The floors are made of brick and are

usually wet. Workers do not rotate between positions in the raw production area. Some workers use platforms to help them reach the top tier of the racks.

Cooked Production

At four stations, workers remove rods of frank links from racks that have traveled through the oven. Two workers are positioned at each station. Each worker removes a rod of cooked franks from the rack and slides the links off into a bin. The empty rod is placed on a cart next to the bin. The worker then stands next to the bin and funnels the franks by hand into a machine that removes the casing. As in the raw production side, the floors are made of brick and are wet in this area. Workers do not rotate between positions in the cooked production area. Some workers use platforms to help them reach the top tier of the racks.

Equipment Used in Frank Production

Racks

A picture of the racks used in both the raw and cooked production areas is shown in Photo 1. The racks travel by overhead conveyor from the raw production area through the oven and into the cooked production area. Workers push the empty racks through an access door between the cooked and raw areas to start back through the system. The dimensions for each rack are 50" wide by 42" high by 31" deep. Each rack has three tiers, the heights of the rack tiers when suspended on the conveyor are 37", 59", and 81" from the floor. Workers in the raw production area hang three to five rods of frank links per tier depending on size and weight of the frank being produced, resulting in 18 to 30 lifts per rack. The rods are hung in no specific order; however, workers tended to hang the rods on various tiers to stabilize and balance the rack. It was observed that if one side of the rack was loaded before rotating to the other side, the rack would lean from the weight and make the working heights of the tiers on the opposite side higher than the measurements shown in the photo. It was unclear whether the racks could be locked into position.

Rods

The metal rods used to hang the frank links are approximately 50" long, and when fully draped with raw franks, weigh from 18 to 38 pounds, depending on the size of the frank being produced.

Cooking reduces the weight of the franks by about 10%. The weight of the rod and cooked franks when removed from the rack in the cooked production area is 16 to 35 pounds.

Photo 1. Fully loaded frank rack in the cooked production area with measured height dimensions.

Platforms

Platforms, designed and built by Foster Farms, were available for workers to stand on in both the raw and cooked production areas. Various size platforms were available ranging from 6" to 9" tall. The platform used in the cooked production area during the site visit was 19" wide by 17" deep by 6" tall. The dimensions of the platform demonstrated in the raw production area were 36" wide by 27" deep by 9" tall.

The NIOSH ergonomics specialists and epidemiologist observed workers hanging and removing franks in both the raw and cooked production areas. NIOSH investigators recorded lift frequencies, working heights, and reach measurements to document the tasks performed by the workers and used a digital camera to record job tasks. A description of the Ergonomics Evaluation Criteria is provided in Appendix A. The RNLE [Waters 1994] was used to help categorize the risk of lifting tasks (calculated LIs) in both the raw and cooked production areas. A full description of the components of the RNLE is provided in Appendix B. In brief, the equation provides the RWL and LI for a lifting task, given certain lifting conditions. The RWL is the weight that can be handled safely by almost all healthy workers in these conditions. The LI is the ratio of the actual load lifted to the RWL. Tasks with a LI > 1.0 may place an increasing number of individuals at risk of low back injury, and tasks with a LI > 3.0 pose a risk of back injury for most workers. Lifting tasks with an LI ≤ 1.0 pose little risk of back injury for most workers. The key to interpreting the risk of injury for a given LI is to understand how injuries increase as the LI increases. A cross-sectional epidemiologic study conducted by NIOSH indicated that as the LI increased for 204 workers performing 50 different lifting jobs in four different industrial facilities, the prevalence of reported back pain also increased [Waters 1999]. The prevalence of back pain lasting a week or more was highest for workers performing lifting jobs in the $2 < LI \leq 3$ category, nearly twice that of workers in non-lifting jobs. The risk of injury for jobs in the $1 \leq LI \leq 2$ category was higher than for non-lifting jobs but the increase in risk was not significant due to small sample size. The best approach to injury prevention is to design jobs for workers that result in LIs ≤ 2. Two reach distances were used for the RNLE calculations: compact and non-compact. A compact lift is considered the best-case scenario because workers hold the rod of franks close to their bodies when performing the lift. A non-compact lift is considered the worst-case scenario because workers reach almost arm's length from their bodies when performing the lift.

Current and former frank hanger employees of Foster Farms were invited to participate in interviews. Former employees are workers who previously performed frank hanging tasks but currently perform other job tasks in the deli division. The NIOSH epidemiologist interviewed 12 employees during the site visit. Employees were asked to provide their age, job title, duration of employment at Foster Farms, hours worked per week, and if they had any musculoskeletal pain over the past year. If they reported

Assessment (continued)

pain over the past year, they were asked additional questions regarding location of pain and tasks associated with the pain. Employees were also given the opportunity to voice any other work-related health and safety concerns.

Results and Discussion

Raw Production

NIOSH investigators used the RNLE to evaluate the frank loading job in the raw production area because it involved significant repetitive lifting. Tables C1–C8 in Appendix C record the assumptions that were made in calculating the LIs for this job.

Table 1 shows RWL and LI results for compact and non-compact frank loading when no platform is used and when a 9" platform is used. These parameters were thought to represent the best and worst case scenarios. However, the upper limit for vertical lift height (as defined by the RNLE) of 70" was used in place of the actual highest destination vertical lift height measured at the work site, 81".

As seen in Table 1, non-compact lifts had LIs almost twice those of compact lifts and heavier lifts had LIs almost twice those of lighter loads. Using the 9" platform slightly improved the lifting hazard. A majority (83%) of the lifts calculated had LIs greater than 1.0, which places an increasing number of workers at risk for low back injuries. Four of the lifts calculated had LIs greater than 3.0, which pose a risk of back injuries for most workers.

Table 1. RWL and LI results for raw production frank hanging tasks

Task	Rack Height	No Platform RWL (lbs)	No Platform LI	9" Platform RWL (lbs)	9" Platform LI
18-pound lift, Compact	Low	26.7	0.7	27.8	0.7
	Middle	17.7	1.0	19.3	0.9
	High	15.6	1.2	15.4	1.2
18-pound lift, Non-compact	Low	13.3	1.4	13.9	1.3
	Middle	9.8	1.9	10.6	1.7
	High	8.6	2.1	8.4	2.2
38-pound lift, Compact	Low	26.7	1.4	27.8	1.4
	Middle	17.7	2.2	19.3	2.0
	High	15.6	2.5	15.4	2.5
38-pound lift, Non-compact	Low	13.3	2.9	13.9	2.7
	Middle	9.8	3.9	10.6	3.6
	High	8.6	4.4	8.4	4.5

Cooked Production

NIOSH investigators used the RNLE to evaluate the unloading job in the cooked production area because it also involved significant repetitive lifting. Tables C9–C16 in Appendix C record the assumptions that were made in calculating the lifting indices for this job. The platform provided in the cooked area was smaller than the one demonstrated in the raw production area; this allowed the workers to stand in various positions around the platform, rather than using it for every lift. During our observation, workers straddled the platform, placed one foot on the platform, placed both feet on the platform, or stood behind the platform to perform lifts. The summary results in Table 2 show RWL and LI results for compact and non-compact frank unloading when no platform is used, when a 6" platform is used, and when lifts are performed standing behind the platform. These are considered best and worst case scenarios. Due to the numerous permutations, not all were calculated. The upper limit for vertical lift height (as defined by the RNLE) of 70" was used in place of the actual highest destination vertical lift height measured at the work site, 81". The upper limit for horizontal distance of the load from the body (as defined by the RNLE) of 25" was used for the calculations when workers were standing behind the platform and reaching in (Tables C15 and C16). This is less than the actual distance of the load from the body at the origin of these particular lifts.

As seen in Table 2, non-compact lifts had LIs almost twice those of compact lifts and heavier lifts had LIs twice those of lighter loads. Using the 6" platform did not improve the lifting hazard. The smaller platforms, observed in the cooked production area, resulted in workers standing behind the platform rather than using it. This extended horizontal reach worsened the LIs, and increased the risk of shoulder and back injuries. A majority (87.5%) of the lifts calculated had LIs greater than 1.0, which places an increasing number of workers at risk for low back injuries. Seven of the lifts calculated had LIs greater than 3.0, which poses a risk of back injuries for most workers.

Table 2. RWL and LI results for cooked production frank unloading tasks

Task	Rack Height	No Platform RWL (lbs)	No Platform LI	6" Platform RWL (lbs)	6" Platform LI	Behind Platform RWL (lbs)	Behind Platform LI
16-pound lift, Compact	Low	24.5	0.7	Not Calculated			
	Middle	21.9	0.7				
	High	18.7	0.9				
16-pound lift, Non-compact	Low	12.3	1.3	12.4	1.3	9.8	1.6
	Middle	10.9	1.5	11.6	1.4	8.8	1.8
	High	9.3	1.7	9.3	1.7	7.5	2.1
35-pound lift, Compact	Low	24.5	1.4	Not Calculated			
	Middle	21.9	1.6				
	High	18.7	1.9				
35-pound lift, Non-compact	Low	12.3	2.9	12.4	2.8	9.8	3.6
	Middle	10.9	3.2	11.6	3.0	8.8	4.0
	High	9.3	3.8	9.3	3.8	7.5	4.7

Employee Interviews

Face-to-face and telephone interviews were conducted with 12 deli-division employees who currently performed or had previously performed frank hanging tasks. Employees were selected for interviews by NIOSH investigators from either an employee roster, upon recommendation from union officials, or by individual worker request. Median length of employment was 54 months, with a range of 9–108 months. Among those interviewed, 8 of 12 (67%) were male. Among the 12 interviewed workers, 6 (50%) hung franks on either the raw or cooked production line full-time; 4 of 12 (33%) hung franks part-time, filling in during breaks, vacations, or other worker absences. Two of the interviewed workers (17%) reported that they no longer worked as frank hangers due to the difficulty of the work.

Among the 10 interviewed workers currently hanging franks, 4 (40%) said that the height of the racks made their work difficult, and 5 of 10 (50%) reported back and/or shoulder pain from their job. All of these workers reported that the pain was minor and was controlled with rest or over-the-counter analgesics. None reported missing work; however, two reported seeking private medical care. None were diagnosed with specific musculoskeletal illnesses. Other historical work-related injuries were reported by 4 of 12 (33%) interviewees; these involved lacerations or slips with no time off work.

Results and Discussion (continued)

Foster Farm's OSHA Form 300 Logs of Work-Related Injuries and Illnesses forms for 2003–2006 were reviewed. A total of four employees with the job title "Hang Franks" reported injury: one in 2003, one in 2004, two in 2005, and zero in 2006. Two of the entries involved shoulder and wrist sprains, with 5 and 12 days restricted duty respectively; one was a contusion and one a laceration, with no job restrictions or time away from work.

Conclusions

On-site assessments and interviews at Foster Farms are the basis for the following conclusions and recommendations. Workers in the raw and cooked production areas who hang and remove franks are exposed to a combination of concurrent risk factors for developing upper and lower extremity MSDs: awkward postures, repetitive motions, and heavy lifts. Most of the interviewed workers reported shoulder and back pain consistent with the ergonomic hazards identified.

The main concern in these two areas is that these jobs require workers to repetitively lift heavy loads above shoulder height. The evaluation method used was not able to fully characterize the highest lift (81") because this is above the upper vertical height limit for the RNLE. The result is a possible underestimation of the actual risk of injury for performing this lift.

Recommendations

The following recommendations are offered to help reduce the risk of WMSDs for employees in the raw and cooked production areas. The preferred method of controlling ergonomics hazards is to provide engineering controls that redesign the workstation and/or job task to reduce or eliminate the risk of WMSDs. Recommendations 1 through 3 provide suggestions for engineering controls. Administrative controls or policies designed to limit workers' exposures to hazardous conditions can be used temporarily until engineering controls are implemented. Recommendations 4 and 5 provide suggestions for administrative controls. In addition, NIOSH investigators recommend training employees to recognize ergonomic hazards and asking them to participate in the process of identifying hazards and making job modifications. Recommendations 6 and 7 will help achieve these goals.

RECOMMENDATIONS (CONTINUED)

1. Lower the conveyor in both the raw and cooked production areas to drop the lift height to a range of 28–60" as it passes by the worker. This will reduce overhead reaching when hanging and removing rods on the racks and thus reduce the risk for back and shoulder injuries.
2. Raise the entire floor on which workers stand in both the raw and cooked production areas, resulting in lifts being performed within the suggested range of 28–60".
3. Design platforms for workers that are at least 9" in height. Platform, such as the one demonstrated in the raw production are, should provide a large surface area to stand on. A minimum recommended size would be 50" wide, 30" deep, and 9" high.
4. Schedule lifting and non-lifting rotation patterns for workers. These rotation patterns should be in accordance with the "short duration" lifting category as defined by the RNLE (< 2 hours). In the raw production area, workers could rotate between running the stuffer/linker machine and hanging franks.
5. If the current lifting conditions are not changed, follow the calculated RWLs. Therefore, lifting would be limited to a range of 9 to 26 pounds. This would require modifying the number of franks per rod.
6. Train workers to minimize horizontal reach distances by stepping as close as possible when hanging and removing rods from racks. Extended reaches cause unsafe postures that can result in shoulder and back injuries as well as lead to slipping on the wet floor and falling.
7. Management and employees should jointly address ergonomic issues routinely and periodically evaluate the effectiveness of implemented engineering and administrative controls.

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Appendix A: Ergonomic Evaluation Criteria

The term MSDs refer to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. WMSDs are a major component of the cost of work-related illness in the United States. A substantial body of data exists providing strong evidence of an association between MSDs and certain work-related factors (physical, work organizational, psychosocial, individual, and sociocultural). The multifactorial nature of MSDs requires a discussion of individual factors and how they are associated with WMSDs. There is strong evidence 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]. There is also strong evidence that job tasks that require a combination of risk factors (highly repetitious, forceful hand/wrist exertions) increase risk for hand/wrist tendonitis [NIOSH 1997]. Lastly, there is strong evidence 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 including: age, gender, smoking, physical activity, strength, and anthropometry. 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/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 worker. Under these conditions, exposures to task factors considered potentially hazardous will be reduced or eliminated.

The criteria used to evaluate the job tasks at Foster Farms were workplace and job design criteria found in the ergonomics literature and recommendations for acceptable lifting weights as determined by the RNLE.

Workstation design should directly relate to the anatomical characteristics of the worker. Because a variety of workers may use a specific workstation, a range of work heights should be considered. Based upon female/male 50th and 95th percentile anthropometric data, workstation heights should be within a range of 27.6" to no higher than 60" [Kroemer 1989]. These heights correspond to knuckle and shoulder dimensions of U.S. civilians, age 20 to 60 years.

The RNLE is a tool for assessing the physical demands of two-handed lifting tasks. The equation provides an RWL and LI for a lifting task, based upon the lifting conditions [Waters 1994]. When initiating a lift, the RNLE provides a recommended vertical height of the hands above the floor at 30". A height of 30" above the floor is considered "knuckle height" for a worker of average height. In ideal lifting conditions, the RNLE provides a maximum RWL of 51 pounds. Therefore, a worker should not lift anything over 51 pounds without assistance from another worker or using a lift assist device [Waters 1994]. In brief, the equation provides RWL and LI for a lifting task, given certain lifting conditions. The RWL is the weight that can be handled safely by almost all healthy workers in similar circumstances. The LI is the ratio of the actual load lifted to the RWL. Tasks with a LI >1.0 may place an increasing number of individuals at risk of low back injury and tasks with a LI > 3.0 pose a risk of back injury for most workers.

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APPENDIX B: FACTORS COMPRISING THE REVISED NIOSH LIFTING EQUATION

Calculation for Recommended Weight Limit (RWL)

RWL = (LC) x (HM) x (VM) x (DM) x (AM) x (FM) x (CM)

	U.S. CUSTOMARY
LC = Load Constant	51 lbs
HM = Horizontal Multiplier	(10/H)
VM = Vertical Multiplier	(1-(0.0075|V-30|))
DM = Distance Multiplier	(0.82+(1.8/D))
AM = Asymmetric Multiplier	(1-(0.0032A))
FM = Frequency Multiplier	(from Table B1)
CM = Coupling Multiplier	(from Table B2)

Where:

H = Horizontal location of hands from midpoint between the ankles
Measured at the origin and the destination of the lift (in)

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

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

A = Angle of asymmetry – angular displacement of the load from the sagittal plane.
Measured at the origin and destination of the lift (°)

Duration is to be defined to be: ≤ 1 hour; ≤ 2 hours; ≤ 8 hours
Assuming appropriate recovery allowances

Appendix B: Factors Comprising the Revised NIOSH Lifting Equation (continued)

Table B1. Frequency Multiplier (FM) for the Revised NIOSH Lifting Equation

Frequency Lifts/min	Work Duration					
	≤ 1 Hour		≤ 2 Hours		≤ 8 Hours	
	V < 30″	V ≥ 30″	V < 30″	V ≥ 30″	V < 30″	V ≥ 30″
0.2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.70	0.70	0.42	0.42	0.22	0.22
8	0.60	0.60	0.35	0.35	0.18	0.18
9	0.52	0.52	0.30	0.30	0.00	0.15
10	0.45	0.45	0.26	0.26	0.00	0.13
11	0.41	0.41	0.00	0.23	0.00	0.00
12	0.37	0.37	0.00	0.21	0.00	0.00
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
>15	0.00	0.00	0.00	0.00	0.00	0.00

Table B2. Coupling Multiplier (CM) for the Revised NIOSH Lifting Equation

Couplings	Coupling Multipliers	
	V < 30″	V ≥ 30″
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations

Raw Production

Tables C1 and C2 contain the variables used for calculating the lowest weight rod of franks (18 pounds) with a compact lift and with a non-compact lift, respectively. Tables C3 and C4 contain the variables used for calculating the highest weight rod of franks (38 pounds). The upper limit for the vertical location of the hands as defined by the RNLE is 70"; therefore 70" was used in the calculations. This is 11" lower than the actual destination height at the work site.

Tables C5 and C6 contain the variables used for calculating the lowest weight rod of franks (18 pounds) using the 9" platform that was demonstrated. Tables C7 and C8 contain the variables used for calculating the highest weight rod of franks (38 pounds) using the 9" platform. Again, the upper limit for the vertical location of the hands as defined by the RNLE (70") was used for the calculations. This is 2" lower than the actual destination height with the platform.

Table C1.
RNLE assumptions and results for: raw production, 18 pounds, no platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	18	18	18
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	34	34	34
Distance of load from the body at the destination (in)	10	11	11
Lift height at the destination (in)	37	59	70 (81)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	26.7	17.7	15.6
Lifting Index	0.7	1.0	1.2

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C2.
RNLE assumptions and results for: raw production, 18 pounds, no platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	18	18	18
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	34	34	34
Distance of load from the body at the destination (in)	20	20	20
Lift height at the destination (in)	37	59	70 (81)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	13.3	9.8	8.6
Lifting Index	1.4	1.9	2.1

Table C3.
RNLE assumptions and results for: raw production, 38 pounds, no platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	38	38	38
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	34	34	34
Distance of load from the body at the destination (in)	10	11	11
Lift height at the destination (in)	37	59	70 (81)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	26.7	17.7	15.6
Lifting Index	1.4	2.2	2.5

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C4.
RNLE assumptions and results for: raw production, 38 pounds, no platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	38	38	38
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	34	34	34
Distance of load from the body at the destination (in)	20	20	20
Lift height at the destination (in)	37	59	70 (81)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	13.3	9.8	8.6
Lifting Index	2.9	3.9	4.4

Table C5.
RNLE assumptions and results for: raw production, 18 pounds, with 9" platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	18	18	18
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	25	25	25
Distance of load from the body at the destination (in)	10	11	11
Lift height at the destination (in)	28	50	70 (72)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	27.8	19.3	15.4
Lifting Index	0.7	0.9	1.2

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C6.
RNLE assumptions and results for: raw production, 18 pounds, with 9" platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	18	18	18
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	25	25	25
Distance of load from the body at the destination (in)	20	20	20
Lift height at the destination (in)	28	50	70 (72)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	13.9	10.6	8.4
Lifting Index	1.3	1.7	2.2

Table C7.
RNLE assumptions and results for: raw production, 38 pounds, with 9" platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	38	38	38
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	25	25	25
Distance of load from the body at the destination (in)	10	11	11
Lift height at the destination (in)	28	50	70 (72)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	27.8	19.3	15.4
Lifting Index	1.4	2.0	2.5

Table C8.
RNLE assumptions and results for: raw production, 38 pounds, with 9" platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	38	38	38
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	25	25	25
Distance of load from the body at the destination (in)	20	20	20
Lift height at the destination (in)	28	50	70 (72)
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	13.9	10.6	8.4
Lifting Index	2.7	3.6	4.5

Cooked Production

Tables C9 and C10 contain the variables used for calculating the lowest weight rod of franks (16 pounds) with a compact lift and with a non-compact lift, respectively. Tables C11 and C12 contain the variables used for calculating the highest weight rod of franks (35 pounds). The upper limit for the vertical location of the hands as defined by the RNLE is 70"; therefore 70" was used in the calculations. This is 11" lower than the actual destination height at the worksite.

Tables C13 and C14 contain the variables used for calculating the lowest and highest weight rod of franks (16 and 35 pounds, respectively) using the 6" platform that was available to the workers. Tables C15 and C16 contain the variables used for calculating the lowest and highest weight rod of franks (16 and 35 pounds, respectively) standing behind the platform and reaching in (thus increasing the horizontal distance of the load from the body). Again, the upper limit for the vertical location of the hands as defined by the RNLE (70") was used for all the calculations. This is 2" lower than the actual destination height with the platform. The upper limit for the horizontal location of the hands as defined by the RNLE (25") was used for the calculations in Tables C15 and C16. This is lower than the actual distance of the load from the body at the origin of these particular lifts.

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C9.
RNLE assumptions and results for: cooked production, 16 pounds, no platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	16	16	16
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	24.5	21.9	18.7
Lifting Index	0.7	0.7	0.9

Table C10.
RNLE assumptions and results for: cooked production, 16 pounds, no platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	16	16	16
Distance of load from the body at the origin (in)	20	20	20
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	12.3	10.9	9.3
Lifting Index	1.3	1.5	1.7

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C11.
RNLE assumptions and results for: cooked production, 35 pounds, no platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	35	35	35
Distance of load from the body at the origin (in)	10	10	10
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	24.5	21.9	18.7
Lifting Index	1.4	1.6	1.9

Table C12.
RNLE assumptions and results for: cooked production, 35 pounds, no platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	35	35	35
Distance of load from the body at the origin (in)	20	20	20
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	12.3	10.9	9.3
Lifting Index	2.9	3.2	3.8

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C13.
RNLE assumptions and results for: cooked production, 16 pounds, with 6" platform, compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	16	16	16
Distance of load from the body at the origin (in)	20	20	20
Lift height at the origin (in)	31	53	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	12.4	11.6	9.3
Lifting Index	1.3	1.4	1.7

Table C14.
RNLE assumptions and results for: cooked production, 35 pounds, with 6" platform, non-compact lift

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	35	35	35
Distance of load from the body at the origin (in)	20	20	20
Lift height at the origin (in)	31	53	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	12.4	11.6	9.3
Lifting Index	2.8	3.0	3.8

Appendix C: Measurements and Assumptions Used in the Revised NIOSH Lifting Equation Calculations (continued)

Table C15.
RNLE assumptions and results for: cooked production, 16 pounds, standing behind the platform

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	16	16	16
Distance of load from the body at the origin (in)	25	25	25
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	9.8	8.8	7.5
Lifting Index	1.6	1.8	2.1

Table C16.
RNLE assumptions and results for: cooked production, 35 pounds, standing behind the platform

Task Variables	Low Tier	Middle Tier	High Tier
Weight of load (lbs)	35	35	35
Distance of load from the body at the origin (in)	25	25	25
Lift height at the origin (in)	37	59	70 (81)
Distance of load from the body at the destination (in)	10	10	10
Lift height at the destination (in)	56	56	56
Asymmetry (°)	No Adjustment	No Adjustment	No Adjustment
Coupling	Good	Good	Good
Frequency of lift (lifts/minute)	3.0	3.0	3.0
Lifting period (hours)	Long (8)	Long (8)	Long (8)
Recommended Weight Limit (lbs)	9.8	8.8	7.5
Lifting Index	3.6	4.0	4.7

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Acknowledgements and Availability of Report

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This report was prepared by Jessica Ramsey and John Gibbins of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Ergonomic field assistance was provided by Daniel Habes. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway. Health communication assistance was provided by Stefanie Evans.

Below is a recommended citation for this report:
NIOSH [2008]. Health Hazard Evaluation Report: Ergonomic evaluation of frank hangers at a turkey processing plant, Livingston, California. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA No. 2007-0098-3061.

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