and baling equipment occurring between 1980 and 1992. Mobile compactors contributed to 31 of these deaths. CFOI data for 1992 to 1994 included 18 fatalities . FACE identified 9 fatal incidents in 7 states due to crushing or amputation in compactor or baling equipment; all but one were stationary machines. A large proportion of the fatal injuries occurred when the victim was caught by the ram (platen) while inside the baling chamber, resulting in amputation or crushing injury. These incidents usually occurred during attempts by the victim to free jammed material inside feed chutes of operating machines. FACE data shows that these fatalities frequently occurred when appropriate hazardous energy control procedures were not implemented during servicing of the machine to clear jammed material. At least two incidents occurred when victims fell into the balers, unknown to their co-workers. Risk factors include failure to de-energize equipment before servicing, lack of hazard recognition on the part of the victim, bypassed or inoperative control interlocks or other safety features, unsafe means of access to the inside of the machine for servicing, and lack of a system to account for the location of workers.

Conclusion. Fatalities due to baling and compacting equipment could be reduced or eliminated if employers and employees would implement and follow appropriate hazardous energy control procedures. Prevention strategies include de-energization of machines prior to and during servicing, provision for safe access to feed chutes and hoppers for clearing jammed material, and compliance with consensus standards.

Factors Limiting the Use of Frame Deflection Monitoring to Predict Material Jams in Baling Equipment—Etherton J, Moore P, Harris J, Zeng S

Recent NIOSH fatality investigations have shown that workers risk amputation and crush injury while attempting to clear jammed material from the loading chambers of operating baling equipment. This type of jam occurs when material fills the gap between the edge of the baler's platen (ram) and an interior wall of the loading chamber. Typical hydraulic actuated cardboard balers generate 50-70,000 pounds force which tends to shear material lodged in the platen-edge internal-wall gap.

This study evaluated the feasibility of developing a process monitor to detect and warn workers of impending jams. A proposal was made at NIOSH that signals generated by strain gage transducers, placed at locations on the machine's frame experiencing large deformations preceding jams, could be used to interrupt platen movement; warn of impending jams by triggering alarms; shut-down the machine; or otherwise provide a new safety control.

A system safety analysis using FaultrEASE software was conducted to describe the sources of variation in operating conditions that could confound the transducer response of the proposed safety device. Adequate signal conditioning is also needed to adjust for the effects of temperature differentials, vibration, electromagnetic interference, and other factors present in the indoor and outdoor operating environments typical for these machines. Limiting factors that reduce the precision of monitoring with a single transducer in a complex operating environment were evaluated.

The study concludes that mechanical blocking of the platen and proper lockout/tagout should remain the primary control of hazardous energy to prevent baling-equipment-related amputation and crushing injury.

Work-Related Back Injuries in Retail Merchandise Workers—Gardner LI, Collins JW, Johnston JJ, Landsittel DP

Back injuries are the single most costly workplace injury and have received much attention in workplaces which require frequent heavy (>25 pounds) lifting. However, in the retail merchandise industry, weights of merchandise are generally modest and seldom above 25 pounds, suggesting that material handling-related back injuries might be of lesser importance relative to trauma-related causes of back injuries. In a typical retail merchandise store, causes of trauma-related back injury include falls associated with the use of ladders, wet surfaces, and being struck by falling merchandise. All of these factors suggest the potential importance of trauma-related back injuries. This analysis documents the distribution and determinants of material handling-related and trauma-related back injuries in this large and growing segment of the workforce. As part of a larger prospective intervention study, the authors collected workers' compensation and payroll data from 51,363 store workers in 97 stores (of the same chain) over a 10-month period in 1996 and 1997. Strain or sprain of the back associated with material handling was the most frequent back injury: 269 of 350 back injuries (78%). Trauma-related back injuries, which included caught by/between, struck by, miscellaneous, slip, trip, or fall accounted for 81 (23%) of the total back injuries. Days off work, a measure of severity, suggested material handling-related injuries were more severe (31% with 1 or more days off), compared with 17% with 1 or more days off for trauma-related back injuries.

The risk factor profiles were similar. In both material handling-related and trauma-related back injuries, less experience on the job was strongly associated with a claim, after adjusting for age, job title, and sex using a Poisson regression model. For material handling-related back injuries, the rate ratio was 2.75, $p<.0001$ for workers with 2.2 months or less of experience compared to those with 10.7 or more months of experience. For trauma-related back injuries for the same groups, the rate ratio was 3.00, $p<.01$. Sex and age were not significant risk factors for either material handling or trauma-related back injuries. The excess risk of material-handling-related back injuries for stockers and receivers compared to workers who only occasionally perform material handling tasks (rate ratio = 1.75, $p<.0001$) was similar for trauma-related back injuries (rate ratio = 1.58, $p = .09$). The only really important difference in the risk factor profile was that the material handling-related back injuries for workers with intermediate levels of job experience (between 2.2 and 10.7 months) had rate ratios above 2.0, but for trauma-related back injuries the rate ratios for the same categories of experience were below 2.0. In summary, we found that the majority of back injuries in these workers were related to material handling and that the severity level for material handling back injuries was higher. But the similarity of risk factor profiles suggests that prevention efforts, whether directed at material handling or at trauma hazards, could be directed at the same workers (stockers and receivers with the least job experience) for the biggest return per dollar of prevention effort.