INCIDENTS DUE TO AERIAL WORK PLATFORMS

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1. BACKGROUND:

The National Institute for Occupational Safety and Health (NIOSH), in collaboration with the National Safety Council (NSC), conducted a surveillance study of aerial platform falls/collapses/tipovers across all industry classifications. This collaborative study's objective was to establish a mechanism to determine research priorities for addressing fall incidents associated with aerial lifts. In respond to this surveillance findings, NIOSH developed an engineering evaluation project to determine the nature of the physical loadings, and environmental and ergonomic factors influencing aerial lift stability and potential for falls, and to determine possible design and engineering interventions to reduce the fall hazard potential.

2. METHOD:

Three databases were used: Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) data (1992-2001), Occupational Safety & Health Administration (OSHA) Incident Investigation Records (1990-2003), and NIOSH Fatality Assessment and Control Evaluation (FACE) reports (1985-2002).

The CFOI program is a multi-source data system that attempts to document all work-related injury deaths across the United States. The database includes both coded and narrative data on each fatally injured person. The analysis conducted for this project was performed with a limited-access research file provided by the Bureau of Labor Statistics. The coding system used by BLS is the Occupational Injury and Illness Classification System (OIICS) which has categories for nature of injury, body part injured, source of injury, secondary source of injury, and event or exposure. Relevant cases were identified in the CFOI database through source of injury codes and key word searches of the CFOI narratives. The source of injury codes used to identify cases involving aerial lifts were the following: 3461 bucket or basket hoist—truck mounted, 3466 manlift, 8515 platform lift truck—high or low lift, and 8516 reach rider lift truck. Key word searches identified many additional cases involving aerial lifts. Narrative information in the CFOI files were used to assign codes, such as style of lift, means of propulsion, worker activity, movement of lift prior to injury event, type of surface, and height of fall.

OSHA conducts worksite investigations in response to employer reports of fatal and serious injuries and for purposes of encouraging compliance with OSHA regulations. Key words were used to identify deaths and injuries associated with aerial lifts from information on the OSHA website, and the OSHA Office of Statistics provided records in the form of an Access database file for further analysis and coding.

NIOSH supports in-depth case-based investigations of targeted types of occupational injury deaths, including those associated with machinery, through the FACE program. Investigations are conducted by NIOSH and a number of collaborating state FACE programs, which are funded through cooperative agreements. Each investigation results in a detailed narrative report which is posted on the NIOSH website, and which is publically disseminated and accessible for research purposes. Keyword searches were used to identify FACE reports involving aerial lifts. Information in the narrative reports was used to assign codes for analysis. The FACE and OSHA databases were matched to identify unique cases, and information from both systems were combined for the analysis.

3. RESULTS:

3.1. CFOI: One hundred eighty nine aerial lift fatalities occurring between 1992 and 2001 were identified and coded. 44% of fatalities occurred in the construction industry. The nature of injury and part of body tabulations indicated that most of the fatal injuries involved the head or multiple internal injuries. The event or exposure tabulation showed that the initial event was most often the fall itself. The most frequently named source of injury was the ground (43%). The

most common secondary sources of injury, which is defined as the object that generated the source of injury or contributed to the event, were bucket or basket hoist, truck mounted (40%), truck (12%), and manlift (11%). Location of the incident was most commonly a street or highway (29%), followed by industrial settings (14%) and construction sites (13%).

The most commonly named general work activities were "trimming, pruning, n.e.c." (16%) and "constructing, assembling, and installing" (12%). Combining related or similar activities resulted in "constructing and repairing" activities accounting for 40% of the cases. In terms of employment status, eighty-five percent were paid employees and 13% were self-employed. Time with employer was reported in 35% of the CFOI cases. Where reported, 30% had been working for their employer for one year or less. Virtually all of the CFOI cases involved males. Where age was reported, 35% of the cases were 35-44 years old; 23% were 45-54 years old; and 21% were 25-34 years old. Table 1 shows the lift style/propulsion combinations that could be discerned from the narratives. Both the style and propulsion could be determined in only 69% of the cases. Height information is summarized in Table 2.

	Propulsion			
Style of Lift	Manually Propelled	Self propelled	Truck mounted	Total*
Scissor	---	9	---	11
Articulated boom	---	---	8	---
Telescoping boom	---	---	---	---
Unspecified boom	---	8	98	106
Total	---	---	109	130

Table 1. Style of Lift vs Propulsion, CFOI. Dashes (---) indicate data do not meet BLS publication criteria.
*Total column includes data not shown separately.

Height	Of Work Area	Of Lift	Of Fall
<10 feet	---	---	---
10-19 feet	17	18	20
20-29 feet	31	30	30
30-39 feet	28	28	28
40-49 feet	16	16	17
50-59 feet	5	6	5
60-69 feet	8	8	8
70-79 feet	---	---	---
80+ feet	---	---	---
Total reported cases	116	117	119

Table 2. Height Information in Falls Associated with Aerial Lifts, CFOI. Dashes (---) indicate data do not meet BLS publication criteria.

Forward, backward, or no movement of the lift was mentioned or could be inferred in 40% of the 189 CFOI cases. A turning maneuver (left, right, or none) was mentioned or could be inferred in 35% of the 189 cases. For these 66 cases, 88% (58) did not make a turning movement. Raising, lowering, or no vertical movement of the lift was mentioned or inferred in 44% of the total cases. Of these cases, 71% involved no upward or downward movement. The type of surface on which the lift was placed was not mentioned in 82% of the cases. Where mentioned, the surface was concrete or gravel. In the 25 cases where the surface condition was mentioned, 36% were sloped and 20% had an edge. The number of workers on the lift was mentioned in 180 (95%) of the cases. Where mentioned, there was one worker in 167 (93%) of the events and two workers in the others. A mechanical failure was mentioned in 57 of the cases (30%). More than two thirds (68%) of the failures were of the lift structure (including control cables).

3.2. OSHA/FACE: One hundred seventy three OSHA incident investigations occurring between 1990 and 2003 and 12 FACE cases occurring between 1985 and 2002 were identified and coded. General work activity was identified and coded in about 84% of the cases. The most common general activities were constructing–, assembling–, and installing–related activities (47% of coded cases). More than 100 different specific job activities were mentioned in the narratives. The single most common activity was tree trimming (12%). By industry division, 53% were in construction. The style of the lift could be determined in 92% of the OSHA/FACE cases. Of the cases for which the

style could be determined, 40% were scissor lifts; 14% were articulated boom lifts; 2% were telescoping boom lifts; and 44% were boom lifts with the type of boom unspecified. The manner of propulsion could be determined in 50% of the cases. Of the cases where propulsion could be determined, 65% were truck mounted; 33% were self-propelled; and 2% were manual. Table 3 shows the lift style/propulsion combinations that could be discerned from the narratives. Both the style and propulsion could be determined in only 48% of the cases. Height information is summarized in Table 4.

	Propulsion			
Style of Lift	Manually propelled	Self propelled	Truck mounted	Total
Scissor	1	21	4	26
Articulated boom	0	1	17	18
Telescoping boom	0	0	2	2
Unspecified boom	0	6	37	43
Total	1	28	60	89

Table 3. Style of Lift vs Propulsion, OSHA/FACE.

Height	Of Work Area	Of Lift	Of Fall
<10 feet	15	17	8
10-19 feet	39	39	43
20-29 feet	37	36	36
30-39 feet	14	14	12
40-49 feet	11	12	12
50-59 feet	12	11	11
60-69 feet	4	4	4
70-79 feet	3	3	3
80+ feet	5	3	5
Total reported cases	140	139	134

Table 4. Height Information in Falls Associated with Aerial Lifts, OSHA/FACE.

Forward, backward, or no movement of the lift was mentioned or could be inferred in 76% of the OSHA/FACE cases. No forward or backward movement was stated or inferred in 75% of the cases where mentioned. Forward movement was mentioned in 16%, backward movement in 3%, and movement in an unspecified direction in 7%. A left, right, or no turning maneuver was mentioned or could be inferred in 66% of the cases. No turning movement was stated or inferred in 96% of these cases. Where motion of the lift was mentioned at all, the specific speed was not. Raising, lowering, or no vertical movement of the lift was mentioned or inferred in 74% of the total cases. Of these cases, 79% involved no upward or downward movement. The remaining cases were about equally divided between upward and downward movements. The type of surface on which the lift was placed was not mentioned in 65% of the cases. Where mentioned, the surface was the floor of a building, platform, ramp, sidewalk, or street (63%) or ground/soil (31%). In the 27 cases where the surface condition was mentioned, 30% were sloped, 30% had holes, 19% had an edge, and 15% were uneven. The number of workers on the lift was mentioned in 168 (97%) of the cases. Where mentioned, there was one worker in 142 (82%) of the events and two workers in 29 (17%). A mechanical failure was mentioned in 43 of the cases (23%). Almost three fourths (74%) of the failures were of the lift structure (including control cables).

3.3. Incident comparisons from the results of CFOI and OSHA/FACE: Several scenarios for falls involving aerial lifts emerge from tabulations of activity against the manner of the fall (Tables 5 and 6). The style of lift was condensed into two categories, scissor and boom. Four manners of fall are considered: fall *from* basket/bucket/platform, tip over, fall *with* basket/bucket, and ejection. The first three categories are self-explanatory. The last category is for cases where the person did not fall with or from the lift and the lift did not tip over. These are principally cases where a boom lift collapsed. A review of CFOI and OSHA/FACE data identified that tip-over was the most frequent manner of fall-incident category associated with scissor lifts. Of the 23 scissor lift fall incidents in the CFOI database, 13 (57%) involved tip-overs, and of the 54 incidents in the combined OSHA/FACE reports, 26 (48%) involved tip-overs. Constructing, assembling, repairing, and maintaining activities, including disassembling and dismantling activities, were the most common applications associated with falls on aerial lifts. A chi square test of the CFOI scissor data indicates no associations between the activity and manner of fall. The same analyses conducted for the boom lifts from

CFOI reveals there is an association ($\chi^2 = 17.92$, d.f.=9, $p<0.05$) between the activity and manner of fall. However, the OSHA/FACE data indicates an association ($\chi^2 = 14.23$, d.f.=6, $p<0.05$) for the scissor lift, but not for the boom lift.

Activity	Manner of Fall				Total
	Fall From	Tip Over	Fall With	Ejection	
Scissor Lifts					
Driving, operating, riding lift	---	---	---	---	6
Constructing, assembling, repairing, etc.	6	7	---	---	13
Other activities	---	---	---	---	---
Scissor lift total	*10*	*13*	---	---	*23*
Boom Lifts					
Driving, operating, riding lift	6	6	---	12	26
Constructing, assembling, repairing, etc.	27	9	5	23	64
Trimming trees	18	---	8	5	33
Other activities	14	6	---	8	31
Boom lift total	*65*	*23*	*18*	*48*	*154*

Table 5. Activity by Manner of Fall and Type of Lift, CFOI Records. Dashes (---) indicate data do not meet publication criteria.

Activity	Manner of Fall				Total
	Fall From	Tip Over	Fall With	Ejection	
Scissor Lifts					
Driving, operating, riding lift	1	2	3	0	6
Constructing, assembling, repairing, etc.	11	16	2	0	29
Painting	7	3	0	0	10
Other activities	3	5	1	0	9
Scissor lift total	22	26	6	0	54
Boom Lifts					
Driving, operating, riding lift	1	4	6	2	13
Constructing, assembling, repairing, etc.	10	6	7	13	36
Painting	3	1	0	1	5
Trimming trees	7	0	11	6	24
Other activities	1	1	2	1	5
Boom lift total	22	12	26	23	83

Table 6. Activity by Manner of Fall and Type of Lift, OSHA/FACE Records

4. DISCUSSION AND CONCLUSION:

A strength of the CFOI data set is the comprehensive nature of its data; CFOI attempts to identify the circumstances of all work-related injury fatalities. However, there is limited narrative information to identify specific fatal circumstances. Therefore, CFOI provides conservative estimates of the numbers of aerial lift-related fatalities and specific injury scenarios since case identification and coding required detailed information that is not typically available in the CFOI database. The CFOI narratives are restricted in length and usually include only a brief, factual description of the incident. Because the CFOI does not investigate the incidents and relies only on available source documents, the ability to identify causes is very limited. Nevertheless, the CFOI narratives are more useful than other population-based data bases. In contrast, OSHA/FACE provides more detailed circumstance information than CFOI. The limitations of the OSHA/FACE data are that investigations are not conducted on all deaths and injuries. Thus, data may not be generalizable to all aerial lift fall incidents.

Although analyzed separately, the data sets of CFOI and OSHA/FACE support each other, leading to a generalizable set of similar scenarios for scissor-lift tip-overs. Regardless of the height of the work area, the extended height of the lift, or the height of the fall, about 40% of the cases in CFOI and 54% of cases investigated by OSHA/FACE involved falls/collapses/tipovers within the height-categories of 10-19 feet and 20-29 feet. Based on these findings, NIOSH developed an aerial lift project that initializes and focuses its laboratory study components on a commercially available 19-foot electric scissor lift. The objectives of the laboratory study are to develop a comprehensive dynamic computer-simulation model of a scissor lift, to systematically investigate the mechanisms of the tip-over of the lift and the related fall of workers from the lift platform, to form preventive strategies and work practices, and to explore the development of effective safety devices. The ultimate goal is to significantly reduce the fatalities and injuries in the operation of scissor lifts.