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SAFETY BRIEF

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ON THE SAFETY OF INFEEDING COMMERCIAL TREE CHIPPERS

By Dennis B. Brickman, P.E.*

ABSTRACT

This paper addresses a commercial mobile tree chipper with a mechanical infeed system that is manually fed. OSHA records associated with commercial tree chipper accidents indicate tree workers have alleged that their arms have been pulled into the chipper feed wheels by branches during the feeding process. An infeed extension pan has been proposed to prevent a tree worker's arm from being pulled into the chipper feed wheels if his gloved hand gets caught in the branches being fed into the infeed hopper. Experiments performed with human test subjects and an anthropomorphic dummy are presented under arm pull-in scenarios to study the safety implications of the proposed infeed extension pan.

INTRODUCTION

The author's previous research has studied whether an operator's arm can be pulled into the infeed hopper of a consumer chipper/shredder [1]. Further research has analyzed whether a tree worker's leg can be pulled into the feed wheels of a commercial tree chipper equipped with an infeed extension pan if the worker places his foot on the extension pan or kicks branches entering the infeed hopper [2]. This paper addresses the question of whether an infeed extension pan on a manually fed commercial tree chipper will prevent a tree worker from being pulled into the feed wheels if his gloved hand gets caught in the branches being fed into the tree chipper infeed hopper. A typical commercial tree disc chipper infeed hopper with a mechanical infeed system is shown in Fig. 1. During the feeding mode, the operator will manually feed the tree branches into the infeed hopper to the feed wheels which in turn bring the branches to the cutting disc. According to the requirements of ANSI Z133.1-2000 [3], brush chippers equipped with a mechanical infeed system shall have a quick stop and reversing device on the infeed system. The activating mechanism for the quick stop and reversing device shall be located across the top, along each side, and close to the feed end of the infeed hopper within easy reach of the worker. The safety control bar illustrated in Fig. 1 satisfies the requirements of ANSI Z133.1-2000 by quickly stopping and reversing the feed wheels when the bar is pushed toward the feed wheels. A review of the Occupational Safety and Health Administration (OSHA) records associated with commercial tree chipper accidents indicates tree workers have alleged that their arms have been pulled into the feed wheels by tree branches during the feeding

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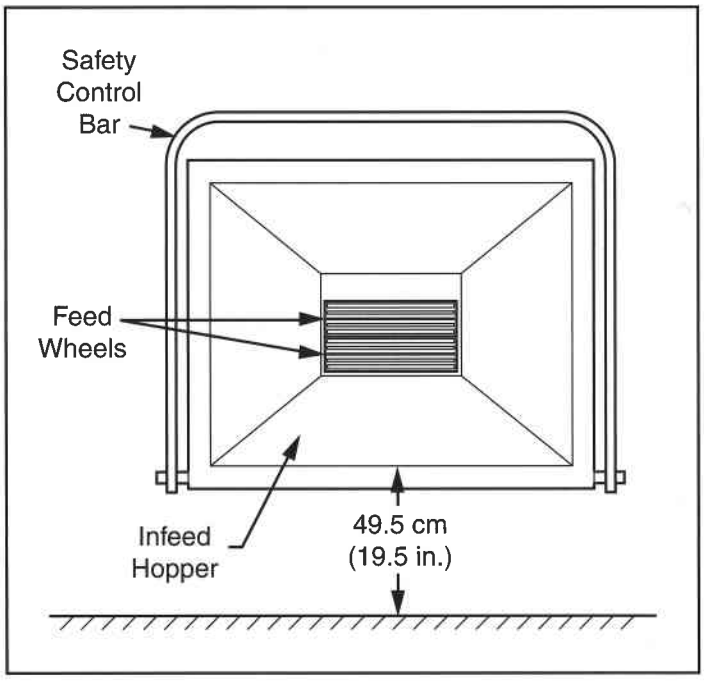


Figure 1 - Commercial Tree Disc Chipper Infeed System

process [4]. Safety specialists have hypothesized that the presence of an infeed extension pan attached to the chipper infeed hopper will prevent a tree worker's snagged gloved hand from being pulled into the feed wheels with the branches. The purpose of this paper is to test this hypothesis through a series of five experiments performed using an anthropomorphic dummy and a commercial tree disc chipper infeed hopper equipped with a proposed infeed extension pan. In addition, further tests with eleven human subjects were conducted to determine their strength resistance when one hand was being pulled into the infeed hopper both with and without an infeed extension pan. Finally, a critical review of the OSHA records associated with commercial tree chipper accidents was performed to analyze whether these accidents have occurred on chippers equipped with infeed extension pans.

DUMMY ARM PULL-IN TESTING WITH INFEED EXTENSION PAN

Test Setup

Figure 2A shows the test setup that was utilized to study the arm pull-in phenomenon in a commercial mobile tree chipper equipped with a 91.4 cm (36 in.) long infeed hopper to the feed wheels inrunning nip and an 83.8 cm (33 in.) long infeed extension pan. The bottom horizontal surface of the infeed hopper test fixture was located 49.5 cm (19.5 in.) above the ground at the leading edge of the infeed hopper. A standing 175.3 cm (69 in.) tall anthropomorphic dummy weighing 95.3 kg (210 lb) is posed behind the infeed extension pan with both of its feet resting on the ground and its torso facing the infeed hopper. The pulling force of the tree chipper infeed rolls is applied to the dummy's left wrist by a winch and pulley system. A cable coming from the winch is attached to a rope which is wrapped around the left wrist of the dummy.

Testing

Five arm pull-in tests were conducted with the anthropomorphic dummy situated at the left, left center, center, right center, and right of the infeed extension pan. Figure 2 is a photographic sequence with the dummy originating at the left of the infeed extension pan. Photograph 2A shows the position of the dummy before the force is applied to its left wrist. In the next photograph, 2B, the dummy's left hand and head have entered the infeed hopper and its right leg has been pulled off the ground. The final photograph, 2C, depicts the dummy's left hand passing through the back of the infeed hopper which simulates the left hand entering the feed wheels. In addition, both of the dummy's legs have been pulled onto the infeed extension pan and the dummy's head and torso have entered the infeed hopper. Similar results were obtained when the dummy originated at the left center, center, right center, and right positions of the infeed extension pan during the testing. Figure 3 displays a photographic sequence with the dummy

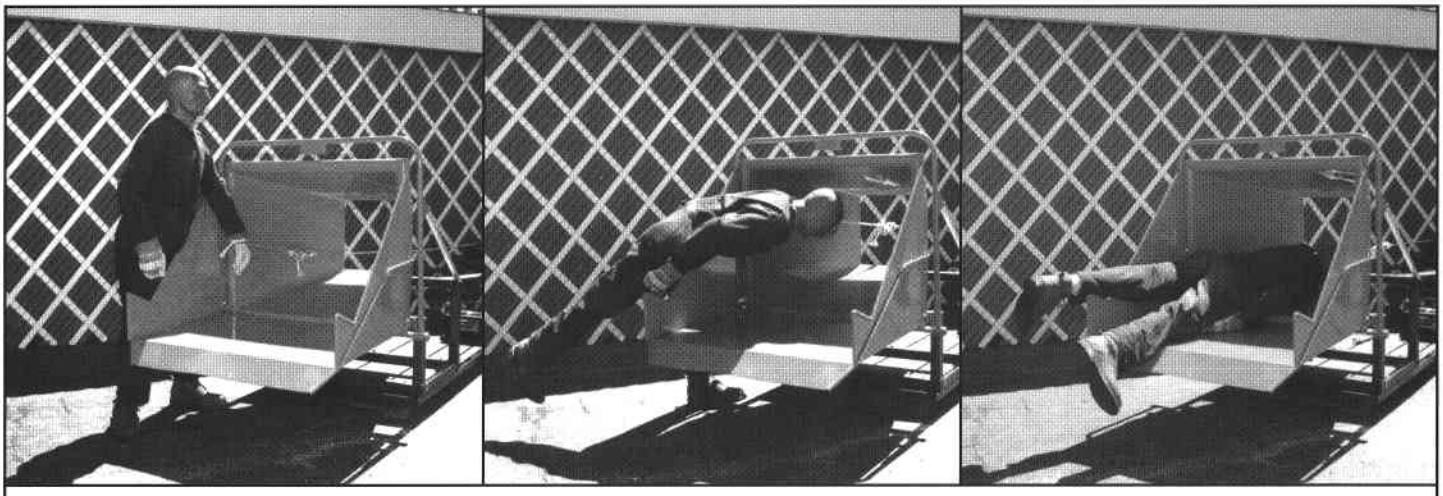


Figure 2 - Arm Pull-In Test With Infeed Extension Pan (Dummy at Left)

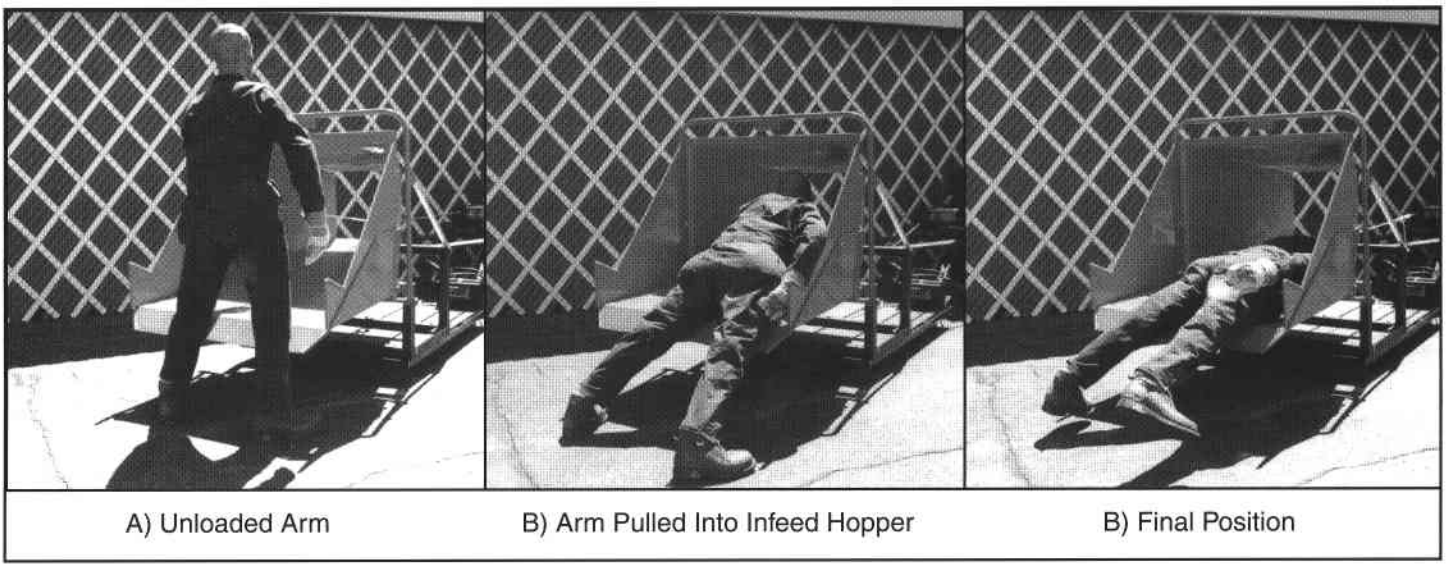


Figure 3 - Arm Pull-In Test With Infeed Extension Pan (Dummy at Center)

starting at the center position of the infeed extension pan and Fig. 4 shows a photographic sequence with the dummy starting at the right position of the infeed extension pan. Results of these five tests indicate that the tree worker's arm can be pulled into the tree chipper feed wheels even with an infeed extension pan given the conditions set forth in this test program.

HUMAN ARM PULL-IN TESTING

Test Setup

Tests were performed with 11 human subjects whose collective average was 182.9 cm (72 in.) in height and 94.8 kg (209 lb) in weight as shown in Table 1. Each test subject participated in two tests where the infeed hopper was equipped with an infeed extension pan and without. The infeed test fixture was equipped with a safety control bar located close to the feed end of the infeed hopper within easy reach of the worker as specified in ANSI Z133.1-2000 [3]. The initial position of the human subjects had both feet on the ground with their torso facing the infeed hopper. Similar to the arm pull-in testing with the anthropomorphic dummy, a cable coming from the winch is attached in series to a load cell and rope which is wrapped around the human subject's gloved left wrist as shown in Fig. 5A. The load cell is connected to a digital display which records the peak tension force exerted by the human subject. Each human subject's left wrist is pulled into the infeed hopper, after which the human subject attempted to exert maximum resistive effort as depicted in Fig. 5B. Peak resistance forces were recorded with and without the infeed extension pan. If the human resistance force exceeds the connection resistance between the snagged worker's gloved hand and the branch, the worker can withstand the pull of the chipper feed wheels.

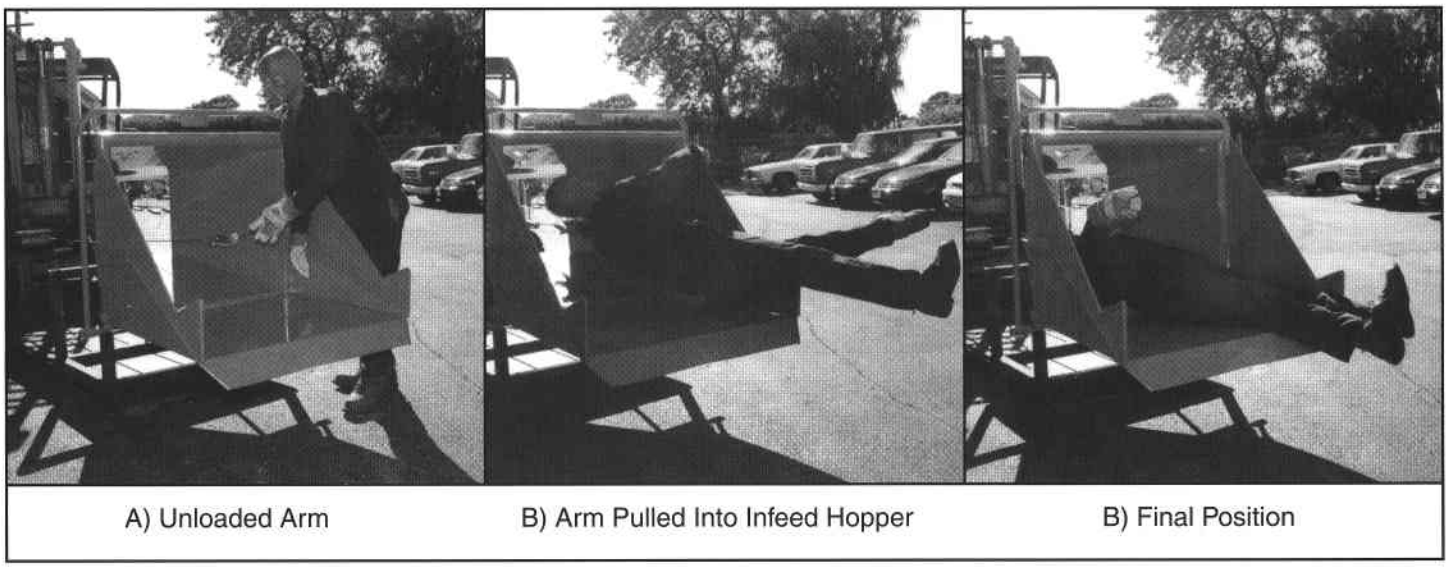


Figure 4 - Arm Pull-In Test With Infeed Extension Pan (Dummy at Right)

Table I - Human Test Subject Resistance

Test Subject	Height - cm (in.)	Weight - kg (lb)	Resistance With Infeed Chute - N (lb)	Resistance With Infeed Extension Pan - N (lb)
1	180.3 (71)	89.8 (198)	1673 (376)	1388 (312)
2	172.7 (68)	83.9 (185)	761 (171)	520 (117)
3	167.6 (66)	83.9 (185)	752 (169)	614 (138)
4	200.7 (79)	127.0 (280)	1508 (339)	863 (194)
5	188.0 (74)	90.7 (200)	1099 (247)	930 (209)
6	182.9 (72)	90.7 (200)	974 (219)	836 (188)
7	182.9 (72)	86.2 (190)	1041 (234)	854 (192)
8	185.4 (73)	88.5 (195)	1415 (318)	1339 (301)
9	182.9 (72)	92.5 (204)	1441 (324)	899 (202)
10	188.0 (74)	104.3 (230)	1201 (270)	1179 (265)
11	185.4 (73)	106.1 (234)	1094 (246)	1045 (235)
Average	182.9 (72)	94.8 (209)	1179 (265)	952 (214)

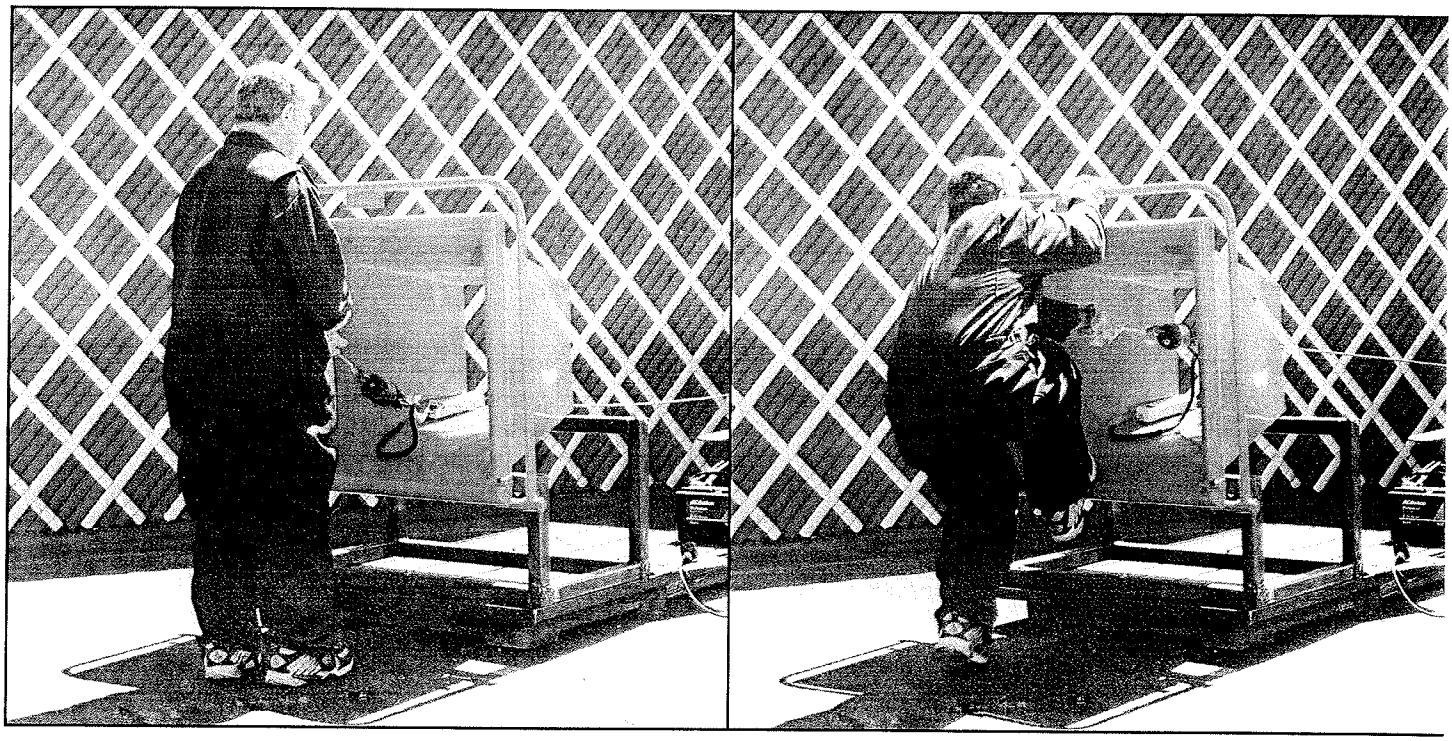
Testing

The maximum resistance forces for the 11 human subjects for the infeed hopper only and for the infeed extension pan are displayed in Table 1. All 11 human subjects recorded higher resistance forces without the infeed extension pan with an average differential of 51 pounds (265 pounds with infeed hopper and 214 pounds with infeed extension pan). As shown in Fig. 6B without the infeed extension pan, human subject number 10 is able to pull with both hands while simultaneously bracing his right shoulder and right leg against the leading edge of the infeed hopper. In contrast, Fig. 6D depicts human subject number 10 with the infeed extension pan where he is off-balance with his left foot off the ground and his right shoulder unsupported. In Fig. 5B showing the infeed hopper condition, human subject number 2 is able to brace his right foot against the bottom leading edge of the infeed hopper and brace his right hand against the safety control bar for maximum resistance effort. In contrast, Fig. 5D depicts human subject number 2 where the infeed extension pan causes the subject to lean forward with both feet on the ground and his right hand against the top leading edge of the infeed hopper in an off-balance condition. Clearly, the presence of the infeed extension pan presents a downside with respect to strength resistance and positioning of the tree worker.

COMMERCIAL TREE CHIPPER ACCIDENT STATISTICS

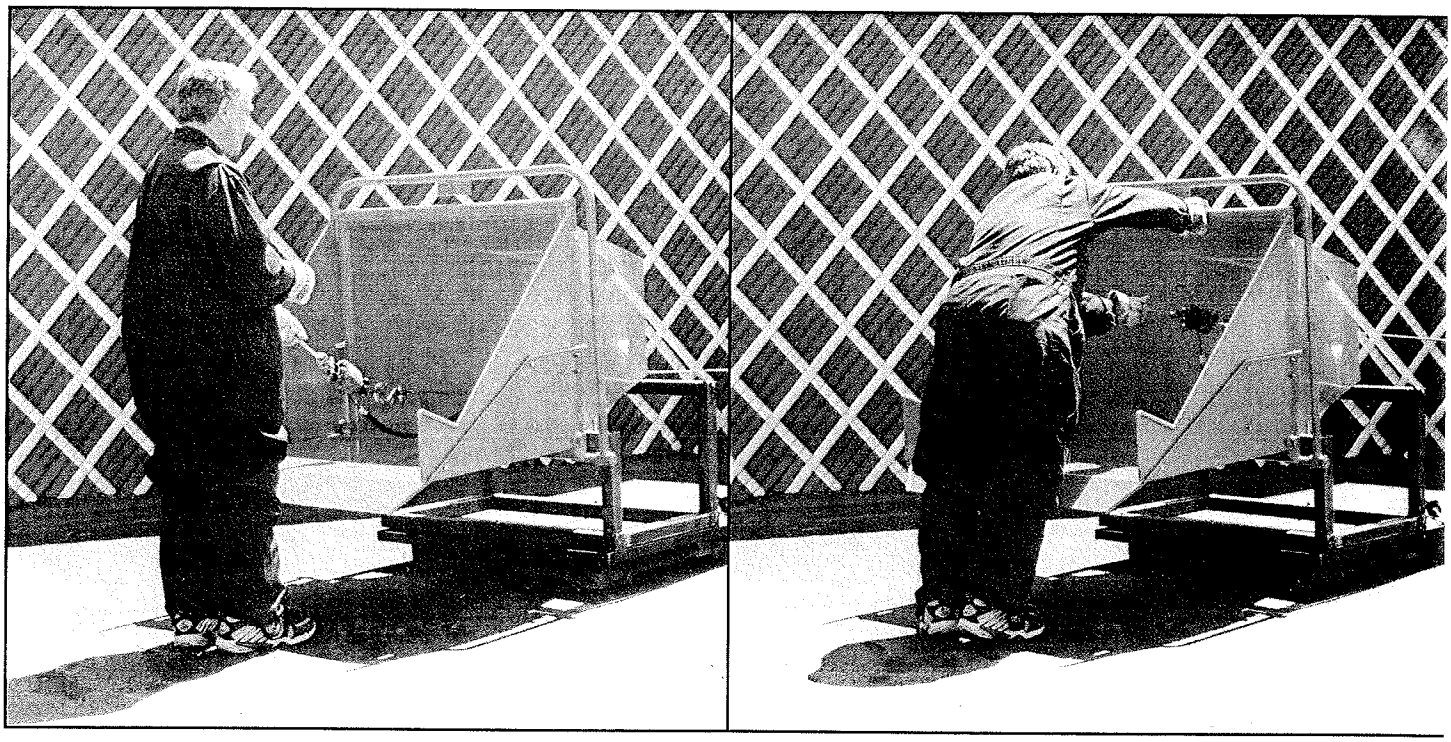
The Occupational Safety and Health Administration (OSHA) has conducted accident investigations associated with commercial tree chippers [4]. Selected OSHA accident abstracts reported for commercial tree chippers equipped with a mechanical infeed system and an infeed hopper extension pan are presented in this section. With the exception of the deletion of the indentity of the commercial tree chipper manufacturers, these abstracts are quoted as they appear in the OSHA accident investigations for commercial tree chippers. The text has not been edited; misspellings and incomplete sentences are unaltered.

On 4/23/97 at approximately 5:00 pm, employee was feeding pruned tree limbs into a Wood Chipper. Employee made contact with the feeder drum, located 63 inches from where he was standing on the ground at the infeed tray and was grabbed by the feed wheel. The feeder wheel fed employee to the chipper drum located inside of the machine where he was chopped to death by the chipper blades. Employee's remains were then deposited into the wood chip receiver truck through the discharge spout of the chipper. there is a reversing safety bar for the feeder drum. It is located at the mouth of the infeed and is bail shaped and goes down both sides and across the top of the feeder.



A) Infeed Hopper - Unloaded Arm

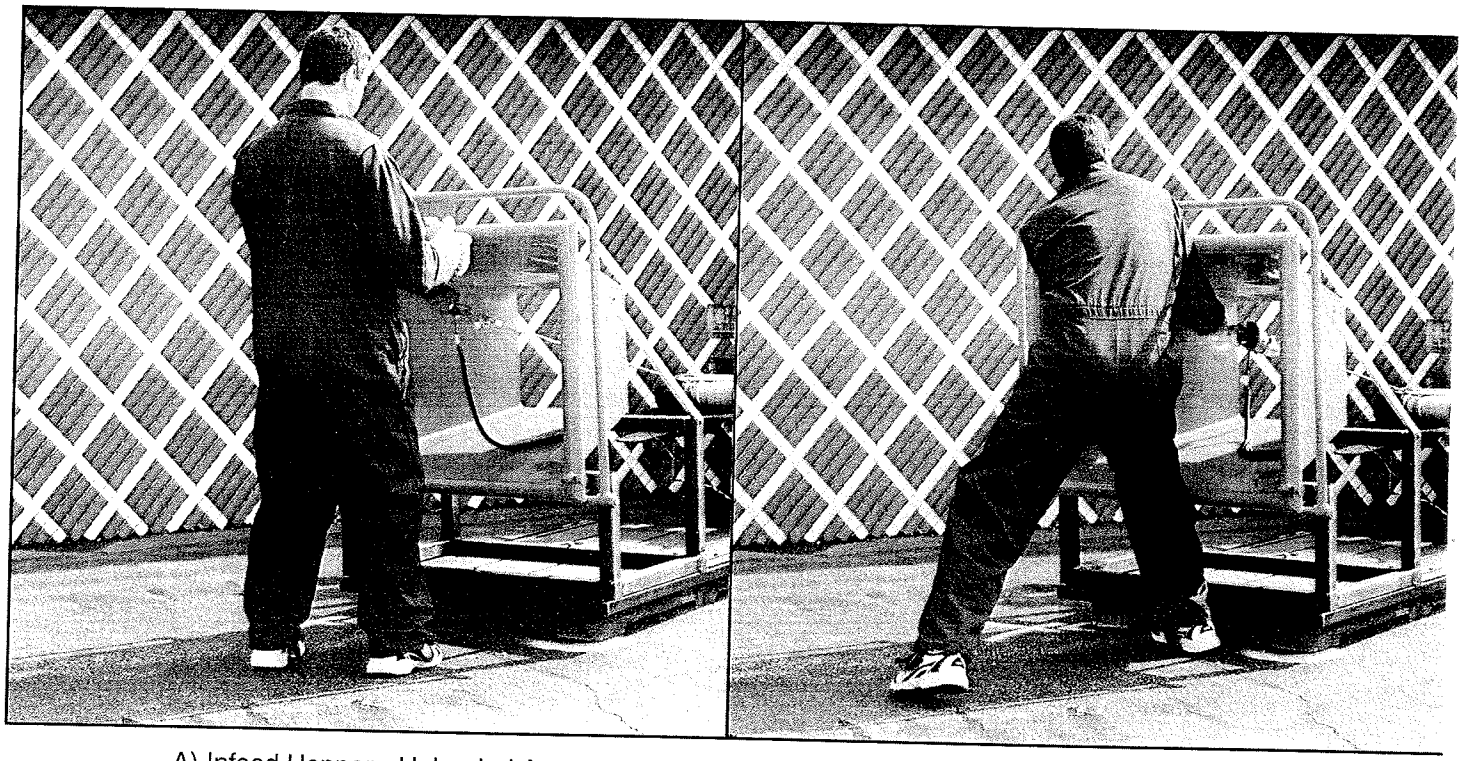
B) Infeed Hopper - Loaded Arm



C) Infeed Extension Pan - Unloaded Arm

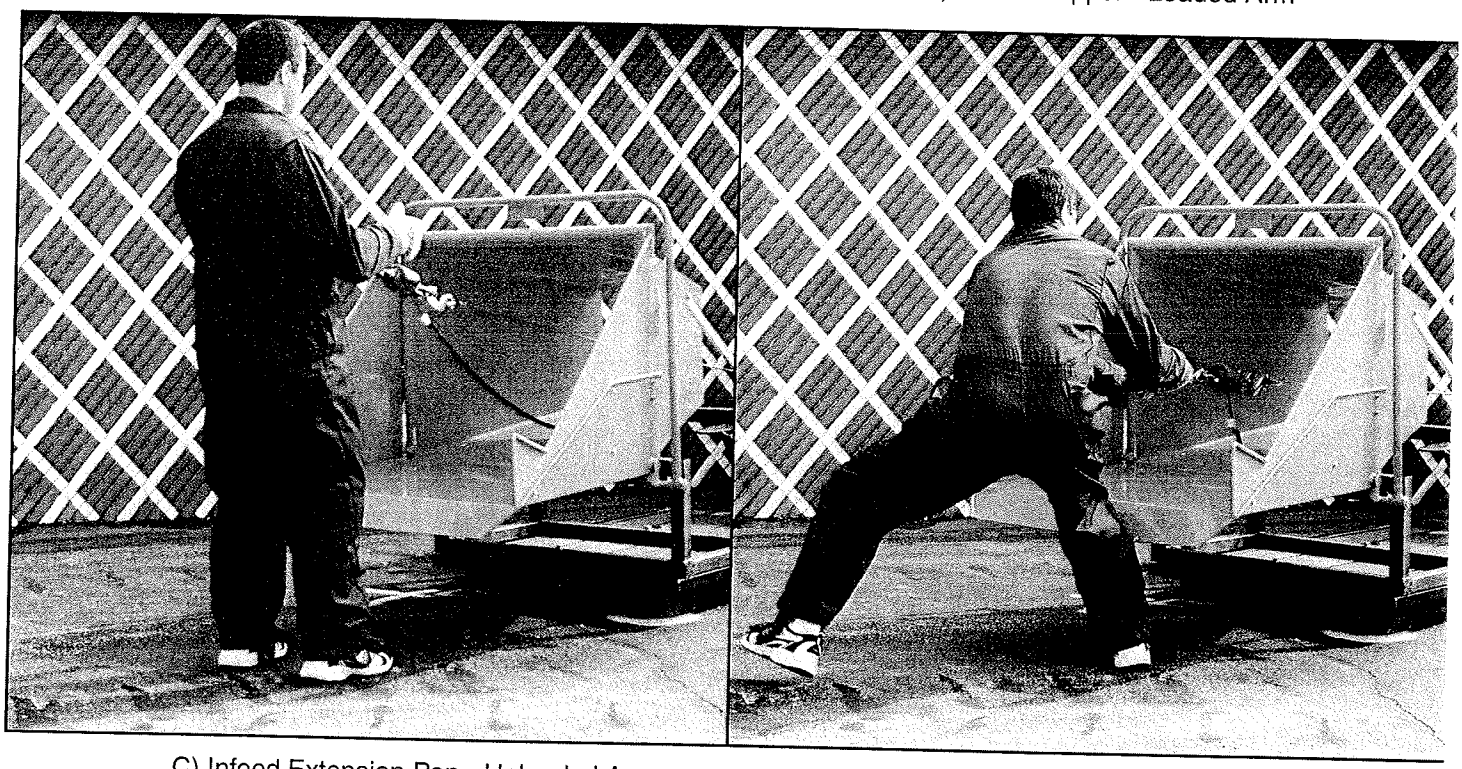
D) Infeed Extension Pan - Loaded Arm

Figure 5 - Arm Pull-In Testing With Human Subject No. 2



A) Infeed Hopper - Unloaded Arm

B) Infeed Hopper - Loaded Arm



C) Infeed Extension Pan - Unloaded Arm

D) Infeed Extension Pan - Loaded Arm

Figure 6 - Arm Pull-In Testing With Human Subject No. 10

On May 27, 1998, a 28-year-old groundsman died after he was caught and pulled into a wood chipper. The victim and two coworkers, a foreman and a climber, were cleaning up limbs after pruning a tulip poplar behind a townhouse. The coworkers were behind the building gathering loose branches while the victim was in front operating the chipper. The coworkers began dragging brush to the chipper. As the climber approached the chipper, he saw the victim's legs sticking out of the infeed hopper. Investigators concluded that the victim either fell or reached into the infeed hopper while feeding short branches. His hands were caught by the feed mechanism, forcing his head and upper torso into the chipper knives.

On 4/22/99, two employees (one of which is crew leader) take a wood chipper into the lemon orchard to trim and mulch the branches. Crew leader trims the branches and brings them to the victim to put in the chipper. Crew leader turns around to go back to trimming and hears a different hum comming from the chipper. Crew leader turns back to see what the problem is and noticed that the victim was gone. Victim had been sent through the chipper. Fatal.

On 11/19/99, employee was pulled into a chipper and suffered major injurries to his head and arms.

ON 15 JULY 2000 AT APPROXIMATELY 1330 HOURS, EMPLOYEE NO. 1 SUFFERED A GRUESOME FATAL WORK INJURY AS RESULT OF A CONTACT WITH THE BRUSH CHIPPER'S BLADES. THE EMPLOYER WAS ENGAGED IN TREE TRIMMING OPERATION IN THE PAST 20 YEARS. A CREW OF 8 WERE ASSIGNED TO DO A HALF A DAY TRIMMING OF EUCALYPTUS AND FINE TREES AT THE SIDE AND FRONT OF AN OFFICE COMPLEX. THE TRIMMING CREW WERE STACKING TREE BRANCHES BY THE TREES, AND THE VICTIM WAS GOING AROUND CHIPPING THE PILES OF BRANCHES. THE BRUSH CHIPPER STAYED HITCHED INTO AN ENCLOSED DUMP-TRUCK AND DEPOSITS THE CHIPS ONTO THE DUMP-TRUCK. BY 1:30 P.M., THE VICTIM WAS CHIPPING A PILE OF MEDIUM AND SHORT FINE TREE LIMBS BY THE FRONT ROAD. HE WAS WORKING ALONE WHILE FEEDING A PILE OF SHORT LIMBS, WITH HIS GLOVES, INTO THE TWO FEED ROLLERS WHEN HE EITHER LOST HIS BALANCE DURING A SNAG AND WAS PULLED INTO THE SHREDDING BLADES OR THE VICTIM WAS LEANING FORWARD ON THE SHORT FEED TABLE WHILE PUSHING, WITH HIS GLOVES, A PILE OF SHORT LIMBS THROUGH THE FEED ROLLERS WHEN HIS GLOVES WERE CAUGHT BY THE FEED ROLLERS THEN PULLED INTO THE SHREDDING BLADES. THERE WERE NO ACTUAL WITNESSES TO THE ACCIDENT. THE FEED ROLLERS FEED TABLE WAS ABOUT 1.5 FEET HIGH, 6.5 FEET WIDE AND 5 FEET LONG. THE 5'8" TALL EMPLOYEE COULD EASILY REACHED THE FEED ROLLER'S BLADES. THE TWO FEED ROLLERS WERE DESIGNED TO OPEN BY SPRINGS SO AS TO EASILY GRAB AND PUSH A LARGE 1-1/2 FEET DIAMETER LOG INTO THE SHREDDING BLADES. THE VICTIM'S ENTIRE BODY WAS SLOWLY CHOPPED INTO SMALL PIECES AT ABOUT 4 TO 6 INCHES PER SECOND. THE EMPLOYEE WAS NOT USING A PUSH- STICK OR ANY LONG TREE BRANCH TO PUSH THE SHORT PIECES OF LIMBS THROUGH THE INTAKE BLADES IN ORDER TO PREVENT THE OPERATOR'S HAND FROM ENTERING THE DANGER ZONE. THE EMPLOYEE WAS OPERATING A HEAVY DUTY BRUSH CHIPPER. THE MACHINE WAS IMPOUNDED BY THE COUNTY CORONER'S OFFICE UNTIL THEY WERE ABLE TO CONCLUDE THAT MOST OF THE VICTIM'S BODY, ABOUT 80, WAS ACCOUNTED FOR. THE, 34 YEARS OLD & UNMARRIED, EMPLOYEE WAS HIRED IN 29 APRIL 1993 AND HAS 7 YEARS EXPERIENCE IN OPERATING BRUSH CHIPPERS. THE CAUSAL FACTOR WHICH CONTRIBUTED TO THE ACCIDENT INCLUDED THE EMPLOYER'S FAILURE IN PREVENTING THE EMPLOYEE FROM PUSHING A PILE OF SHORT LIMBS, WITH HIS HANDS, INTO THE FEED ROLLER'S BLADES. THE EMPLOYER WAS FOUND IN VIOLATIONS OF T8CCR 342(a) AND 3428(a). CITATIONS WERE ISSUED WITH PENALTIES.

On 5/24/02, an employee of tree service while operating a wood chipper which had no safety control bar was pulled into the feeding wheel up to his left arm elbow before an employee was able to reverse the feeding wheel.

The following observations can be made regarding the commercial tree chipper accidents presented:

1. Accidents have occurred on commercial tree chippers equipped with a mechanical infeed system and an infeed hopper extension pan.

2. The commercial tree chipper accident statistics corroborate the test results presented in this paper.

3. Tree workers who were pulled into the feed wheels were unable to successfully use the safety control bar to prevent themselves from being pulled in.

4. Investigators concluded that tree workers reaching into the infeed hopper while feeding short branches was a contributing factor in some accidents.

CONCLUSIONS

1. Experimental testing using an anthropomorphic dummy under arm pull-in conditions has disproved the hypothesis that an infeed extension pan will prevent a snagged tree worker's gloved hand from being pulled into the chipper feed wheels given the conditions set forth in this test program.

2. Testing using human subjects revealed that a greater strength resistance to arm pull-in can be achieved without the presence of the infeed extension pan. The strength resistance results obtained in the human subject arm

pull-in test program exceed the static connection resistance test results for gloves nailed to branches reported in a prior study [1].

3. OSHA accident investigations associated with commercial tree chippers equipped with a mechanical infeed system and an infeed hopper extension pan corroborate the test results presented in this paper.

4. Manufacturers of commercial tree chippers have admonished workers not to place their body parts into the infeed hopper. Similar admonitions are contained in the commercial tree chipper safety literature [5-7]. In addition, ANSI Z133.1-2000 [3] requires that "arborists, workers and mechanics shall not reach into the infeed hopper when the cutter disc or rotary drum or feed rollers are moving." Following warnings and instructions of this type will contribute to reducing tree worker arm injuries.

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