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# SAFETY BRIEF

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## Commercial Tree Chipper: The Leg Pull-in Hypothesis

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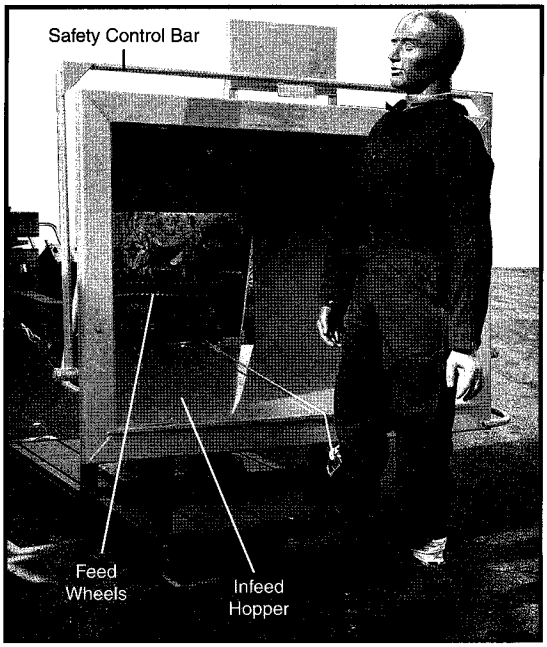


*Figure 1 - Commercial Tree Disc Chipper Infeed System*

## ABSTRACT

This paper addresses a commercial mobile tree chipper with a mechanical infeed system that is manually fed. The purpose of this paper is to show that tree branches and brush presented to a disc chipper through the infeed hopper will not pull an erectly standing operator's leg off the ground and into the feed wheels given the conditions set forth in this test program. In order for an erectly standing operator's leg to contact the feed wheels, it is necessary for the leg to be pulled off the ground and over the bottom leading edge of the infeed hopper. Experiments demonstrate that the operator's leg is pulled up against the lower leading edge of the infeed hopper and lodges there during pull-in scenarios using a winch, cable, and rope attached to the operator's ankle. Two safety devices, an infeed extension pan and a safety control bar are explored in this paper.

## INTRODUCTION

The author's previous research has been performed to study the question of whether an operator's arm can be pulled into the infeed hopper and discharge chute of a consumer chipper/shredder [1, 2]. This paper addresses the question of whether an erectly standing operator's leg can be pulled off the ground and into the feed wheels of a commercial mobile tree chipper with a mechanical infeed system that is manually fed. A typical commercial tree disc chipper infeed hopper with a mechanical infeed system is shown in Fig. 1. During the feeding mode, the

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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. The Occupational Safety and Health Administration (OSHA) has conducted investigations of accidents associated with commercial tree chippers [3, 4]. A review of the OSHA records associated with commercial tree chipper accidents indicates tree workers have alleged that their legs have been pulled into the feed wheels by tree branches during the feeding process. The purpose of this paper is to test whether an erectly standing operator's leg will be pulled into the feed wheels of a commercial tree disc chipper during a pull-in excursion of the tree branches fed into the infeed hopper. A series of 15 experiments were conducted using an anthropomorphic dummy and a commercial tree disc chipper infeed hopper. In addition, further tests using an anthropomorphic dummy were conducted with an infeed extension pan affixed to the infeed hopper to determine if the infeed extension pan would prevent an operator's leg from being pulled into the feed wheels once the leg had entered the infeed hopper due to the operator intentionally standing on the infeed hopper or kicking the tree branches entering the infeed hopper. Finally, tests with human subjects were performed to investigate whether a tree worker could stop or reverse the feed wheels by activating the safety control bar after sensing his leg being pulled toward the feed wheels.

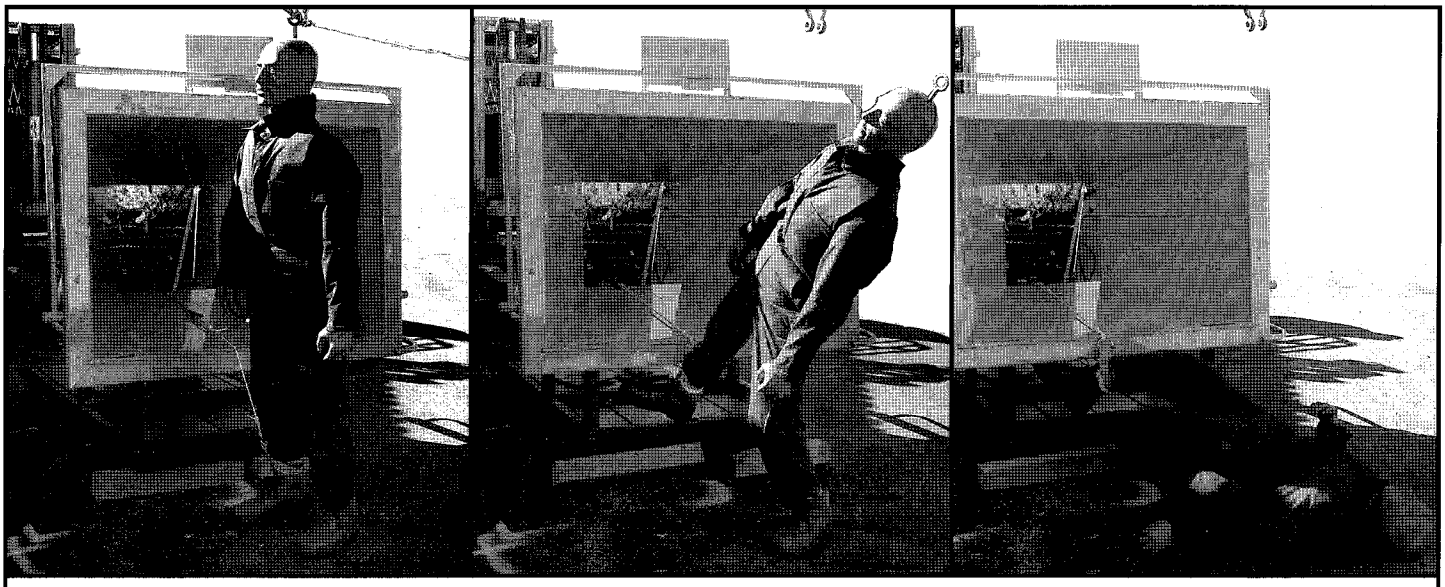
## COMMERCIAL TREE CHIPPER SAFETY STANDARDS

OSHA's regulations for brush chippers associated with electric line tree trimming are contained in 29 CFR 1910.269 [5]. In addition, OSHA's regulations addressing chipping in in-woods locations for logging operations where timber is harvested are covered in 29 CFR 1910.266 [6]. According to the OSHA General Duty Clause, each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees [7]. An OSHA compliance officer will cite this when he sees an unsafe act or condition, but cannot find a specific reference in OSHA requirements [8]. Instead, the employer is cited under the General Duty Clause and a specific reference is made to an industry standard, such as the American National Standard for Arboricultural Operations – Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush – Safety Requirements, known as ANSI Z133.1-2000 [9].

## TESTING - LEG PULL IN

### Test Setup

Figure 2A shows the test setup that was used to study the leg pull-in phenomenon in a commercial mobile tree chipper. The bottom horizontal surface of the infeed hopper test fixture was located 57.2 cm (22.5 in.) above the ground at the leading edge of the infeed hopper. An erectly standing 175.3 cm (69 in.) tall anthropomorphic dummy weighing 93.9 kg (207 lb) is posed next to the infeed hopper with both of its feet resting on the ground and its right side facing the infeed hopper. The dummy's right foot is positioned approximately 30.5 cm (1 ft) away from the leading edge of the infeed hopper. The dummy is supported by an eyehook in the top of its head which is connected to the forks of a forklift truck with a pin and rope arrangement. The pulling force of the tree chipper infeed rolls is applied to the dummy's right leg by a winch and pulley system which produces an infeed speed of approximately 90 feet per minute. A cable coming from the winch is attached with rope to metal rings on a leather strap which is wrapped tightly around the right ankle of the dummy.



A) Unloaded Leg | B) Leg Pulled Against Bottom of Infeed Hopper | C) Final Position

*Figure 2 - Leg Pull-In Test (Dummy's Feet On Ground)*

## Testing

A total of 15 leg pull-in tests were conducted. Twelve of the 15 tests were performed with the anthropomorphic dummy's feet resting on the ground. Four tests each were carried out with the dummy located at the left, center, and right positions in front of the infeed hopper. Three of the 15 tests were performed with the dummy's feet suspended approximately 2.54 cm (1 in.) above the ground with the dummy located at the left, center, and right positions in front of the infeed hopper. During the 12 tests with the dummy's feet resting on the ground, the pin is pulled out of the eyehook in the dummy's head immediately after the winch starts to pull the dummy's right leg into the infeed hopper. During the three tests with the dummy's feet suspended above the ground, the pin remains inserted in the eyehook in the dummy's head for the duration of the tests.

A typical photographic sequence for the tests with the dummy's feet starting on the ground is shown in Fig. 2. Here, the dummy is situated at the center of the infeed hopper. Photograph 2A is taken at the start of the test before the winch begins to pull the dummy's right leg. Photograph 2B depicts the dummy's right leg being lifted off the ground against the bottom member of the infeed hopper. It is clear in photograph 2B that the pin has been pulled out of the eyehook in the dummy's head. Photograph 2C shows the final resting place of the dummy on the ground with its right ankle pulled up against the bottom member of the infeed hopper and its right foot positioned under the infeed hopper. In all 12 tests with the dummy's feet starting on the ground, the dummy's right leg did not get pulled into the infeed hopper.

Figure 3 depicts a typical photographic sequence commencing with the anthropomorphic dummy's feet raised off the ground. Photograph 3A is taken with the dummy at the center of the infeed hopper before the test sequence begins. In photograph 3B, the dummy's right leg moves about the dummy's hip toward the infeed hopper. Photograph 3C depicts the final position of the dummy with its right leg against the bottom member of the infeed hopper. The dummy's right leg did not enter the infeed hopper in any of the three tests with the dummy's feet starting above the ground. Results of these 15 tests indicate that a worker's leg cannot be pulled off the ground into the infeed hopper by tree branches and enter the feed wheels given the conditions as set forth in this test program.

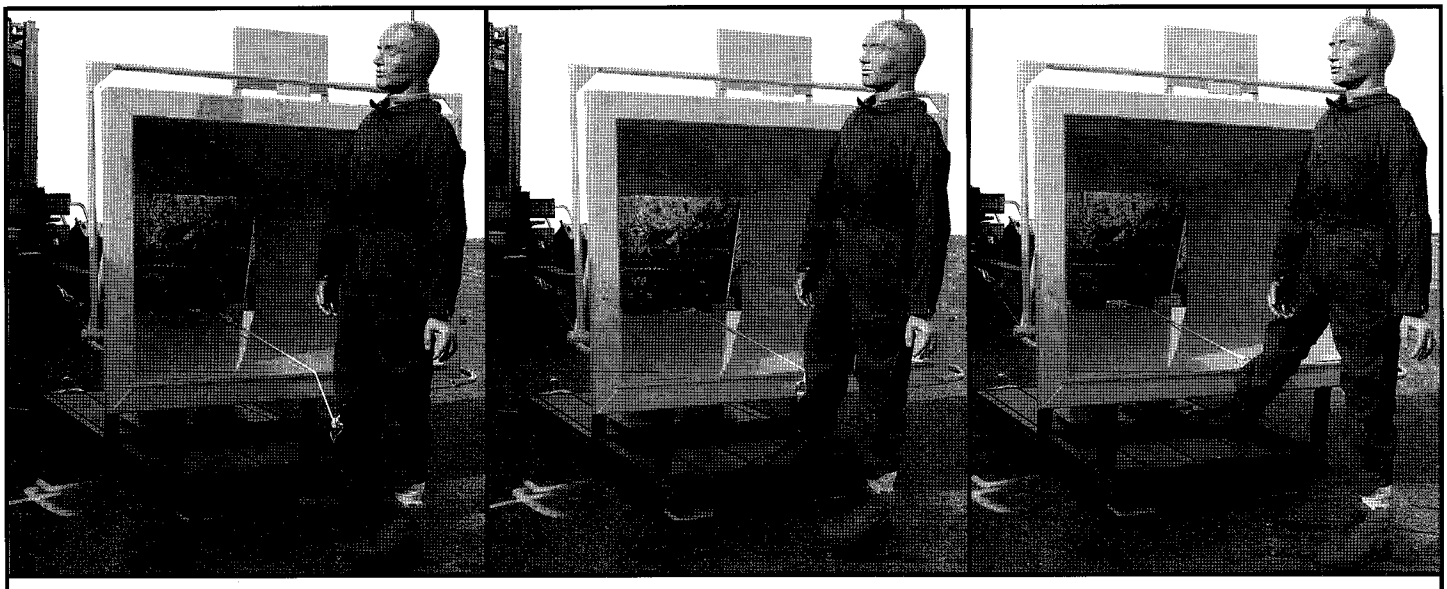
## TESTING - LEG PULL IN WITH INFEED EXTENSION PAN

### Test Setup

Figure 4 shows the infeed hopper test fixture equipped with a 76.2 cm (30 in.) long infeed extension pan. The anthropomorphic dummy is situated with its left foot on the ground and its right foot on the infeed extension pan at the interface with the infeed hopper. This position simulates a worker stepping onto the infeed extension pan or kicking material entering the infeed hopper. The dummy is supported by an eyehook in the top of its head which is connected to a forklift truck with a pin and rope arrangement. As the pulling force is applied to the dummy's right leg by a winch and pulley system, the pin is removed from the dummy's head.

### Testing

Three tests were conducted with the infeed extension pan: once with the anthropomorphic dummy situated at the left, one at the center, and one at the right of the infeed hopper.

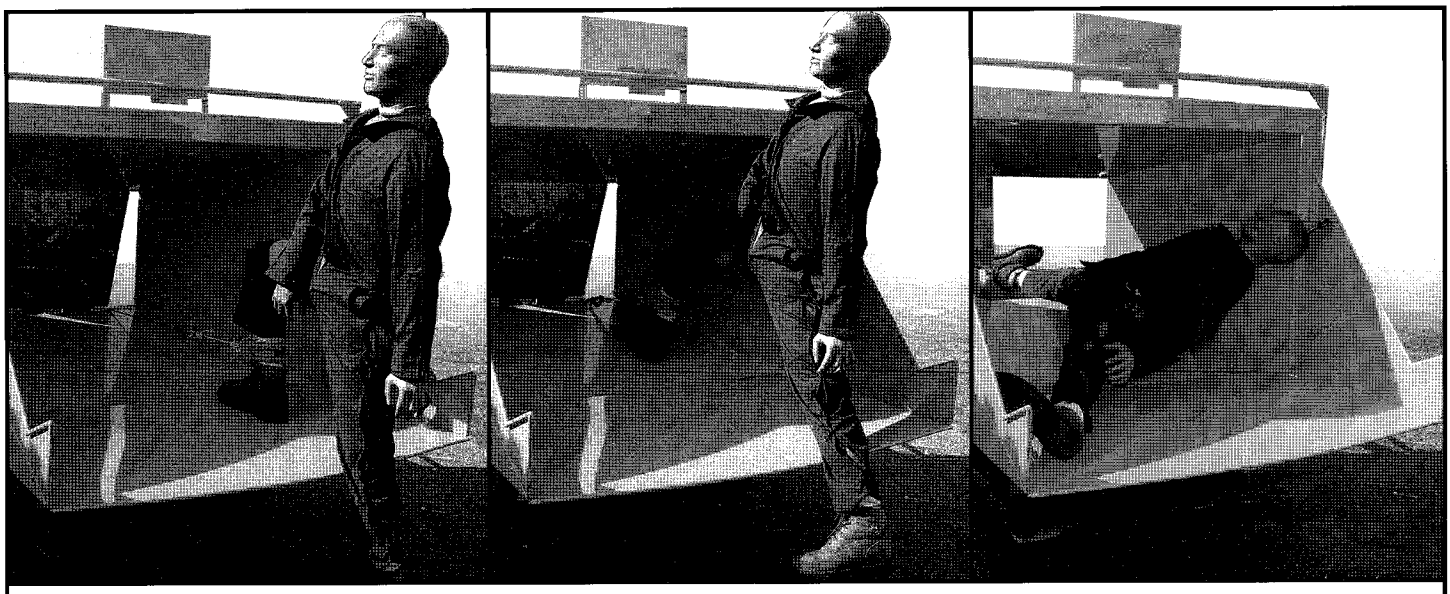


A) Unloaded Leg

B) Leg Pulled Toward Bottom of Infeed Hopper

C) Final Position

*Figure 3 - Leg Pull-In Test (Dummy's Feet Off Ground)*



A) Unloaded Leg

B) Leg Pulled Toward Feed Wheels

C) Final Position

*Figure 4 - Leg Pull-In Test with Infeed Extension Pan*

Figure 4 is a photographic sequence with the dummy originating at the right of the infeed hopper. Photograph 4A shows the position of the dummy before the force is applied to its right leg. In the next photograph, 4B, the dummy's right leg has entered the infeed hopper and its left leg has been pulled off the ground. The final photograph, 4C, depicts the dummy's left leg passing through the back of the infeed hopper which simulates the left leg entering the feed wheels. In addition, the dummy's right leg has 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 and center positions of the infeed hopper during the testing. Results of these three tests indicate that the tree worker's leg can be pulled into the tree chipper feed wheels even with an infeed extension pan if the worker places his foot on the extension pan or kicks branches entering the infeed hopper.

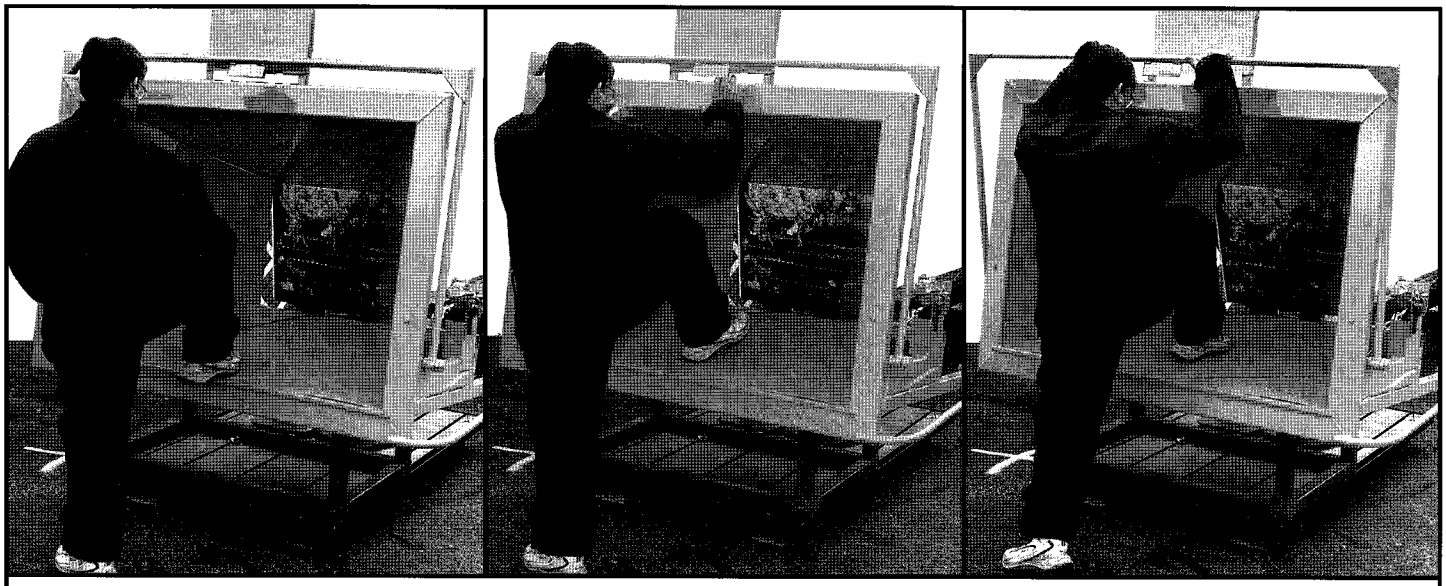
## TESTING - SAFETY CONTROL BAR ACTIVATION

### Test Setup

Tests were performed with 10 human subjects whose collective average was 182.9 cm (72 in.) in height and 93.9 kg (207 lb) in weight as shown in Table 1. Each test subject participated in three tests, being positioned at the left, center, and right of the infeed hopper, respectively. No infeed extension pan was utilized during these tests. 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 [9]. The safety control bar could be activated across the top and along both vertical sides for quick stop and reverse of the feed wheels as shown in Fig. 5A. The initial position of the human subjects had their left foot on the ground and their right foot placed at the bottom horizontal surface at the leading edge of the infeed hopper as depicted in Fig. 5A. Similar to the leg pull-in testing with the dummy, a cable coming from the winch is attached with rope to a leather strap wrapped tightly around the human subject's right ankle. Each human subject's right leg is pulled into the infeed hopper at a speed of approximately 90 feet per minute, after which point the human subject attempted to contact and move the safety control bar into a position that would either stop or reverse the feed wheels.

*Table 1 - Human Test Subjects*

| Test Subject | Height - cm (in.) | Weight - kg (lb.) |
|---|---|---|
| 1 | 182.9 (72) | 88.4 (195) |
| 2 | 180.3 (71) | 88.4 (195) |
| 3 | 182.9 (72) | 74.4 (164) |
| 4 | 177.8 (70) | 88.4 (195) |
| 5 | 185.4 (73) | 99.8 (220) |
| 6 | 185.4 (73) | 77.1 (170) |
| 7 | 170.2 (67) | 97.5 (215) |
| 8 | 200.7 (79) | 127.0 (280) |
| 9 | 193.0 (76) | 115.7 (255) |
| 10 | 172.7 (68) | 83.9 (185) |
| Average | 182.9 (72) | 93.9 (207) |



A) Unloaded Leg

B) Leg Pulled Toward Feed Wheels

C) Safety Control Bar Activated

*Figure 5 - Safety Control Bar Activation with Human Subject*

## Testing

In all 30 tests, the human subjects were able to successfully activate the safety control bar into the neutral or reverse feed wheel position before their right legs had entered the feed wheel space. Photograph 5A depicts the starting position of a human subject situated at the center of the infeed hopper. In the next photograph, 5B, the human subject's right foot has been pulled into the infeed hopper and the subject is in the process of reaching for the safety control bar. The final photograph, 5C, shows that the human subject has contacted and activated the safety control bar before his right foot entered the feed wheel space. The total time elapsed in the test sequence shown in Fig. 5 was approximately 0.5 seconds. Results of these 30 tests indicate that the human subjects were able to perceive that their right leg was being pulled, react to their leg being pulled, move their hands to make contact with the safety control bar, and activate the safety control bar into the neutral or reverse feed wheel positions before their right leg entered the feed wheel space.

## CONCLUSIONS

1. An erectly standing operator's leg will not be pulled into the feed wheels of a commercial tree disc chipper equipped with a mechanical infeed system during a pull-in excursion as set forth in this test program.

2. A tree worker's leg can be pulled into the feed wheels of a tree chipper equipped with an infeed extension pan when the worker places his foot on the extension pan or kicks branches entering the infeed hopper.

3. During a leg pull-in excursion, each human test subject was able to perceive that his leg was being pulled, react to his leg being pulled, move his hands to make contact with the safety control bar, and successfully activate the safety control bar into the neutral or reverse feed wheel position before his leg entered the feed wheel space.

4. Manufacturers of commercial tree chippers have admonished workers not to place their body parts into the infeed hopper and not to use their feet to try to kick wood into the machine. Similar admonitions are contained in the commercial tree chipper safety literature [10, 11]. In addition, ANSI Z133.1-2000 [9] 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 leg injuries.

## REFERENCES


1. Brickman, D.B. and Barnett, R.L., "On the Safety of Infeeding Vertical Garden Shredders," IMECE 2001/SERA-24000, Proceedings of 2001 ASME International Mechanical Engineering Congress and Exposition, American Society of Mechanical Engineers, New York, Nov. 11 – 16, 2001, pp. 1 – 6.

2. Barnett, R.L. and Brickman, D.B., "Chipper/Shredder: The Pull-In Hypothesis," DETC99/RSAFP-8868, Proceedings of the 1999 ASME Design Engineering Technical Conferences, American Society of Mechanical Engineers, New York, Sep. 12 – 15, 1999, pp. 1 – 9.

3. "Chipper Accident Search Detail," Occupational Safety & Health Administration, U.S. Department of Labor, Washington, D.C., 1984 to 2001.

4. "The OSHA File – A Case Study: April's Study – Improper Feeding of a Chipper Causes Serious Injury," The Treeworker, No. 214, Apr. 2000, p. 3.

5. "Brush Chippers," 29 CFR 1910.269(r)(2), Occupational Safety & Health Administration, Washington, D.C., Jul. 1, 1999.

6. "Chipping (in-woods locations)," 29 CFR 1910.266(h)(4), Occupational Safety & Health Administration, Washington, D.C., Jul. 1, 1999.

7. "OSHA General Duty Clause," U.S. Code, Vol. 29, Sec. 654, 1970.

8. Gerstenberger, P. and Clancy, T., "OSHA's Unlucky Seven," Tree Care Industry, Jul. 1990, p. 25.

9. "American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements," ANSI Z133.1-2000, American National Standards Institute, New York, Oct. 19, 2000.

10. "Chipper Use and Safety," The Treeworker, No. 125, Nov. 1992, p.2.

11. Guyette, J.E., "Chipper/Shredder Safety Precautions," Landscape Management, Vol. 32, No. 5, May 1993, pp. 24 & 26.

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