

State of California
Department of Industrial Relations
Division of Occupational Safety and Health
Memorandum

Date: April 07, 2022

To: Christina Shupe, Executive Officer
Occupational Safety and Health Standards Board
2520 Venture Oaks Way, Suite 350
Sacramento, CA 95833

From: Eric Berg, Deputy Chief of Health *Eric Berg*
Division of Occupational Safety and Health

Subject: Evaluation of Petition No. 596 to amend title 8 section 3441.

1.0 INTRODUCTION

On December 23, 2021 the Division of Occupational Safety and Health (Cal/OSHA) received a petition from Jake Winters and Praveen Penmetsa (Petitioners), representing Zimeno Inc dba Monarch Tractor. Monarch Tractor is a private company established in 2018, based in Dublin, California.

The petitioners are requesting a change to title 8 section 3441(b) "Operation of Agricultural Equipment" to permit the use of self-driving agricultural tractors without an operator physically on the equipment and at the controls.

Labor Code Section 142.2 permits interested persons to propose new or revised standards concerning occupational safety and health, and requires the Occupational Safety and Health Standards Board (Standards Board) to consider such proposals. California Labor Code section 147 requires the Standards Board to refer to Cal/OSHA for evaluation any proposed occupational safety and health standard.

2.0 BACKGROUND AND REGULATORY HISTORY.

The first title 8 regulation requiring an operator stationed at the operating controls of agricultural tractors while in motion was promulgated under title 8 section 3298.5(a) circa 1960. The regulation was renumbered in the early 1970's to section 3441(a) with the same language. In 1976, section 3441(a) was amended to adopt provisions for an alternate location of driving controls. In 1977, the section was renumbered to section 3441(b) and the first sentence was changed to read as follows: "All self-propelled equipment shall, when under its own power and in motion, have an operator stationed at the vehicular controls." A regulatory review of section 3441 was conducted by the Standards Board in 1985 that found section 3441(b) necessary and no changes were made. Since the time of the Standards Board review in 1985, the language of subsections 3441(b) and (b)(1) has remained the same as the current regulation in effect.¹

On November 16, 2018 Petition 571 was submitted to the Standards Board by the Association of Equipment Manufacturers to change section 3441(b) to permit the operation of tractors without an onboard operator. In May 2019, the Standards Board denied Petition 571.

¹ OSHSB Variance file No. 02-V-011

3.0 AUTOMATED TRACTOR TECHNOLOGY

Monarch Tractor developed a self-driving agricultural tractor (Figure 1) from concept to completion with the ability to operate without a human operator physically stationed on the equipment. The tractor utilizes full electric power for propulsion producing 40 horsepower and is designed to operate under autonomous mode during daylight and nighttime hours under various environmental conditions such as wind, rain and fog, and conditions of limited visibility such as dusty conditions and pesticide spray mist. A fail-safe in the control systems of the tractor includes a default for the tractor to stop in the event environmental conditions cause the onboard sensors to fail. Each wheel of the tractor is monitored for traction when driving on slippery surface conditions such as mud to maintain safe operation.

Several technologies are employed in the tractor design to navigate and avoid collision with objects including workers on foot. Collision avoidance technology includes 3-D cameras mounted at the front and rear of tractor as well as wide-angle cameras mounted on each side, front, and rear. A deep learning² neural networks computer is programmed to work with the cameras to identify humans and control the tractor. This computer uses a database of human images to detect the presence of humans. The computer and cameras have the ability to recognize humans in various positions such as standing, prone or lying on the ground.

For navigation, the tractor is equipped with a real-time kinetic global positioning system. This system uses a satellite and a base unit located at the facility to triangulate the location of the tractor to within a 2-inch-by-2-inch area. The tractor is programmed to stop when the navigation system fails to obtain information due to conditions such as poor signal strength.



Figure 1. Monarch Tractor, with cameras mounted on the roll-over protection roof.

² Deep learning is a class of machine learning computer algorithms that uses multiple layers to progressively extract higher-level features from the raw input allowing the system to differentiate input data such as shapes of objects.

Additional safety features of the tractor include seatbelts that are electrically interlocked to prevent tractor operation when an operator is present and the seatbelts are not worn and buckled. This feature serves to prevent the operator from being ejected and crushed during a rollover event. A proximity device prevents workers from contacting the tractor's power take off (PTO) located at the rear of the equipment. This device consists of a camera integrated with the tractor's control system to stop the tractor when a worker encroaches within 3.3 feet (1 meter) of the PTO.

4.0 PETITIONERS' PROPOSED AMENDMENTS TO TITLE 8 REGULATIONS

The petitioners proposes the following changes to section 3441 of title 8 General Industry Safety Orders. No specific location was within section 3441 was proposed by the petitioners.

Notwithstanding section 3441(b), self-propelled equipment is not required to have an operator onboard the vehicle when the following conditions are met:

- The manufacturer certifies that the technology has gone through appropriate safety protocols in the following: Product development; Monitoring and testing of the technology; and the technology meets the operational requirements of the stages listed below:
 - Stage 1-zero to 500 hours or one year of operation of the tractor technology with an operator on the tractor at all times, allowing for advancement to Stage 2 only if there are no close calls, incidents, injuries, or accidents;
 - Stage 2-an additional 500 hours of operation of the tractor technology and operation during all four seasons (summer, fall, winter, spring) without an operator on the tractor so long as an onsite remote operator was alerted whenever the tractor detects an obstacle, allowing for advancement only if there are no close calls, incidents, injuries, or accidents.
- There are posted signs, visible from 50 feet during daytime or nighttime, at the entry and exit of every site where autonomous technologies are deployed, reading "Driver Optional Vehicle in Use";
- The driver-optional vehicle shall be provided with a perception system capable of detecting and locating persons or other obstacles relative to the machine;
- The driver-optional machinery shall be provided with a system capable of locating and positioning the driver-optional machinery as required for the operations involved while preventing unintended excursions beyond the boundary of the working area;
- Emergency stop buttons shall be affixed at the outermost perimeter on both sides and the rear of the tractor, depressing the emergency stop buttons shall immediately initiate braking to stop the tractor; and
- The tractors shall come to a full stop before any human encroaches a 7-foot radius from the tractor, and the 7-foot clearance applies regardless of the agricultural operation or the implements attached to the tractor.

The proposal above from the petitioner is based primarily on conditions imposed in the Cal-OSHA experimental variance granted to Monarch Tractor on August 6, 2021 (see Attachment 1). Other proposed

requirements including postings, speed limits, and worker training were based on the International Standard ISO 18497-2018 consensus standard “*Agricultural Machinery and Tractors – Safety of Highly Automated Agricultural Machines — Principles for Design*” (see Attachment 2).

5.0 PETITIONERS BASIS FOR NEW TITLE 8 REGULATION

5.1 Enhanced Worker Safety.

The petitioner asserts that their autonomous tractor technology enhances worker safety. In support of this, the petitioners cite two benefits provided by technology included in the tractor design.

One of these technologies is an anti-rollover system in which an on board IMU (inertia measurement unit) sensor measures tilt angle or the slope of the ground. This sensor first provides warnings to the operator driving onboard or remotely located of terrain conditions that could lead to a roll over, and then shuts the tractor off before the roll over incident. The IMU sensor is an important safety feature the petitioner contends because rollover accidents continue to be the leading cause of injury and fatalities in agricultural tractors.³

A second benefit of the Monarch tractor is during spraying operations of pesticides. Due to the absence of an operator, the petitioner argues that the use of self-driving tractor during pesticide application operations eliminate worker exposure to hazardous chemicals.

5.2 The Current Title 8 Regulation is Outdated

The petitioner asserts that section 3441(b) has not been amended since its promulgation in the 1970’s. Therefore, the petitioner argues that section 3441(b) does not account for equipment and machinery that incorporate self-driving technology such as sensors, computers, and artificial intelligence. The petitioner contends its technology, outlined above, eliminates the risk of injury to agricultural workers. The petitioner adds that there is self-driving machinery already in use in California and that the autonomous navigation software of this equipment provides equal safety to an onboard operator. Moreover, the petitioner cites that the ambiguity in existing regulations and lack of regulations addressing self-driving technology as the reason why there are currently companies in California operating self-driving equipment that are not in compliance with section 3441(b) and without a Cal-OSHA experimental temporary variance.

6.0 APPLICABLE TITLE 8 REGULATIONS

Title 8 regulations address the hazards of the operation of agricultural equipment in section 3441 of the General Industry Safety Orders. Subsection 3441(b) of these orders requires an operator be stationed on the equipment at the operational controls.

General Industry Safety Orders
 Group 3. General Plant Equipment and Special Operations
 Article 13. Agricultural Operations
 §3441. Operation of Agricultural Equipment.

* * * * *

³ <https://www.cdc.gov/niosh/topics/aginjury/default.html>

(b) All self-propelled equipment shall, when under its own power and in motion, have an operator stationed at the vehicular controls. This shall not prohibit the operator occupying or being stationed at a location on the vehicle other than the normal driving position or cab if controls for starting, accelerating, decelerating and stopping are provided adjacent and convenient to the alternate position. If the machine requires steering other than ground or furrow steering or operates at ground speeds in excess of two miles per hour, steering controls shall also be provided at the alternate location. Seedling planters and other similar equipment traveling at a speed of two miles an hour or less where a control that will immediately stop the machine is located at the operator's work station will satisfy this requirement.

(1) Furrow guided self-propelled mobile equipment may be operated by an operator not on the equipment provided that all of the following are complied with:

(A) The operator has a good view of the course of travel of the equipment and any employees in the immediate vicinity.

(B) The steering controls, when provided, and the brake and throttle controls are extended within easy reach of the operator's station.

(C) The operator is not over 10 feet away from such controls and does not have to climb over or onto the equipment or other obstacles to operate the controls.

(D) The equipment is not traveling at over two miles per hour ground speed.

* * * * *

7.0 APPLIABLE FEDERAL OSHA REGULATIONS

Federal OSHA regulations do not have a requirement for operators of agricultural vehicles to be stationed on the equipment.

8.0 APPLICABLE CONSENSUS STANDARD

The International Organization for Standardization (ISO) addresses highly automated agricultural machines (HAAM) in ISO 18497 *Agricultural Machinery and Agricultural Machines – Safety of Highly Automated Agricultural Machines – Principles for Design* (First Edition, 2018) (Attachment 2). Examples of autonomous agricultural equipment cited in ISO 18497 are agricultural tractors, tractor implement systems, implements, and self-propelled machinery.

ISO 18497 is a performance-based standard that specifies the principles in the design of self-driving tractors to achieve safe operation. To be compliant with ISO 18497, self-driving tractors must contain, at the minimum, all of the following features into their design:

- A perception system capable of detecting and locating persons or other obstacles relative to the machine;
- A perception system capable of locating and positioning the equipment to prevent unintended excursions beyond the boundary of the working area;
- Be able to ensure that there is no obstacle in the hazard zone prior to moving;

- Give audible or visual alarms and enter its defined safe state when an obstacle is detected or an obstacle enters its hazard zone;
- Have the means to enable a local or remote operator to stop or start highly automated operation; and
- Allow for adequate supervision by a local or remote operator.

9.0 HAZARDS TO WORKERS

In California, there are a variety of agricultural activities that require employees to work in proximity to agricultural equipment such as tractors and harvesters. Harvesting of crops such as lettuce, broccoli, and corn and laying irrigation lines all require employees to walk alongside tractors and trailers. This exposes employees to the hazard of being struck or run over by agricultural equipment which can result in serious and fatal injuries including:

- Fractures
- Crushing injuries
- Amputations
- Contusions
- Abrasions

10.0 ANALYSIS

10.1 Technology Utilized by the Monarch Tractor is New to Agricultural Vehicles

The use of IMU sensors, remote application of pesticides, and the use of proximity sensors on PTO's are new technologies for agricultural tractors. Cal-OSHA agrees these technologies, if reliable at all times, can enhance worker safety. However, as this technology is still new to applications for agricultural vehicles, Cal/OSHA believes that further substantiating the safe implementation of this technology is needed to ensure worker safety.

10.2 Lack of Consideration of the Petitioners' Technology Does Not Establish Enhanced Worker Safety

Cal/OSHA agrees that subsection 3441(b) does not take into account the viability of Monarch's self-driving technology. The regulatory language of section 3441(b) has remained the same since it was established 1977 and reviewed in 1985. Monarch's tractor was developed starting in 2018 from concept to construction utilizing a combination of modern technology for self-driving that was not available in 1985. However, the petitioners' argument that the Standards Board did not address this technology in prior rulemaking is not evidence that the new technology is safe or will enhance worker safety.

10.3 The Petitioner's Claim of the Complete Elimination of Hazards is Unproven

The petitioner's assertion the Monarch tractor completely eliminates potential injuries to workers in the agricultural field is unproven. The petitioner provided data indicating 590 hours of autonomous operation with 40,498 human detections and zero human injuries. Although no injuries occurred during the recorded

period, the dataset is still too small to conclude that equal safety to that of a sentient operator at the tractor controls will be provided.

This sentiment was echoed by Professor Stavros Vougioukas of University of California Davis (UC Davis) who conducts research and development in the Biological and Agricultural Engineering program of automated agricultural equipment. When contacted by Cal/OSHA staff during the evaluation of Petition 571, Professor Vougioukas expressed that, generally speaking, automation of agricultural equipment is not yet a solved problem. During the approved temporary experimental variance, Cal-OSHA intends to verify the data and observe that self-driving tractors can provide, at least, equivalent safety to having an onboard operator. Cal/OSHA believes that such efforts, in addition to an increased amount of data and more datasets, should be considered prior to approval of the proposed petition.

10.4 Title 8 Subsection 3441(b) is Not Ambiguous

The petitioner asserts that section 3441(b) is ambiguous and has caused other companies in California to utilize self-driving tractors in violation of Cal-OSHA regulations. Cal/OSHA disagrees with the petitioners' assertion. Section 3441(b) is clear in its requirements to have an operator stationed at the controls of agricultural equipment. Although the language of section 3441 does not specifically address modern self-driving tractors, this does not limit the applicability of the regulation to this type of equipment. Any employer in the state of California who operates self-driving tractors without an operator stationed at the controls is in violation of section 3441(b) unless they have a variance from this regulation.

10.5 Temporary Experimental Variance is Still in Progress

Cal-OSHA determined, during the May 2019 evaluation of Petition No. 571, that the agricultural industry lacked sufficient experience in the use of self-driving tractors. Cal-OSHA recognized the trend in the agricultural industry in its move to utilize robotics and autonomous equipment. In January 2020, Cal-OSHA began working with Monarch Tractor to develop an experimental variance. The approved variance included conditions that would test the tractor's self-driving capabilities while at the same time keeping workers safe. The experimental variance was limited to two facilities in northern California to minimize hazard exposure to workers.

Cal-OSHA is interested in the tractor's performance during varying seasonal weather conditions. Weather variations affect the ground surface conditions which can, in turn, affect traction of the tractor's wheels. Weather conditions also affect instrumentations used by the tractor. Dust can occlude camera visibility; humidity can cause condensation on camera lenses that affect its clarity, and extreme heat or cold can affect the performance of electronic sensors and computers.

Cal-OSHA is interested in the tractor's performance cultivating various crops grown in the extremes of California weather and geography. However, the experiment performed by the petitioners associated with the approved variance has not yet concluded and sufficient evaluation of the proposed automated equipment in different extreme environments is not complete.

The experimental variance was initially scheduled to last five years and staged to increase autonomy of the self-driving tractors progressively. In August 2021, after nineteen months of information gathering and compromise over terms and conditions, the California Department of Industrial Relations approved the experimental variance. Monarch Tractor was allowed to include 500 hours of operation conducted from June 2020 to August 2021 in which no injuries or accidents occurred in the initial stage (stage one) of operation. In January 2022, Cal-OSHA approved proceeding to stage two of the experimental variance

which requires an additional 500 hours of autonomous operation and a minimum of one calendar year in which remote operations of the tractor is allowed.

On December 23, 2021 the applicant submitted Petition No. 596 while the experimental variance is still underway. Cal/OSHA needs information gathered after completion of the experimental variance to assist in determining if new or amended regulation within section 3441(b) is prudent and necessary. As of the date of this evaluation, Cal/OSHA does not have all the data and information sought through the experimental variance process.

On February 17, 2022 Cal-OSHA conducted a field visit to verify compliance with the terms of the experimental variance. Cal-/OSHA Research and Standards Safety Unit staff discovered workers were removed from the field in which testing of the self-driving tractors were being conducted. This situation defeats the intended purpose of the experimental variance, which was to examine the tractor's ability to avoid collision with workers in a field. Further revisions in the terms and conditions of the experimental variance are necessary in order to obtain the information needed to ensure an adequate evaluation of the tractor's performance.

11.0 CONCLUSION

Cal/OSHA recommends that the current experimental variance continue to completion. The experience and knowledge gained by completing the experimental variance process will provide valuable safety data for automated tractors and benefit the eventual drafting of regulations for self-driving agricultural equipment.

Cal-OSHA believes it would be premature to initiate rulemaking based on the petitioners' proposal before conclusion of the experimental variance and recommends that Petition No. 596 be DENIED.

cc: Jeff Killip, Yancy Yap, Jason Denning

Attachment 1 - Monarch Tractor on August 6, 2021

DEPARTMENT OF INDUSTRIAL RELATIONS
DIVISION OF OCCUPATIONAL SAFETY AND HEALTH

Headquarters Office

1515 Clay Street, 19th Floor

Oakland, CA 94612

Tel: (510) 286-7000 Fax: (510) 286-7037

Douglas L. Parker, Chief



August 6, 2021

Jake Winters, Chief of Staff
Zimeno Inc. dba Monarch Tractor
203 Lawrence Drive, Suite A,
Livermore CA 94551-5152

Wente Vineyards
5565 Tesla Road
Livermore, CA 94550.

Crocker and Starr
700 Dowdell Lane
St Helena, CA 94574

Re: Approval of temporary experimental variance for use of autonomous tractor in agriculture

Dear: Mr. Winters:

This letter responds to your request of December 4, 2020 for a temporary experimental variance from California Code of Regulations title 8 section 3441(b) "Operation of Agricultural Equipment." You requested the temporary experimental variance on behalf of the following employers:

- Wente Vineyards; 5565 Tesla Rd, Livermore, CA 94550
- Crocker and Starr, 700 Dowdell Ln, St Helena, CA 94574

You requested a temporary experimental variance to participate in an experiment to use a new and improved alternative method of protecting employees from tractor rollovers, spraying of hazardous substances, and fatigue through use of an autonomous tractor. To allow use of the autonomous tractor, an experimental variance is needed from section 3441(b), which states the following:

§ 3441. Operation of Agricultural Equipment.

* * * *

(b) All self-propelled equipment shall, when under its own power and in motion, have an operator stationed at the vehicular controls. This shall not prohibit the operator occupying or being stationed at a location on the vehicle other than the normal driving position or cab if controls for starting, accelerating, decelerating and stopping are provided adjacent and convenient to the alternate position. If the machine requires steering other than ground or furrow steering or operates at ground speeds in excess of two miles per hour, steering controls shall also be provided at the alternate location. Seedling planters and

other similar equipment traveling at a speed of two miles an hour or less where a control that will immediately stop the machine is located at the operator's work station will satisfy this requirement.

(1) Furrow guided self-propelled mobile equipment may be operated by an operator not on the equipment provided that all of the following are complied with:

(A) The operator has a good view of the course of travel of the equipment and any employees in the immediate vicinity.

(B) The steering controls, when provided, and the brake and throttle controls are extended within easy reach of the operator's station.

(C) The operator is not over 10 feet away from such controls and does not have to climb over or onto the equipment or other obstacles to operate the controls.

(D) The equipment is not traveling at over two miles per hour ground speed.

* * * *

The California Department of Industrial Relations and Division of Occupational Safety and Health (Cal/OSHA) grants a temporary experimental variance from subsections 3441(b) to Monarch Tractor, Wente Vineyards, and Crocker and Star as permitted by Labor Code section 6452.

This temporary experimental variance only applies to subsection 3441(b) and does not affect any other title 8 requirement. The variance is not a finding of compliance with any title 8 requirement. The variance shall remain valid provided Monarch Tractor, Wente Vineyards, and Crocker and Star comply with the following mandatory conditions:

1. Use of the Monarch tractor shall comply with all applicable requirements of title 8 safety orders except where the provisions of the variance permit alternative compliance to section 3441(b).
2. The applicant shall proceed with autonomous operation of the tractor technology (i.e., the same safety hardware and software configuration across multiple tractor units) in accordance with the following phases and record any close calls (where a person needs to quickly move out of the way of the tractor because it appears the tractor may contact them), incidents, injuries, or accidents related to the vehicle and its operation and make such records available to Cal/OSHA immediately upon request (see conditions 23 and 24 below). The autonomous operation phases are:
 - a. Stage one, zero to 500 hours or one year of operation of the tractor technology, whichever occurs later. A trained operator is on the tractor at all times. Applicant may proceed to stage two only if there are no close calls, incidents, injuries, or accidents, and Cal/OSHA is satisfied that the data complies with conditions 23 and 24.
 - b. Stage two, additional 500 hours of operation of the tractor technology and operation of the tractor technology at some point during all four seasons (summer, fall, winter, spring) during Stage one and/or during Stage two. The vehicle may be operated autonomously without an operator on the tractor if all of the below are complied with:
 - i. Video feed from the tractor is always available to an operator who is onsite and can stop the tractor when necessary.
 - ii. The onsite remote operator is alerted whenever the tractor detects an obstacle as described in condition 8a. If the tractor fails to initiate braking as described in 8b, the

- operator, using remote control, shall initiate braking and effect a stop as described in 8c.
- iii. The onsite remote operator monitors the video feed to ensure safe operation and proper functioning of the tractor, including but not limited to, whenever there is an alert as described above in condition 2bii and twice per hour.
 - iv. If the onsite remote operator notes any function by the tractor not in compliance with condition 8, the onsite remote operator stops the tractor immediately and documents the details of the incident. The tractor shall not be restarted until the tractor is evaluated and adjusted or repaired as necessary to ensure safe operation in compliance with condition 8.
 - v. If an emergency stop is initiated by a field worker on foot or an emergency stop is initiated by the tractor's autonomous braking, the remote operator shall establish audio communication with someone physically with the tractor before proceeding with the tractor movement to verify workers are not in danger of being run over. When such an incident happens, the applicant shall make a record of the incident including data identifying the cause for emergency stoppage. Such data shall be provided to Cal/OSHA as part of condition 24.
 - vi. The applicant may proceed to stage three only if there are no close calls, incidents, injuries, or accidents, and Cal/OSHA is satisfied that the data complies with conditions 23 and 24.
- c. Stage three, autonomous operations allowed with video feed available at all times to an onsite remote operator. The onsite remote operator shall monitor the video feed to ensure safe operation and proper functioning of the tractor. Applicant shall provide information on any injuries, incidents, close calls, and data from conditions 23 and 24 every six months.
3. Use of the Monarch tractor under autonomous mode shall be limited to grape cultivation that includes only the following activities: mowing, spraying, under vine cultivation, disking, spading, leaf pulling, hedging, and seeding for cover crop.
 4. Use of the autonomous tractors under this variance shall take place only at:
 - a. Wente Vineyards, 5565 Tesla Road, Livermore, California 94550.
 - b. Crocker & Starr, 700 Dowdell Lane, St Helena, California 94574.
 5. The tractor under autonomous mode operation may be used on private farm roads and in-between row crops, but shall not be used on or to cross any public road.
 6. Only Monarch tractors serial numbers PS10053, PS10054, and PS10055 may be operated within the scope of this variance.
 7. All three tractors listed in Condition 6 shall be equipped with following technologies for collision avoidance and navigation and shall be fully functional at all times during autonomous tractor operation:
 - a. Real time kinematic global positioning system with an onsite base unit.
 - b. A total of 8 cameras (Two 3D Color Cameras each at the front and rear of the tractor and one wide angle camera each at the front and rear and both sides).
 - c. Deep Learning Neural Networks computer.
 - d. Emergency stop buttons.
 8. The following safety features shall be fully functional when the tractor is operating in autonomous mode:

- a. When moving forward or reverse, the tractor shall produce an audible and visible warning when humans are detected between 16 to 33 feet (5 to 10 meters) away in the direction of movement.
 - b. When moving forward or reverse, the tractor shall initiate braking to slow the movement of the tractor when humans are detected between 7 to 16 feet (2 to 5 meters) away in any direction.
 - c. The tractors shall come to a full stop before any human encroaches a 7-foot radius from the tractor. The 7-foot clearance applies regardless of the agricultural operation or the implements attached to the tractor.
 - d. The tractor shall be limited to 3.1 miles per hour (5 kilometers per hour) maximum speed under autonomous operation.
9. The tractor shall be equipped with lights readily visible during daylight hours from any approach angle to the vehicle. The lights shall operate continuously while the vehicle is in autonomous mode.
 10. The operator shall operate the tractor in manual mode in the event that one or more of the autonomous safety features listed in Condition 7 and 8 are not fully operational.
 11. Emergency stop buttons shall be affixed at the outermost perimeter on both sides and the rear of the tractor. Depressing the emergency stop buttons shall immediately initiate braking to stop the tractor.
 12. The tractor shall have a manual mode capable of movement in reverse or forward after the emergency stop has been initiated.
 13. The tractor's detection and avoidance system listed under Conditions 7 and 8 shall be tested for proper function in the field environment where the tractors will be operated, prior to the start of each work day. The function tests shall be repeated whenever the autonomous equipment is moved to a new field location (address).
 14. The tractor operator shall receive effective training for the following:
 - a. The operational functions of the navigation system and the detection and collision avoidance system.
 - b. To render first aid and CPR.
 - c. Procedures and tractor functions necessary to extricate a worker who is pinned under the tractor.
 15. The tractor operator shall ensure an effective means of communication such as a cellular phone or a radio for use during emergencies.
 16. All workers who are accessing the field where the autonomous tractor will operate shall wear high visibility reflective vests (ANSI/ISEA 107-2020 Class 3) and receive training in the following:
 - a. The operational functions of the navigation system and the detection and collision avoidance system.
 - b. The emergency stop functions of the tractor.
 - c. To report unintended contact or close calls with an autonomous tractor to the applicant as soon as possible.
 17. All workers are prohibited from laying down, sleeping, or taking naps in the fields while the tractor is operating under autonomous mode. Additionally, workers are prohibited from wearing headphones, earbuds, and any device that can impede the ability to hear ambient sounds unless those devices are needed for work related communications.

18. Signage in compliance with title 8 section 3340 reading “Warning Autonomous Vehicle in Operation” shall be posted at each field where the tractor will be in autonomous operation. The signs shall be in English, Spanish, and other languages spoken by workers. The signs shall contain contact information for a person who can quickly stop the tractor. The warning signs shall be posted at each corner of the field and at every usual point of entry to the field including each road, footpath, walkway, or aisle entering the field. The signs shall be posted at intervals not to exceed 600 feet in areas adjacent to public right of way that are not otherwise protected by a fence at least six feet high. The signs shall be legible at 25-feet away by a person with normal vision.
19. The tractor under autonomous mode shall not be operated from sunset to sunrise unless posted signs required by Condition 18 are sufficiently illuminated to make them readily visible.
20. The tractor shall not be operated under autonomous mode in the sloped areas of the Wente Vineyard field.
21. The designated primary and secondary coordinators representing Monarch Tractor in the Cal-OSHA experimental variance are Jake Winters, (614)849-2840, jwinters@monarchtractor.com. Mark Schwager (833)247-4797 or (347)277-8687, mschwager@monarchtractor.com respectively. The primary and secondary coordinators shall maintain availability for communication as necessary with Cal-OSHA. The primary and secondary coordinators shall have the authority to immediately stop usage of the autonomous equipment covered by this variance. Any change of personnel for the primary and secondary coordinators will be reported to the Cal/OSHA Research and Standards Unit within 24 hours.
22. In addition to notifications required by title 8 section 342, the applicant shall notify the Cal/OSHA Research and Standards Safety Unit within 24 hours of any injury (recordable or non-recordable) to any worker related to the driverless tractor operations.
23. The applicant shall conduct an investigation of any injury (recordable or non-recordable) to any worker related to the driverless tractor operations. Additionally, an investigation shall be conducted when the applicant is aware of a close call or the tractor making unintended contact with a person. The investigation shall include the following information if available: date and time of the incident, equipment involved, photographs of the scene, autonomous technology being used, failure cause (i.e., A - obstacle occluded due to crops, dust, fog, snow, rain. B - sensors obstructed identifying the obstruction. C - poor or intense lighting. D- misalignment of sensors and its cause. E- terrain conditions. F- latency due to computational overload), operator information (name, employer, title, address and phone number), witness information, exact field location, agricultural operation taking place, environmental conditions, grounds conditions, and any additional pertinent information. The applicant shall provide the results of the investigation to the Cal-OSHA Research and Standards Safety Unit within one week of completion of the investigation.
24. The applicant shall provide the following safety and health related data and any other pertinent information as part of the experimental variance. The data shall be provided at the completion of each stage in condition 2, and when any condition 23 incident or close call occurs. The data shall be provided in a readily understandable format and include the following information regarding the autonomous operation:
 - a. Total distance traveled.
 - b. Total hours of operation
 - c. Collision avoidance incidents.
 - d. Incidents recorded per condition 2.b.v above (applicable to stage two only)

- e. Replacement of any of condition 7 components except for replacement-in-kind resulting from normal wear and tear (i.e., expected deterioration occurring from ordinary use over time). This includes any replacement or upgrades in hardware and software of the deep learning neural networks computer
25. Wente Vineyard and Crocker& Starr shall provide immediate unannounced access to its premises covered by this variance to Cal-OSHA representatives for the purpose of conducting inspections or otherwise reviewing compliance with this variance. Wente Vineyard and Crocker& Starr shall provide Cal/OSHA access to privately interview workers to assess their experience working with and around the autonomous vehicle.
26. Cal-OSHA reserves the right to revoke and terminate this variance immediately if it deems the above conditions are not met or if it deems workers are at risk.
27. This variance will end when the earliest of the following occurs:
- a. The Occupational Safety and Health Standards Board grants or denies a permanent variance regarding autonomous tractor use in the places of employment covered by this temporary experimental variance.
 - b. A title 8 regulation allowing for autonomous tractors in agriculture is established.
 - c. 5 years from the issuance of this variance unless an extension is granted by Cal/OSHA.

Sincerely,



Douglas Parker, Chief

cc: Katie Hagen, Eric Berg, Jason Denning, Yancy Yap

Attachment 2 - ISO 18497 *Agricultural Machinery and Agricultural Machines – Safety of Highly Automated Agricultural Machines – Principles for Design* (First Edition, 2018)

Due to copyright laws Attachment 2 is not available for review