



## **WELCOME TO THE IOA/PAG AGRI-FOOD TASK FORCE WEB SITE**

This web site contains the following items of information, all dealing with the use of ozone for the treatment of agricultural and food products for one or multiple purposes.

Statements by the International Ozone Association Concerning Food Treatment with Ozone

Uses for Ozone in Treating Agricultural Products and Foods

Criteria for Evaluating User Success Reports

User Success Reports of Installed, Commercial Applications of Ozone in Agriculture and the Treatment of Foods.

### **STATEMENTS BY THE IOA CONCERNING FOOD TREATMENT WITH OZONE**

The following statements represent the positions of the International Ozone Association with respect to the treatment of foods with ozone for any purpose. These statements were adopted by the IOA International Board of Directors in 2004.

- A. IOA supports the applications of ozone in the agriculture and food treatment areas, as long as such applications are made under conditions that are protective of workers involved and of the safety of humans and their possessions in facilities being treated with ozone.
- B. IOA will NOT support the indiscriminate application of ozone in any manner that endangers the health of workers during treatment of foods or agricultural products with ozone.
- C. IOA will provide space on its web site(s) and will sanction publication in IOA documents to present information on known procedures of applying ozone to treat agricultural products or foods for purposes of improving their quality under conditions stated in A and B above.
- D. IOA is a U.S. Internal Revenue Service-recognized not-for-profit association under Section 501(c)(3) of the U.S. Internal Revenue Code. As such, IOA will provide an organizational umbrella under which industrial representatives in the ozone and agriculture and/or food processing industries can meet to discuss technical, safety and regulatory issues and to advance the causes of ozone without fear of anti-trust suits, as long as pricing and similar issues are not discussed.

## **USES FOR OZONE IN TREATING AGRICULTURAL PRODUCTS AND FOODS**

Microorganisms are present everywhere food is present and handled, from the fields in which agricultural crops are planted and raised to harvest, animal breeding and rearing houses to the facilities that process crops and animals, to packaging and food storage plants. Control of microorganisms, particularly pathogenic microorganisms (those that cause diseases in humans and animals), is important at all stages. Strong measures are necessary for microorganism control.

Classical chemical control methods based on chlorine or bromine compounds are effective for controlling microorganisms, but their use can result in halogenated byproducts being formed and these subsequently can be incorporated into the food product itself. Ozone, consisting only of oxygen atoms, is one of the strongest disinfectants available, and does not form halogenated byproducts. Additionally, ozone can be applied in the gas as well as aqueous phases, providing additional processing benefits. Uniquely, combining ozone with other materials (hydrogen peroxide or ultraviolet radiation) produces the very reactive intermediate, hydroxyl free radical, which is a stronger oxidizing agent than is ozone itself.

Ozone is both a strong oxidizing agent as well as a strong disinfectant. Because of this, both benefits (oxidation and disinfection) can be achieved during the single step of ozonation. When considering oxidation, however, one also must recognize that not all oxidizable substances can be totally destroyed even by ozone, the strongest oxidant and disinfectant commercially available. In most cases, oxidation reactions proceed through intermediate stages, arriving at CO<sub>2</sub> and water only when the pollutant is provided with a sufficient concentration of ozone for a sufficient period of time to allow complete oxidation (mineralization).

This point is very important in treating foods, which are organic in nature, with ozone. The indiscriminate over-use of ozone to control microorganisms can easily partially oxidize surface organic materials on the food being treated, and can change the nature of that food surface. The key to successful application of ozone for contacting foods is to add sufficient ozone to allow it to accomplish its intended purpose, but not enough to cause damage to the food itself. This requires testing and development of ozonation conditions to apply to specific food products.

Water is an essential processing agent in agriculture and food processing. It can be used in many instances to carry the ozone. Since water contacts foods, it is critical that it be as clean as possible. Due to the ever-rising costs of treating potable water, increasing economic pressure is being placed on reuse of processing water in food and agriculture applications. Ozone has a long and proven history of application in treating water and wastewater, and thus has many potential applications in agriculture and food processing facilities. Water containing ozone is being used in many food processing plants currently to spray or wash food products, and to wash processing and storage equipment.

Many agricultural products are stored after harvest, prior to packaging and sale. Gas phase ozone, applied properly with attention to concentration, relative humidity, and exposure times, can maintain low microorganism and insect levels in/on the product(s) during such storage, thus

increasing storage life while maintaining high product quality – resulting in less product loss during storage.

A recent agricultural development in Switzerland involves the close to simultaneous application to crops of high voltage, pulsed negatively charged water, then an aqueous spray containing ozone, then high energy UV radiation (Steffen, 2005a,b; Rice and Steffen, 2005). This approach stimulates a reaction in growing plants termed “Systemic Acquired Resistance”. The result is that the growing plants do not need to be sprayed with pesticidal chemicals. Periodic application of this new Phyto3 Tech technology maintains plant cleanliness, free of pathogens, without the necessity of chemical sprays. This means no chemical residuals on the harvested products, and no chemicals washed into the soils.

### **USER SUCCESS REPORTS OF INSTALLED, COMMERCIAL APPLICATIONS OF OZONE IN AGRICULTURE AND THE TREATMENT OF FOODS**

The Agri-Food Task Force believes that it is instructive to provide specific examples of many applications of ozone for treating agricultural and food products and processing plants on this web site. That being said, the question next arises as to what constitutes an appropriate User Success Report (Case Study) of Agri-Food Treatment With Ozone.

The literature is replete with published articles describing ozone treatment of agricultural and food products. However, the IOA Agri-Food Task Force believes that User Success Reports (USRs) to be listed on this web site must be complete to rather rigid standards. It is not sufficient to say only that ozone will accomplish some specific treatment task without providing all of the procedures for generating and applying ozone, and without reporting data to support the claims made. Conditions should be described that will allow the reader to duplicate the procedure and to develop his/her own data.

To this end the Agri-Food Task Force has developed the following criteria for case studies to be reviewed and posted on this web site:

- Title of Case Study
- Description of Problem
- Description of Plant or Process
- Details of Ozone System and Application
- Case Study Information
  - Cost savings / Return on Investment (ROI)
  - Shelf-life extension
  - Reduction in spoilage
  - Improvement in product
  - Other synergies/additional benefits
  
- Employee Health & Safety Issues
- Submitter—Job title – contact details
- Reference – original article(s), if applicable

The Task Force also believes that one of the very best examples of a User Success Report is one wherein the User has found cost benefits from installing a system based on ozone. If ozone can produce a higher quality product or simplified treatment process, with increased shelf-life, and has provided cost benefits, that surely represents a true User Success.

In practice, whenever a proposed User Success Report is submitted to the Task Force for posting on this web site, a systematic evaluation/review procedure is followed. Selected members of the Task Force review the submission and compare the content to the criteria listed above. If all criteria are met, the submission is circulated to Task Force members for review and comment. Upon receipt of these comments, the document is revised and returned to the submitter for review, comment and approval. The cycle repeats until the Task Force and the submitter agree, and the document then is approved for posting on this web site.

### **CASE STUDY EXAMPLES OF AGRICULTURAL AND FOOD PRODUCTS OR PROCESSING OR PLANT TREATMENT WITH OZONE**

Please review the following USRs and contact the IOA at [info@io3a.org](mailto:info@io3a.org) with any questions or comments

- **GARLIC PROCESSING PLANT – SPRAY BAR RINSE SYSTEM**
- **MIDWESTERN FOOD PROCESSING PLANT CHILLER WATER TREATMENT FOR REUSE**
- **BULK STORAGE AND CURING OF HARVESTED ONIONS**
- **STORAGE OF POTATOES – Potato Grower (#1)**
- **STORAGE OF POTATOES – Walker Farms, Menan, Idaho**
- **OZONE FOR TREATMENT AND STORAGE OF GRAIN**

Other Case Studies of treating agricultural or food products, processing or processing plants with ozone are under review and will be posted on this web site as they are approved.

### **REFERENCES**

STEFFEN, H., 2005a, New PhytO3 Tech Crop Protection Technology for Controlling Harmful Microorganisms and Insects By Means of Ozonated Water, Dipole-Electrical Air-Jet Spray Technology and UV-C Radiation, in Proc. Ozone IV, Fresno, CA, March, paper ID No. 4zb2.

STEFFEN, H., 2005b, New PhytO3 Tech Crop Protection Technology for Controlling Harmful Microorganisms and Insects By Means of Ozonated Water, Dipole-Electrical Air-Jet Spray Technology and UV-C Radiation, in Proc. Intl. Ozone Assoc, EA3 Group, 17<sup>th</sup> Ozone World Congress, Strasbourg, France, Aug., paper ID No. WS-2.4.

RICE, R.G. and STEFFEN, H., The PhytO3 Tech Crop Protection Technology for Microorganism and Insect Control Using Ozone, UV, and Dipole-Electrical Air Jet Spray Technologies – Technical Basis and Chemistries Involved, in Proc. IOA/PAG Meeting, Oct. 2005, Lanier Islands, GA.

# IOA/PAG AGRI-FOOD TASK FORCE

## *USER SUCCESS REPORT*

**TITLE: GARLIC PROCESSING PLANT – SPRAY BAR RINSE SYSTEM**

**ABSTRACT:**

A garlic processor used to spray clove garlicks with solutions of sodium hypochlorite by means of a spray bar. Numerous maintenance problems were encountered with hypochlorite, including pitting of the stainless steel rollers, and the high total dissolved solids plugged the spray bar holes, corroding the feed pump and plumbing. Finally, sodium hypochlorite was leaving a residual in the wastewater pond, which is located directly over a source water aquifer. Granular activated carbon (GAC) scrubbing of air was required, to remove and destroy odors from 100-125 ppm sodium hypochlorite solutions. Also, sodium hypochlorite reacts with organics, causing a strong ammonia odor, and has the potential for imparting a hypochlorite (or reaction product) residual on the plant product.

Replacement of the hypochlorite system by an ozone/water system eliminated the maintenance costs of hypochlorite, eliminated pitting and corrosion of equipment, eliminated the need for GAC scrubbing of odors, and lowered processing costs significantly. Other applications for aqueous ozone are being investigated at this plant as a result.

### **A. DESCRIPTION OF THE PROBLEM**

The company serves large companies as a food ingredient supplier and also serves prisons, schools, restaurant chains, etc. The plant products are whole peeled garlic, private-label garlic purées, and Jalapeño pepper products.

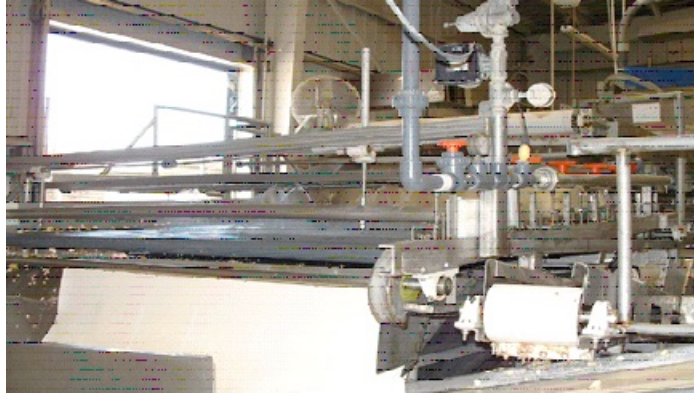
Prior to installation of the ozone system, sodium hypochlorite solution was employed to maintain cleanliness of the spray bar rinse system. For whole peeled garlic, the objectives of the hypochlorite solution were to reduce aerobic plate counts (APCs) from in the 100,000s to the 10,000s (measurable counts per mL), and to reduce levels of lactic acid (spoilage) bacteria and mold. Solutions contained 100-125 ppm of sodium hypochlorite. The hypochlorite system is still in place as back-up for the ozone system.

Sodium hypochlorite was pitting stainless steel rollers. This led to higher maintenance costs. High TDS (total dissolved solids) from sodium hypochlorite was plugging the spray bars, corroding the feed pump and plumbing, and sodium hypochlorite was leaving a residual in the wastewater pond, which is located directly over a source water aquifer.

Additionally, granular activated carbon (GAC) scrubbing of air was required, to remove and destroy odors from 100-125 ppm sodium hypochlorite solutions. Also, sodium hypochlorite

reacts with organics, causing a strong ammonia odor, and has the potential for imparting a hypochlorite (or reaction product) residual on the plant product.

The sodium hypochlorite itself cost the plant \$3,000/year. Maintenance costs for the system were \$500 - \$600/month, an additional \$6,000 - \$7,200 annually.



The spray bar rinse system.

## **B. DESCRIPTION OF PLANT OR PROCESS**

A ClearWater Tech (HDO3-II skid-mounted) ozone delivery system was installed in March, 2002 to replace the hypochlorite approach on the garlic spray bar rinse system. Ozone is applied to the rinse water in a single pass configuration at 13 gpm. A dissolved ozone residual level of 1.3 ppm is maintained, but is capable of adding and maintaining up to 5.0 ppm of dissolved ozone.

## **C. DETAILS OF OZONE SYSTEM AND APPLICATION**

The skid-mounted, pre-plumbed and pre-wired ozonation system includes the following components:



- a 20 g/h, variable output Corona Discharge ozone generator
- a 15 SCFH oxygen concentrator capable of 90%+ purity and -100°F dew point
- a 1 hp, stainless steel booster pump
- a Kynar® injector
- Back-flow prevention (J-break)
- Stainless steel contact vessel
- Contact vessel vent valve (stainless steel)
- Fully integrated dissolved ozone monitor
- Full instrumentation
- System draws 1 kW/hour

**The CWT HDO3-II skid-mounted ozonation unit.**

The plant source water comes from a deep well on the property, and is fed directly to the HDO3 system @ 20 psi. The HDO3 unit adds 1.3 ppm dissolved ozone into water, which is fed directly to the spray bar at 13gpm @ 20 psi. Spray heads were increased in size to accommodate the lower psi of the ozone system.

A 4-20 mA signal from the integrated dissolved ozone monitor controls output from the ozone generator. The system also includes a 10 gpm wash down wand and an ambient ozone monitor installed to ensure safety of workers.



Conveyor system and ambient ozone monitor (mounted on wall to the right).

## **D. CASE STUDY INFORMATION**

### **1. Attainment of Microbial Goals**

The ozone system produced an overall 20-30% reduction in aerobic plate counts (APCs) (checked twice/month). This percentage reduction is not a full log. Both hypochlorite and ozone reduce the plate count levels from about 100,000/mL to 5,000/mL. The plant's requirement is plate count results below 10,000/mL.

### **2. Equipment and Maintenance Effects**

Maintenance costs have been reduced and pitting of the stainless steel rollers has been eliminated.

Spray bar plugging (formerly caused by the high TDS of sodium hypochlorite) and corrosion has been eliminated. This saves \$500-\$600/month in materials and maintenance costs. The air scrubbing system has been shut down completely, saving approx. \$150/month in operating and maintenance costs.

Annual maintenance costs for the ozonation system are estimated at about \$450, less than the maintenance costs for one month with the former hypochlorite system.

### **3. Wastewater Effects**

Wastewater from the spray bar system now contains less than 1 ppm of sodium hypochlorite (too low to leave a residual in the wastewater pond).

### **4. Improved Product Quality**

Because of the replacement by ozone, there is no potential for hypochlorite-derived chemical residuals on the plant garlic product. Neither are ozone-derived chemical residuals known to contaminate the plant product.

### **5. Process Reliability**

The company reports more consistent sanitation results with the reduced system maintenance requirements.

### **6. Product Marketing**

With ozone treatment, it is now easier to get the plant product certified "organic" to the USDA/NOP final rule, subsection 205.605. Ozone is an allowed ingredient used in or on an organic products (garlic coming to the plant from the field).

## **7. COST SAVINGS / ROI**

Prior to installing the ozonation system, chemical costs for sodium hypochlorite totaled \$3,000 annually. Maintenance costs on the hypochlorite system were \$500-\$600 per month (average \$550/mo), and the air scrubbing system costs \$150/month to operate. These costs (\$700/mo) = \$8,400 annually (plus \$3,000 for the NaOCl = \$11,400) were eliminated when the ozonation system was installed.

The ozonation system cost \$16,500, plus \$2,500 for installation (total = \$19,000). First year savings to the plant totaled \$11,400. On this basis, the return on investment is estimated to be about 17 months.

### **E. EMPLOYEE HEALTH & SAFETY ISSUES**

Food safety is an important issue and ozone helps - both in employee safety (less chemical handling since sodium hypochlorite is no longer used) and increased food quality (reduced spoilage). By its nature, garlic processing requires a good deal of ventilation to protect the plant workers. Garlic odors react rapidly with ozone in the ambient air. Since garlic odor levels in the plant are quite high, any stray ozone is quickly quenched. Additionally, the wall-mounted ambient ozone monitor checks to ensure that ambient ozone levels, if any, are far below OSHA requirements.

### **F. ADDITIONAL COMMENTS**

The plant management is so pleased with the replacement of hypochlorite with ozone, that they plan to use the ozone system for equipment wash down and hard surface cleaning (a 10 gpm spray wand is in place). Also, ozone is being considered for spray bar rinsing in the jalapeño processing line and in garlic purée processing.

### **G. SUBMITTER – JOB TITLE – CONTACT DETAILS**

Paul Vervalle, Ozone Water Systems Inc., 5109 Diablo Drive, Sacramento, CA 95842. Ph. 916-348-8267; fax 916-348-0288, cell: 916-216-0784. [Vervalle@ozonewatersystems.com](mailto:Vervalle@ozonewatersystems.com); [www.ozonewatersystems.com](http://www.ozonewatersystems.com)

### **H. REFERENCE(S) – ARTICLE(S)**

“Garlic Processing”, powerpoint presentation, presented at Ozone II Conference, Fresno, CA, 2003, and available from ClearWater Tech LLC, 850-E Capitolio Way, San Luis Obispo, CA 93401; tel: 800-262-0203; 805-549-9724; [www.cwtozone.com](http://www.cwtozone.com)

## **I.     DISCLAIMER**

This report is based on information provided by commercial organizations and manufacturing firms that has been submitted to describe an application or applications for ozone that are based on data developed by the providers. IOA is not responsible for the accuracy of the information and data submitted.

R.G. Rice – May 16, 2006

# IOA/PAG AGRI-FOOD TASK FORCE

## *USER SUCCESS REPORT*

**TITLE: MIDWESTERN FOOD PROCESSING PLANT CHILLER WATER TREATMENT FOR REUSE**

**ABSTRACT:**

Prior to installing ozone to treat a 5,000 gallons of water in a chiller loop, the water had to be drained and the loop refilled anywhere between 1 to 7 days, due to excessive microbial contamination. Ozonation systems were installed in several of the firm's food processing plants, and the drain/refill time was extended to up to 6 months. Annual process water consumption prior to ozone treatment was an estimated 1,123,000 gallons, but that has been reduced to 72,000 gallons with ozonation. Labor costs have been lowered, along with process downtime, since ozonation was installed,

**A. DESCRIPTION OF THE PROBLEM**

Foods (bean dip, salsa, and other related products) are cooked and packaged in 5-8 lb lots in plastic bags, which then are chilled in a 5,000 gallon chilling water loop and storage tank. Microbial contamination (from slight spillage on the bags during filling and/or occasional bag breakage) caused excessive drain and refill of the chiller water, requiring the chiller system to be drained and refilled anywhere from 1 day to 1 week. An ozone system was installed to treat the chiller water in an attempt to reduce the frequency of draining and refilling the chiller water loop. The goal is to keep water in chill water loop safe from microbial contamination for a longer period of time, thus saving on water consumption, labor, and reducing process downtime.

**B. DESCRIPTION OF PLANT OR PROCESS**

The product is first cooked then packed into polyethylene bags at 180°F and sealed, then placed into a chilled water bath at 35-40°F for approximately two hours until the product has reached 60-65°F.

**C. DETAILS OF OZONE SYSTEM AND APPLICATION**

This application used the HDO3-1 system from Clearwater Tech LLC (San Luis Obispo, CA). An independent side stream loop was created so as not to interfere with the chiller and its hydraulics. 1.15 ppm of dissolved ozone is delivered to the 5000 gallon tank. System features include stainless steel construction, integrated dissolved ozone monitor, adjustable ozone output, and air-cooled, stainless steel ozone reaction chambers. The unit is skid-mounted and comes pre-plumbed and pre-wired. A process schematic diagram is included at the end of this report.

## **D. CASE STUDY INFORMATION**

The chiller water prior to installation of the ozone system could only be kept for reuse anywhere from 1 day to 1 week, depending on organic loading, primarily spillage on the outside of bags during filling, before microbial contamination caused the need to drain the 5,000 gallon tank. Annual process water consumption prior to ozone was an estimated 1,123,000 gallon. After ozone system installation, the chiller water has been kept for reuse up to 6 months in some of the company's plants, reducing the annual process water consumption to 72,000 gallons.

### **1. COST SAVINGS / ROI**

The company has installed the system in four plants total, which has resulted in a savings of 1,051,000 gallons of water annually at the four plants overall. Water savings results in cost savings of \$1,600 (total of the four plants).

As a result of the extended life of the process water, the four plants have been able to reduce maintenance costs associated with the cleaning and maintenance of the chiller water tanks. These maintenance cost savings are estimated at 9,000 annually (total of the four plants).

Total annual savings in water and maintenance at the four plants equals \$10,600.

Costs for the ozonation equipment and their installation in the four plants totaled \$70,000 (\$25,000 for plant one and \$45,000 for plants 2, 3 and 4). This results in an apparent return on investment of 6.61 years.

However the local city water department offers grant funds for companies that are able to implement systems to reduce water usage. The city water department is monitoring water savings as a result of ozone system implementation, and projects that the company will receive an \$11,000 grant to offset the cost of ozonation system installation.

The \$11,000 grant thus would reduce the R-O-I from 6.61 years to 5.57 years.

## **E. EMPLOYEE HEALTH & SAFETY ISSUES**

The only concern was that the chilling water tank was directly in the middle of the cookers. Employees work 360° around the tank, so off-gassing of ozone from the open top tank was a concern. The skid system provided delivers the ozone completely dissolved in the chilled water. Because of this, and the cold water temperature (35-40°F), and the fact that employees are about 10-20 feet from the tank, no ozone can be measured in the air around the employee stations. Additionally, the plant air contains odors of cut onions and garlic, which quickly react with ambient ozone.

## F. ADDITIONAL COMMENTS

The newest of the four company processing plants uses the HDO3-II ozone system from ClearWater Tech, and has two 10,000 gallon chilling tanks.

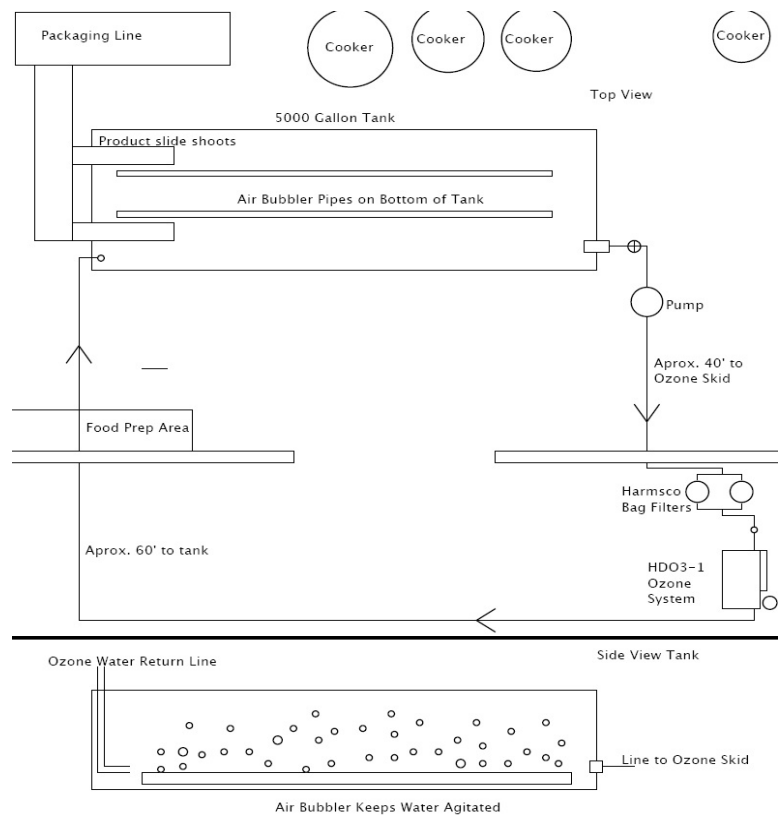
## G. SUBMITTER – JOB TITLE – CONTACT DETAILS

Submitter: John Dittberner  
Job Title: Factory Representative, ClearWater Tech. LLC, San Luis Obispo, CA  
Contact Details: cell: 402-740-5639; fax: 402-454-3393 [jdittberner@cwtozone.com](mailto:jdittberner@cwtozone.com)

## H. REFERENCE(S) – ARTICLE(S) – AS APPROPRIATE



HDO3-1 Ozone Generation system



Schematic of chiller water treatment system

## I. DISCLAIMER

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*R.G. Rice March 23, 2006*

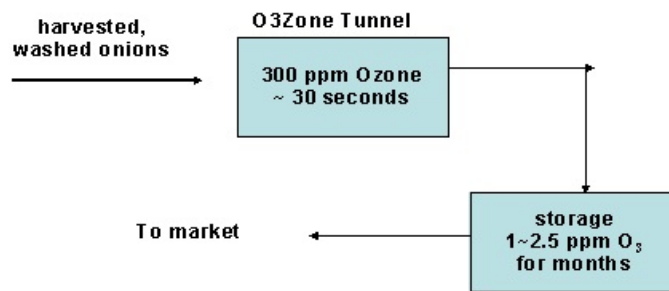
# IOA/PAG AGRI-FOOD TASK FORCE

## USER SUCCESS REPORT

**TITLE: BULK STORAGE AND CURING OF HARVESTED ONIONS – A West Coast onion grower, 2003 crop**

### ABSTRACT:

Onions were stored in ozone-containing air (1~2.5 ppm) for many months, during which time “neck rot” (a fungus-caused disease) did not spread from the few infected onions to other onions, thus extending the shelf life of the entire crop. A capital cost for ozone equipment of \$116,000 (and negligible operation cost) resulted in an additional income to the onion grower of \$166,500 for the single crop stored. The equipment is being used on subsequent crops.



Schematic diagram of gas phase ozone treatment and storage process

### A. DESCRIPTION OF THE PROBLEM

#### Situation Analysis

Onions classically have been bagged in the field and left there to cure. This method is labor-intensive, and recent approaches have been to store bagged onions in covered storage bins. Bulk storage prior to bagging could further decrease labor costs. However, bulk storage increases problems caused by storage diseases. If storage of onions in an ozone-containing atmosphere can mitigate the effects of storage diseases, considerable savings can accrue to the onion farmer.

## **Response**

At this particular West Coast onion growing facility, 240,000 bags of onions from the 2003 crop were stored in a single shed. Of these, 158,500 bags came from a single field. An estimated 30% of the 158,500 bags were contaminated with decay and neck rot (see Section F, Additional Comments) that could not be detected on the sorting table. Based on past experiences, only 20-30% of these contaminated bags would result in marketable onions, at best, but the entire stored volume of onions might have been lost had nothing been done to change the expected outcome.

Ozone was applied to the onions as they were sent into the storage shed, as well as during storage (see below). Mold (causing neck rot) growing on contaminated onions could not be stopped, but ozone treatment prevented the spread of mold to good onions. Consequently, some 60-65% of the stored crop was marketable after ozone treatment and storage.

### **B. DESCRIPTION OF PLANT OR PROCESS**

Onions are mechanically harvested, and brought to storage in bulk trucks with belt unloading. The onions are unloaded onto a machine where dirt, debris, and damaged or spoiled onions are removed. The onions then are conveyed into the storage building on conveyor belts and piled into storage. One of the conveyors (the O3Zone Tunnel – see graphic below) is provided with a cover to contain the ozone in that conveyor and allow an uneven flow of onions to pass through. The ozone is contained within the O3Zone Tunnel so that workers are not exposed to ozone. Ozone concentrations in the O3Zone conveyor Tunnel are maintained above 300 ppm.



The graphic shows the Tunnel mounted on a conveyor. The vertical pipe is for excess ozone discharge when ozone is sensed downstream. Excess ozone is discharged into the air, until the concentration of ozone drops to a safe level in the vicinity of workers. The discharge runs only on rare occasion, and then only for a short time.

Once the onions are placed into storage, ozone then is applied through the ventilation system to maintain a low concentration of ozone (about 1~2.5 ppm) surrounding the onions throughout the storage period. The premise is to reduce significantly the pathogen population on the onions going into storage (by exposure to ca 300 ppm of ozone for 15-30 seconds) and then keep the

pathogens under control during storage with ozone at about 1~2.5 ppm. The storage ozone concentration is low so that no damage occurs to the onions, yet is high enough to keep the pathogens under control.

Temperature within the storage area is maintained within 0.5-1°F of the set point. Each storage has a large air plenum the entire length. Air is delivered from the plenum under the onions by cross tubes or ducts in the floor that have openings to allow the air to move up through the pile. About 2 cfm of air per hundred pounds of onions is provided. The onions are stored in bulk from 10 to 20 feet deep or in bins stacked 20 ft high. In either case, ventilation air is provided to control the temperature and gas buildup.

### C. DETAILS OF OZONE SYSTEM AND APPLICATION

A single ozonation system, manufactured by the O3Co (Aberdeen, Idaho, USA). provides ozone for (initially) the conveyor O3Zone Tunnel (patent applied for) during transfer of onions into storage, and (later) for treating the storage atmosphere. Ozone is prepared from ambient air dried to -65°F dew point, and is produced at concentrations of about 1.7 % by weight. Application is controlled and modified in terms of grams per hour of applied ozone. In O3Co's O3Zone Tunnel, onions are exposed to ca 300 ppm of ozone for 15-30 seconds. During bulk storage, onions are exposed to about 1~2.5 ppm of ozone for months. Ozone is applied continuously during storage, but the supply is shut off for 2-3 hours every 2-3 days to allow the stored onions to be examined as desired.

### D. CASE STUDY INFORMATION

Had the contents of the storage shed not been treated with ozone and had been lost to mold growth during storage, the loss in marketable onions would have amounted to a value of about \$750,000. Had only the lot from the single field been lost to rot, the market value would have been about \$300,000. Without ozone treatment, only some 30% of the 158,000 bags (47,550 bags) of onions were expected to be marketable.

Instead, ozone treatment resulted in *an additional* 55,500 bags of onions being marketable at *an additional* income of \$166,500.

The capital cost of the O3Co Ozone Tunnel was \$116,000, including ozone generation and control equipment. Operating costs: 1 lb of ozone requires 10 to 15 kWh to produce. The O3Co ozone generating unit produces ca 3 lbs of ozone/day. At \$0.10/kwh x 15 kWh x 24 h x 3 lbs/day = \$108/day = ca \$20,000 over 6 months. The income realized from the additional 55,000 bags of onions, saved by ozone storage, was \$166,500, meaning that this extra income alone more than paid for the ozonation equipment, which is being used on subsequent crops of stored onions.

## **E. EMPLOYEE HEALTH & SAFETY ISSUES**

### **SAFETY FEATURES OF THE O3Co O3ZONE TUNNEL**

The O3Zone Tunnel is a patent-pending process by O3Co. The Tunnel is fitted to the customer's portable conveyor, 30, 36 or 42 inches wide. O3Co furnishes a cover composed of sections that are clamped on the conveyor and sealed with foam sealing strips and the joints are caulked. The ozone is contained in the Tunnel by means of an air lock system on each end of the tunnel composed of two sets of special brushes spaced 18 inches apart. The brushes are free to follow the irregular shape of the top of the produce on the conveyor. Ozone that leaks past the first set of brushes is trapped between the two sets of brushes. A slight vacuum is maintained between the brush sets on the discharge end by the off-gas blower. The off-gas blower system removes any ozone that leaks past the first set of brushes and discharges it either into the storage air plenum then into the onion pile, or away from any people.

Ozone sometimes is carried out of the air lock between the produce, and the ozone concentration downstream near the conveyors may reach or exceed the maximum recommended OSHA workplace concentration of 0.10 ppm. An ozone sensor is placed downstream so it will sense and signal when ozone has reached concentrations above the OSHA safe standard where people are working. When this condition occurs, a blower on the discharge end is turned on and remains on until the ozone concentration has dropped below the OSHA recommended maximum level.

The ozone concentration is monitored in the Tunnel, and when the concentration reaches a set point slightly above the desired operating concentration, the CT2000 controller begins shutting down ozone generating chambers. The automatic shutdown continues until the ozone concentration drops to the selected operating concentration or all chambers are off. When the ozone concentration drops below the lower set point, all chambers are turned back on.

Each O3 Zone Tunnel system is supplied with a hand-held ozone monitor so that the ozone concentrations can be monitored where people work. Corrective action can be taken to ensure that safe ozone concentrations exist where people work. The only location on an O3Zone Tunnel system where ozone concentrations have been observed above the OSHA safe concentration of 0.10 ppm is immediately after the discharge from the tunnel. Ozone concentrations above 0.10 ppm have never been observed beyond 20 feet of the tunnel discharge.

In the event that ozone concentrations above 0.10 ppm are observed in the storage building, an exhaust ventilation fan can be turned on for a short time to clear the ozone from the storage where people may be working.

The electrical power to the ozone generator can be turned off in an emergency with the main disconnect outside the trailer in the unlikely event that large concentrations of ozone occur.

A portable ozone monitor (Porta Sense) is supplied with each system. It is recommended that ozone concentrations be monitored in areas where people are working. If the ozone

concentration becomes higher than the maximum OSHA safe level of 0.10 ppm, corrective action should be taken: 1) Move the people to a work station where ozone concentrations are safe; 2) place fans so the ozone can be blown away from the line workers; 3) under extreme conditions, shut off the ozone generator.

#### **F. ADDITIONAL COMMENTS**

Neck Rot is a fungus-caused disease that spreads quickly from onion to onion, regardless of whether the onions are stored in boxes, bags or piled atop each other. Prior to adopting ozone, onions surrounding a source onion (infected with neck rot) would become soft and rotten. After applying ozone, the source onions, infected in the field, remain unfit for consumption during storage. However, the onions surrounding a source onion are not infected with neck rot.

#### **G. SUBMITTER – JOB TITLE – CONTACT DETAILS**

Lynn Johnson, President, O3Co. [lynn@o3co.com](mailto:lynn@o3co.com). Mr. Johnson is the designer of the O3Zone Tunnel, and provides technical support for customers. He is an engineer by training.

#### **H. REFERENCE(S) – ARTICLE(S) – AS APPROPRIATE**

[www.O3Co.com](http://www.O3Co.com);

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R.G. Rice - March 23, 2006

## IOA/PAG AGRI-FOOD TASK FORCE

### USER SUCCESS REPORT

**TITLE: STORAGE OF POTATOES – Potato Grower (#1), Idaho Falls, Idaho, USA  
– 2003 Crop**

#### **ABSTRACT:**

Potatoes are harvested, then a large percentage of the crop is stored for future sales. Many harvested potatoes are infected with *Phytophthora erythroseptica*, or “Pink Rot”, a fungus-causing disease that spreads rapidly to uninfected potatoes, and these cannot be sold. Storage of harvested potatoes under gaseous ozone does not cure Pink Rot on infected potatoes, but does prevent the spread of the infectious disease to other potatoes. This farmer purchased a novel ozone treatment system to treat his 2003 potato crop, thereby saving much of his harvest from Pink Rot, and returning a financial benefit of \$240,000 for that single year. The ozone equipment, which cost \$116,000, is being used to increase the marketable output of subsequent potato crops by this farmer.

#### **A. DESCRIPTION OF THE PROBLEM**

In 2003, this farmer had infestations of *Phytophthora erythroseptica*, or “Pink Rot”, a fungus-causing disease that spreads rapidly to uninfected potatoes, and Pythium in one field of his potatoes. The potatoes were sampled going into storage and the percentage of infected potatoes ranged between 11% and 15%. When the percentage of field-infected potatoes is greater than 5% to 7% it is generally accepted that the infection is too high and potatoes will not store more than 45 to 90 days and they probably could not be sold into the fresh market. The farmer had crop insurance on the potatoes and the claim was settled.. He was given the opportunity to extend the storage and keep anything above the amount of the insurance settlement.

Harvested potatoes (80,000 cwt) were run through the O3Co Tunnel and put into storage 1<sup>st</sup> of October and the maintenance ozone dosage was doubled. The potatoes were carefully monitored and were sold in July. Samples were taken as the potatoes were removed from storage and the percentage of rot was found to be the same as when placed into storage. The use of ozone thus resulted in no increase in rot during storage.

The difference in the July price and the insurance settlement was \$3.00/cwt. This means that ozone storage resulted in a return of \$240,000 above the insurance settlement.

#### **B. DESCRIPTION OF PLANT OR PROCESS**

Potatoes are mechanically harvested, and brought to storage in bulk trucks with belt unloading. The potatoes are unloaded onto a machine where dirt, debris, and damaged or spoiled potatoes

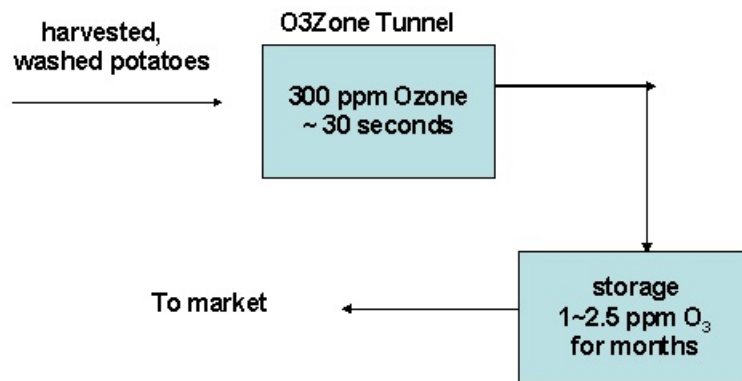
are removed. The potatoes then are conveyed into the storage building on conveyor belts and piled into storage. One of the conveyors (the O3Zone Tunnel) is provided with a cover to contain the ozone in that conveyor and allow an uneven flow of potatoes to pass through. The ozone is contained within the O3Zone Tunnel so that workers are not exposed to ozone. Ozone concentrations in the O3Zone conveyor Tunnel are maintained above 300 ppm.



The O3Co O3Zone Tunnel

The graphic above shows the Tunnel mounted on a conveyor. The vertical pipe is for excess ozone discharge when ozone is sensed downstream. Excess ozone is discharged into the air, until the concentration of ozone drops to a safe level in the vicinity of workers. The discharge runs only on rare occasion, and then only for a short time.

Once the potatoes are placed into storage, ozone then is applied through the ventilation system to maintain a low concentration of ozone (about 1 ppm) surrounding the potatoes throughout the storage period. The premise is to reduce significantly the pathogen population on the potatoes going into storage (by exposure to ca 300 ppm of ozone for 15-30 seconds) and then keep the pathogens under control during storage with ozone at about 1 ppm. The storage ozone concentration is low so that no damage occurs to the potatoes, yet is high enough to keep the pathogens under control. A schematic diagram of the overall process is shown below.



**Schematic diagram of gas phase ozone treatment and storage process**

## **DETAILS OF OZONE SYSTEM AND APPLICATION**

A single ozonation system, manufactured by the O3Co (Aberdeen, Idaho, USA) provides ozone for (first) the conveyor O3Zone Tunnel during transfer of potatoes into storage, and (later) for treating the storage atmosphere. Ozone is prepared from ambient air dried to - 65°F dew point, and is produced at concentrations of about 1.7% by weight. Application is controlled and modified in terms of grams per hour of applied ozone. In O3Co's O3Zone Tunnel, potatoes are exposed to ca 300 ppm of ozone for 15-30 seconds. During bulk storage, potatoes are exposed to about 2 ppm of ozone for months. Ozone is applied continuously during storage, but the supply can be shut off for 2-3 hours every 2-3 days to allow the stored potatoes to be examined as desired.

### **D. CASE STUDY INFORMATION**

#### **1. COST SAVINGS / ROI**

Storage of potatoes for 10 months in the ozone-containing atmosphere allowed the owner to sell the potatoes in July 2004, rather than in December 2003 (when spoilage would have been projected without ozone exposure). A higher price was realized in July 2004 than would have been obtained in December 2003. The additional monies realized were \$240,000 for the 80,000 cwt of potatoes in storage.

**Capital cost** of the O3Co ozonation equipment (ozone generators plus the O3Co Tunnel and control equipment) was \$116,000. For this one crop, the return of \$240,000 paid for the \$116,000 investment in 6 months.

**Operating costs:** 1 lb of ozone requires 10 to 15 kWh to produce. The O3Co ozone generating unit produces ca 3 lbs of ozone/day. At \$0.10/kwh x 15 kWh x 24 h x 3 lbs/day = \$108/day = ca \$54,000 over 10 months

## **2. SHELF LIFE EXTENSION**

For this crop of potatoes, put into storage on October 1, 2003, the expected shelf-life was 10 weeks (to Dec. 15, 2003) if ozone had not been used. With ozone treatment during storage, the shelf-life of the potatoes increased at least until July, 2004 (10 months).

## **3. REDUCTION IN SPOILAGE**

Storage in an ozone-containing atmosphere stopped the spread of Pink rot. The percentage rot (11%-15%) was the same at the end of 10 months storage as when the potatoes entered storage.

## **4. IMPROVEMENT IN PRODUCT QUALITY**

Not applicable.

## **5. OTHER SYNERGIES / ADDITIONAL BENEFITS**

Not applicable.

## **E. EMPLOYEE HEALTH & SAFETY ISSUES**

### **SAFETY FEATURES OF THE O3ZONE TUNNEL**

The O3Zone Tunnel is a patent-pending process by O3Co. It is fitted to the customer's portable conveyor, 30," 36" or 42." O3 Co furnishes a cover composed of sections that are clamped on the conveyor and sealed with foam sealing strips and the joints are caulked. The ozone is contained in the Tunnel by means of an air lock system on each end of the tunnel composed of two sets of special brushes spaced 18" apart. The brushes are free to follow the irregular shape of the top of the produce on the conveyor. Ozone that leaks passed the first set of brushes is trapped between the two sets of brushes. A slight vacuum is maintained between the brush sets on the discharge end by the off-gas blower. The off-gas blower system removes any ozone that leaks past the first set of brushes and discharges it either into the storage air plenum then into the potatoe pile, or away from any people.

Ozone sometimes is carried out of the air lock between the produce, and the ozone concentration downstream near the conveyors may reach or exceed the maximum recommended OSHA workplace concentration of 0.10 ppm. An ozone sensor is placed downstream so it will sense

and signal when ozone has reached concentrations above the OSHA safe standard where people are working. When this condition occurs, a blower on the discharge end is turned on and remains on until the ozone concentration has dropped below the OSHA recommended level.

The ozone concentration is monitored in the Tunnel, and when the concentration reaches a set point slightly above the desired operating concentration, the CT2000 controller begins shutting down ozone generating chambers. The automatic shutdown continues until the ozone concentration drops to the selected operating concentration or all chambers are off. When the ozone concentration drops below the lower set point, all chambers are turned back on.

Each O3 Zone Tunnel system is supplied with a hand held ozone monitor so that the ozone concentrations can be monitored where people work. Corrective action can be taken that will ensure safe ozone concentrations exist where people work. The only location on an O3Zone Tunnel system where ozone concentrations have been observed above the OSHA safe concentration of 0.10 ppm is immediately after the discharge from the tunnel. Ozone concentrations above 0.10 ppm have never been observed beyond 20 feet of the tunnel discharge.

In the event ozone concentrations above 0.10 ppm are observed in the storage building, an exhaust ventilation fan can be turned on for a short time to clear the ozone from the storage where people are working.

The electrical power to the ozone generator can be turned off in an emergency with the main disconnect outside the trailer in the unlikely event that large concentrations of ozone occur.

A portable ozone monitor (Porta Sense) is supplied with each system. It is recommended that ozone concentrations be monitored in areas where people are working. If the ozone concentration becomes higher than the maximum OSHA safe level of 0.10 ppm, corrective action should be taken: 1) Move the people to a work station where ozone concentrations are safe; 2) place fans so the ozone can be blown away from the people; 3) under extreme conditions, shut off the ozone generator.

**F. ADDITIONAL COMMENTS**

**G. SUBMITTER – JOB TITLE – CONTACT DETAILS**

Lynn Johnson, President, O3Co, Aberdeen, ID. [lynn@o3co.com](mailto:lynn@o3co.com) Mr. Johnson is the designer of the O3Zone Tunnel, and provides technical support for customers. He is an engineer by training.

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R.G. Rice – March 23, 2006

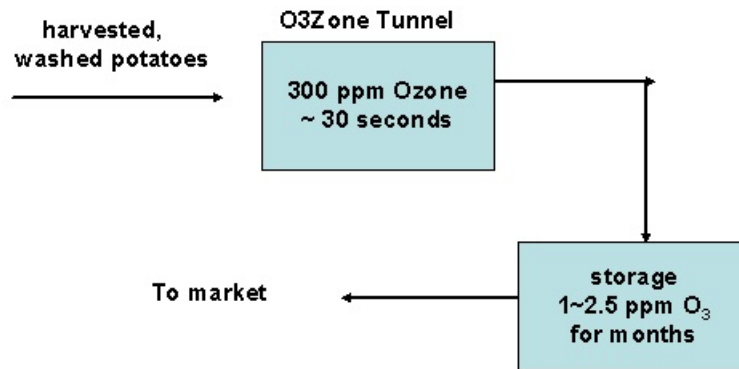
# IOA/PAG AGRI-FOOD TASK FORCE

## USER SUCCESS REPORT

**TITLE: STORAGE OF POTATOES – Walker Farms, Menan, Idaho, 2002 Crop**

**ABSTRACT:**

Potatoes are harvested, then a large percentage of the crop is stored for future sales. Many harvested potatoes are infected with *Phytophthora erythroseptica*, or “Pink Rot”, a fungus-causing disease that spreads rapidly to uninfected potatoes, and these cannot be sold. Storage of harvested potatoes under gaseous ozone does not cure Pink Rot on infected potatoes, but does prevent the spread of the infectious disease to other potatoes. This farmer purchased a novel ozone treatment system to treat his 2002 potato crop, thereby saving much of his harvest from Pink Rot, and returning a financial benefit of \$306,000 for that single year. The ozone equipment, which cost \$116,000, is being used to increase the marketable output of subsequent potato crops by this farmer.



**Schematic diagram of gas phase ozone treatment and storage process**

## **A. DESCRIPTION OF THE PROBLEM**

Walker Farms grows over 6,000 acres of potatoes each year. In 2002 Walker Farms produced 160 acres, about 80,000 cwt, of potatoes with over five percent of these potatoes infected with *Phytophthora erythroseptica*, or “Pink Rot”. Upon placing an initial 8,000 cwt of potatoes into the cellar, Walker Farms determined that the entire 80,000 cwt would not store. Due to the significant amount of Pink Rot, Walker Farms felt the risk of losing the entire field was too high; therefore, the decision was made to not harvest the infected potatoes and to move on to the next field.

Upon completing the harvest of this 2002 crop, Walker Farms returned to the infected field and harvested the remaining potatoes that were filled with Pink Rot. They placed these potatoes in a separate cellar and ran the potatoes through O3Co’s O3Zone Tunnel. Ozone then was applied to these potatoes stored within the cellar. No ozone was applied to the original 8,000 cwt of potatoes.

The potatoes were harvested the last week of September 2002. By mid-November, the first potatoes, not put through the O3 Co’s O3Zone Tunnel, were rotted to the point that they had to be abandoned, as expected. These potatoes were hauled to the dump for disposal.

The remaining potatoes that were put through the Tunnel and stored with ozone did not show any signs of the Pink Rot spreading among the potatoes. The original Pink Rot of five percent was still present; however, none of the other potatoes had become infected. In April and May of 2003 these potatoes were sold in the normal marketing order. Ozone had extended the storage life of these potatoes and created a financial gain for Walker Farms.

There were 72,000 cwt of potatoes that were sold for \$4.00/cwt. If they had been abandoned, the infected crop would have cost approximately \$.25/cwt to haul them out and dispose. The ozone treatment returned a financial benefit worth \$306,000.

## **B. DESCRIPTION OF PLANT OR PROCESS**

Potatoes are mechanically harvested, and brought to storage in bulk trucks with belt unloading. The potatoes are unloaded onto a machine where dirt, debris, and damaged or spoiled potatoes are removed. The potatoes then are conveyed into the storage building on conveyor belts and piled into storage. One of the conveyors (the O3Zone Tunnel – see graphic below) is provided with a cover to contain the ozone in that conveyor and allow an uneven flow of potatoes to pass through. The ozone is contained within the O3Zone Tunnel so that workers are not exposed to ozone. Ozone concentrations in the O3Zone conveyor Tunnel are maintained above 300 ppm.

The graphic shows the Tunnel mounted on a conveyor. The vertical pipe is for excess ozone discharge when ozone is sensed downstream. Excess ozone is discharged into the air, until the concentration of ozone drops to a safe level in the vicinity of workers. The discharge runs only on rare occasion, and then only for a short time.

Once the potatoes are placed into storage, ozone is applied through the ventilation system to maintain a low concentration of ozone (about 1~2.5 ppm) surrounding the potatoes throughout the storage period. The premise is to reduce significantly the rot-causing bacteria or fungus population on the potatoes going into storage (by exposure to ca 300 ppm of ozone for 15-30 seconds) and then keep the microorganism levels under control during storage with ozone at about 1~2.5 ppm. The storage ozone concentration is low so that no damage occurs to the potatoes, yet is high enough to keep the pathogens under control. A process schematic diagram is shown in the figure in the Abstract.



The O3Co O3Zone Tunnel

### **C. DETAILS OF OZONE SYSTEM AND APPLICATION**

A single ozonation system, manufactured by the O3Co (Aberdeen, Idaho, USA) provides ozone for (1) the conveyor O3Zone Tunnel during transfer of potatoes into storage, and (2) for later treating the storage atmosphere. Ozone is prepared from ambient air dried to - 65°F dew point, and is produced at concentrations of about 1.7 % by weight. Application is controlled and modified in terms of grams per hour of applied ozone. In O3Co's O3Zone Tunnel, potatoes are exposed to ca 300 ppm of ozone for 15-30 seconds. During bulk storage, potatoes are exposed to about 1~2.5 ppm of ozone for months. Ozone is applied continuously during storage, but the supply can be shut off for 2-3 hours every 2-3 days to allow the stored potatoes to be examined as desired.

### **D. CASE STUDY INFORMATION**

#### **1. COST SAVINGS / ROI**

There was 72,000 cwt of potatoes that were sold for \$4.00/cwt (\$288,000). If they had been abandoned it would have cost about \$0.25/cwt to haul them out and dispose (\$18,000). The ozone treatment, therefore, was worth \$306,000 (\$288,000 + \$18,000).

Capital cost for the O3Co ozonation equipment and Tunnel, including control equipment, was \$116,000. This means that the ozone equipment and Tunnel was paid for in about four months.

Operating costs: 1 lb of ozone requires 10 to 15 kWh to produce. The O3Co ozone generating unit produces ca 3 lbs of ozone/day. At \$0.10/kwh x 15 kWh x 24 h x 3 lbs/day = \$108/day = ca \$27,000 over 8 months

## **2. SHELF LIFE EXTENSION**

Potatoes were stored 8 months with ozone treatment. Without ozone treatment, this crop was not deemed worth storing, due to Pink Rot infection.

## **3. REDUCTION IN SPOILAGE**

Without ozone treatment, this crop was not deemed worth storing, due to Pink Rot infection.

## **4. IMPROVEMENT IN PRODUCT QUALITY**

Quality of the potatoes not infected by Pink Rot initially was maintained over the 8 months of ozone storage.

## **E. EMPLOYEE HEALTH & SAFETY ISSUES**

### **SAFETY FEATURES OF THE O3ZONE TUNNEL**

The O3Zone Tunnel is a patent-pending process by O3Co. It is fitted to the customer's portable conveyor, 30, 36 or 42 inches. O3Co furnishes a cover composed of sections that are clamped on the conveyor and sealed with foam sealing strips and the joints are caulked. The ozone is contained in the Tunnel by means of an air lock system on each end of the Tunnel composed of two sets of special brushes spaced 18 inches apart. The brushes are free to follow the irregular shape of the top of the produce on the conveyor. Ozone that leaks past the first set of brushes is trapped between the two sets of brushes. A slight vacuum is maintained between the brush sets on the discharge end by the off-gas blower. The off-gas blower system removes any ozone that leaks past the first set of brushes and discharges it either into the storage air plenum then into the potato pile, or away from any people.

Ozone sometimes is carried out of the air lock between the produce, and the ozone concentration downstream near the conveyors may reach or exceed the maximum recommended OSHA workplace concentration of 0.10 ppm. An ozone sensor is placed downstream so it will sense and signal when ozone has reached concentrations above the OSHA safe standard where people are working. When this condition occurs, a blower on the discharge end is turned on and remains on until the ozone concentration has dropped below the OSHA recommended level.

The ozone concentration is monitored in the Tunnel, and when the concentration reaches a set point slightly above the desired operating concentration, the CT2000 controller begins shutting

down ozone generating chambers. The automatic shutdown continues until the ozone concentration drops to the selected operating concentration or all chambers are off. When the ozone concentration drops below the lower set point, all chambers are turned back on.

Each O3 Zone Tunnel system is supplied with a hand-held ozone monitor so that the ozone concentrations can be monitored where people work. Corrective action can be taken that will ensure safe ozone concentrations exist where people work. The only location on an O3Zone Tunnel system where ozone concentrations have been observed above the OSHA safe concentration of 0.10 ppm is immediately after the discharge from the tunnel. Ozone concentrations above 0.10 ppm have never been observed beyond 20 feet of the tunnel discharge.

In the event that ozone concentrations above 0.10 ppm are observed in the storage building, an exhaust ventilation fan can be turned on for a short time to clear the ozone from the storage where people are working.

The electrical power to the ozone generator can be turned off in an emergency with the main disconnect outside the trailer in the unlikely event that large concentrations of ozone occur.

A portable ozone monitor (Porta Sense) is supplied with each system. It is recommended that ozone concentrations be monitored in areas where people are working. If the ozone concentration becomes higher than the maximum OSHA safe level of 0.10 ppm, corrective action should be taken: 1) Move the people to a work station where ozone concentrations are safe; 2) place fans so the ozone can be blown away from the line workers; 3) under extreme conditions, shut off the ozone generator.

**F. ADDITIONAL COMMENTS**

**G. SUBMITTER – JOB TITLE – CONTACT DETAILS**

Lynn Johnson, President, O3Co, Aberdeen, ID. [lynn@o3co.com](mailto:lynn@o3co.com) Mr. Johnson is the designer of the O3Zone Tunnel, and provides technical support for customers. He is an engineer by training.

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R.G. Rice – March 23, 2006

# IOA/PAG AGRI-FOOD TASK FORCE

## *USER SUCCESS REPORT*

**TITLE: OZONE FOR TREATMENT AND STORAGE OF GRAIN – Harvest States Amber Milling, Huron, OH, USA**

### **ABSTRACT:**

Mold and bacteria in grain traditionally are addressed by the use of chlorinated water. However, this technique frequently is inadequate for removing these harmful materials allowing tempering bins, holding containers, and processing lines to become contaminated and have to be cleaned. This requires complete shutdown of the plant and results in production and financial losses. Elevated bacterial and mold counts sometimes cause final products to fail to meet client microbial standards. Returned shipments can cost up to \$5,000 per rail car plus reprocessing costs. Chlorine also causes corrosion in metal parts in the mixing and grain transfer equipment and is a hazardous chemical to store and handle. Furthermore, chlorine chemically reacts with some materials and organics, and the resulting chlorinated compounds sometimes remain in the final product as contaminants. A project sponsored by the Electric Power Research Institute (EPRI) at Harvest States Amber Milling demonstrated that ozone and ultraviolet radiation overcame the problems encountered with chlorine use, and resulted in significant cost savings to the plant as well.

### **A. DESCRIPTION OF THE PROBLEM**

Grain is produced by plants growing in open fields and, as such, arrives at a processing mill carrying some foreign matter in addition to plant leaves, dust, and stalks. The milling process separates the grain from the other material and grinds it into flour. Chlorinated water normally is used to control bacteria and mold during the process.

Milling begins with the grain being mechanically separated from stalks and foreign matter. The next step is to increase the moisture content of the grain. This is necessary because hard wheat is too dry to grind into flour. Consequently, water is added to bring the grain's moisture content up from about 12 percent to approximately 15 percent (this latter number varies within the industry). Moisturizing is accomplished via automated temper systems, which are large augers that mix and move the grain while a carefully regulated stream of water is added. The test plant had three augured temper systems.

Chlorine is added to the water to control bacteria and mold which typically are present in the grain. At the test plant, chlorinated water (450 ppm) is applied at a flow rate of four gallons per minute in each temper system, or a total of 12 GPM for the three units together. The temper systems convey the moistened grain into large concrete tempering tanks or bins, which are approximately 45 feet high and 8 feet in diameter. The grain flows continuously, and residence

time in the bins is approximately 18 to 24 hours, which allows the water to be absorbed. Next the grain is conveyed through tubes to the wheat rolling mill where the grain is abraded to loosen the bran, which then is separated by sifters and air purifiers. The grinding continues until the grain reaches the proper level of fineness, at which point it is packaged or shipped in bulk.

## 1. **Problems With the Current Process**

- ***Contamination of grain prior to and during processing***  
Wheat and other grains collect dust, insects and other foreign matter – such as insects, soil, and feces – in the fields where they are grown. When the wheat is harvested, inevitably some foreign matter accompanies the grain and plant material. The grain is exposed to additional contamination from bacteria and foreign material through transportation vehicles, storage containers, fertilizers, rain, and moisture in the air. The result is a potentially high level of bacteria and mold on the preprocessed grain surfaces. Further exacerbating the problem is the necessary addition of water to the grain to increase its moisture content, creating warm, moist tempering conditions prior to milling. This moist grain supports growth of mold and bacteria. It is to combat these inherent problems of contamination that grain processors treat the grain with chlorinated water during the tempering process when water is added to the grain to increase its moisture content.
- ***Effectiveness of chlorine treatment***  
Although problems of mold and bacteria in grain traditionally are addressed by the use of chlorinated water, this technique frequently is inadequate for removing these harmful materials. As a result, tempering bins, holding containers, and processing lines become contaminated and have to be cleaned. This requires complete shutdown of the plant and results in production and financial losses.
- ***Returned shipments***  
In addition, elevated bacterial and mold counts sometimes cause final products to fail to meet client microbial standards. Returned shipments can cost up to \$5,000 per rail car plus reprocessing costs.
- ***Other problems***  
Chlorine is a reactive chemical and causes corrosion in metal parts in the mixing and grain transfer equipment. In addition it is a hazardous chemical to store and handle. Furthermore, chlorine chemically reacts with some materials and organics, and the resulting chlorinated compounds sometimes remain in the final product as contaminants. Some of these compounds, trihalomethanes (THMs) have suspected carcinogenic properties.

This project, supported by the Electric Power Research Institute (EPRI), showed that the combination of ozone (generated by UV radiation) plus UV radiation is an economical replacement for chlorinated water currently used for bacteria and mold control in this wheat processing plant.

## B. DESCRIPTION OF PLANT OR PROCESS

The project was installed at the Harvest States Amber Milling plant in Huron, OH, USA, and was designed to test the effectiveness of ozone (generated by corona discharge and by UV radiation at 185 nm and applied simultaneously with UV radiation at 254 nm) as an antimicrobial agent for flour milling. Ozone was used in three ways in the project:

- in steeping water applied to wheat during the flour milling process (CD-generated ozone)
- in gaseous phase in conjunction with UV light and hydroxyl radicals during tempering (Figure 1)
- in gaseous phase as a facility-cleaning agent for further bacteria and mold control.

A plant survey and evaluation of the existing process was made in 1999. The project began early in 2000 with process design, equipment specification, and installation performed by RGF Industries (West Palm Beach, FL, USA). Testing of the ozonation process began in May 2000 and was continuing at the time of this detailed report (Chester et al., 2000).

Figure 1. UV hood in grain plant in combination with UV/ozone system. Left side = closed; right side = open (courtesy of RGF Industries). Note the UV bulbs in the open cover (right side).



## C. DETAILS OF OZONE SYSTEM AND APPLICATION

The treatment system used in the study consisted of ozone (generated by corona discharge, absent UV radiation) treatment supplemented by “photo-ionization” (a term coined by RGF Industries), delivering both ultraviolet light and ozone to create hydroxyl radicals for the control

of microorganisms, mold, and yeast on the wheat grain and the processing equipment. The system has three major components:

- A skid-mounted corona-discharge ozonation system with a dry air feed to dissolve ozone in the water used to temper the grain.

This system is placed adjacent to the existing water tank. It is sized to provide sufficient ozone for 12 to 15 GPM – 4 GPM for each of the three temper systems, even though it was used to supply only one tempering auger during this study. The major components of the system include a corona discharge ozone generator with pressure swing adsorption air drying system, venturi mixer, chlorine destruction filter, ozone destruction for ozone off-gas, recirculating stainless steel pump/motor assembly, and pressurized contact vessel. An integrated dual metering system is used to measure and control the levels of dissolved ozone in the water and to measure and control the levels of ozone present in the ambient air.

- A stainless steel photo-ionization chamber mounted over the grain-mixing auger to supply UV light and UV-generated ozone (Figure 1).

The purpose of this combined system (as stated by RGF Industries) is to create hydroxyl radicals to attack the surface of the grain. The ionization hood consists of a series of UV/ozone emitters shrouded for protection in an FDA-approved plasticized shroud targeted on titanium dioxide (TiO<sub>2</sub>). The hoods are hinge-mounted to the top of the existing temper augers and employ a safety system to automatically shut down the UV lamps if the hood is opened by plant personnel.

- An ozone generator to supply gaseous ozone in elevated concentrations to the grain storage tempering bin and the roll bin to suppress bacteria and mold growth.

A dried air-fed corona discharge system generates the ozone gas and delivers it to the application points via Teflon tubing. It too is accompanied by a dual metering system to monitor ozone levels in the bin as well as in ambient air surrounding the bins.

### **Evaluation and Data Gathering**

To determine the effectiveness of ozone treatment, more than 1,000 samples of flour ready for shipment were evaluated. These samples were tested for total plate count bacteria. To establish a base of comparison, 365 of the samples were taken from flour processed using traditional chlorinated water disinfection. The remaining 650 samples were taken from flour processed using ozone disinfection. Figure 2 summarizes the many data points obtained during this study.

Because the Harvest States plant does not perform mold counts, visual inspections were used to determine the effectiveness of ozone for mold control in comparison to chlorinated water. In addition to microbial analysis and mold estimation, the study evaluated operation of the plant using ozone water *versus* chlorinated water.

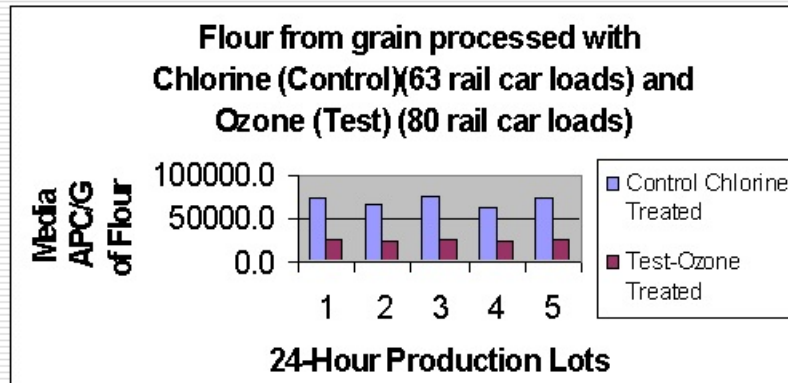


Figure 2. Summary of test data from grain mill study (Chester et al., 2000).

#### D. CASE STUDY INFORMATION

##### 1. RESULTS -- ANTIMICROBIAL ACTION

Data gathered during the project indicate a potential 75 to 80 percent reduction in total plate count bacteria in comparison to conventional treatment with chlorinated water. The anaerobic plate count (APC) of one group of flour samples from grain treated with chlorinated water averages 181,675 cfu/g. In comparison, the average APC for flour from ozone-treated grain was 42,627 cfu/g, a reduction of 77 percent. Later data on 195 samples of flour processed during late July and August had 75 lots (38%) with APC of less than 10,000 cfu per gram.

Although, the project did not include mold counts to quantify the effectiveness of ozone over chlorine in mold abatement, visual inspection of equipment and lines by plant staff indicated a similar reduction of mold growth in the equipment.

##### 2. COST SAVINGS / ROI

According to RGF, the company supplying ozonation and UV equipment for the project, there is a cost savings of about \$40,000 per year by using ozonation and UV in place of chlorination. (Electrical costs to operate the ozone system are \$0.18 per hour or approximately \$1,600 per year.) ***This rate of savings would pay out the capital investment in the ozonation and UV equipment in 30 months.*** This analysis does not include potential additional savings from some reduction in maintenance and plant downtime previously needed to remove mold from lines and equipment, and costs for reprocessing grain failing to meet microbial standards.

## **E. EMPLOYEE HEALTH & SAFETY ISSUES**

The hoods are hinge-mounted to the top of the existing temper augers and employ a safety system to automatically shut down the UV lamps if the hood is opened by plant personnel, thus avoiding inadvertent exposure of plant personnel to ultraviolet radiation.

The levels of ozone in the work place at the points of application are monitored by ambient ozone monitors designed to effect complete system shutdown if excess levels of ozone are sensed.

## **F. ADDITIONAL COMMENTS**

### ***Equipment Compatibility***

The ozone system is located on the top floor of the flour mill near the existing chlorine tank. The ozone gas and water plumbing go to the floor below where the grain processing and storage equipment are located. The ozonation system is completely independent of the plant chlorine system so the plant still has access to this method of sanitation.

## **G. SUBMITTER – JOB TITLE – CONTACT DETAILS**

Rip G. Rice, RICE International Consulting Enterprises, 1710 Hickory Knoll Road, Sandy Spring, MD 20860; 301-774-4493 (phone/fax); [RGRice4ozone@aol.com](mailto:RGRice4ozone@aol.com)

## **H. REFERENCE(S) – ARTICLE(S) – AS APPROPRIATE**

Chester, T., Graham, D., Schwartz, C., and Sopher, C., "Ozone and UV for Grain Milling Systems", EPRI, Palo Alto, CA, 2000. EPRI Report No. 1000591 (2000).

Rice, R.G., "Recent Studies on Ozone and UV Combinations for Food Processing Plants in the USA", paper presented at IOA/Pan American Group Annual Conference on "Advances in Ozone Technology", Newport Beach CA., May 5-9, 2001, Session 7 – Food Applications of Ozone.

## **I. DISCLAIMER**

This report is based on information provided by commercial organizations and manufacturing firms that has been submitted to describe an application or applications for ozone that are based on data developed by the providers. IOA is not responsible for the accuracy of the information and data submitted.

R.G. Rice – 1 Sept. 2006