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MANUAL

Best-practice user manual for Citrus high pressure washers

Citrus Australia

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Best-practice user manual for Citrus high pressure washers

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1 BEST-PRACTICE USER MANUAL FOR CITRUS HIGH PRESSURE WASHERS

General introduction

High-pressure washing is an effective postharvest treatment for removal of insects and external contaminants. In order to maximise the effectiveness of these washers and minimise insect interceptions, the following procedures and tests have been developed and are recommended for use to detect operational problems with high pressure washing systems.

While there are differences in the specific design of citrus washers, the methods provided here provide tools to optimise washer capability. Some of these methods may not relate specifically to each individual washer, but they highlight key areas for all washers. If these procedures and suggestions are carried out regularly, the value of the significant capital investments and running costs of HPW systems will be recognised.

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2 GENERAL OBSERVATIONS DURING OPERATION

2.1 What is this test for?

To ensure treatment is being carried out effectively by observing water pressure, fruit feed and movement, and general operation of the unit.

2.2 Why should we do this test?

Regular careful inspection of the unit can highlight issues that might reduce the effectiveness of the machine, with serious economic consequences if phytosanitary obligations are violated.

2.3 How to do this test?

Water pressure is an important factor and should be carefully monitored. While a pressure gauge is normally found at the pump outlet, it is best practice that an accurate gauge be placed on each gantry and as close to the nozzles as practical because pressure (head) loss occurs along pipes. We recommend at least two gauges for each washer (Figure 1).

The pressure gauges should be calibrated at the start of each season by comparison to a gauge known to be correct. Any changes in pressure in the season can be verified by swapping gauges (if more than one gauge is used). Having a spare new pressure gauge in stock allows for rapid changes and checks to be made. An increase in pressure on one gantry can indicate nozzle blockage, although small blockages and pressure differences are unlikely to be detected. A decrease in pressure (generally over a long time) suggests excessive nozzle wear.
A pressure decrease may also indicate a lost nozzle, blocked pump inlet filters or other pump problems.

Pressure gauges should be oil-filled or have other features that protect against vibration, especially if the pump is a piston type. When the pump is off, checking that the gauges read zero should be done regularly, because gauge wear or over-pressure can cause significant gauge errors.

Figure 1. Pressure gauge at the gantry, an important check on pressure in addition to a gauge at the pump.

Examine fruit loading onto the washer brushes. Is there excessive “doubling up” with two fruit in one position, i.e. on top of each other? This can lead to incorrect cleaning of the extra (non-aligned) fruit.

The machine may be designed to use different nozzle sizes in different locations, but the sizes can easily be confused, especially when removed for maintenance. Are the correct nozzles fitted in the right locations on the washer? Read the size numbers on the nozzles (possibly by removing them or using a digital optical inspection probe (as shown in Figure 2), or to observe that the spray angle is correct. We recommend packers convert to quick fit nozzles with a proven track record. ProMax® QuickJet® nozzles (e.g. QPTA-15-40) have proven to be effective for insect removal on apples in New Zealand. However, this may mean changes to pump capacity.

Figure 2. Example of simple inspection camera system (cost <$400).
These units are useful for a range of applications in a typical packhouse.

The general cleanliness of the unit is also very important. The build up of organic matter on the gantry and HPW structure can lead to increased wear, and is also a food safety and general cleanliness concern. A simple hose down with a hand-held high pressure hose, or even a domestic water blaster, at the end of each day is recommended (Figure 4).

Figure 4. (A) An example of organic matter build up on the gantry of a HPW.

(B) A quick and easy remedy is to wash down with a domestic water blaster.

2.4 Health and safety

Misuse of water blasters in Packhouses may cause serious injury such as blindness and serious high pressure water injection injures. Therefore the following expectations apply"

- Only trained people to operate waterbalsters
- Standard Operating Procedures (SOP's) to be adhered to at all times
- Compliance to all organisational and federal health and safety laws
- Appropriate Personal Protection Equipment (PPE) must be used i.e steel cap boots with non slip soles, ear, eye and face protection, gloves
- Clothing worn near operating machinery must not be lose fitting

3 SPRAY PATTERN

3.1 What is this test for?

To observe the spray pattern of nozzles to check they are operating correctly.

3.2 Why should we do this test?

It is critical that the water jets are not blocked or missing (Figure 5), are oriented correctly and have a clear path to hitting the fruit. We have observed a range of problems including jets hitting (interacting with) each other, nozzles rotated 90° (i.e. not operating laterally across the washer), blocked and partially blocked nozzles (Figure 6).

3.3 How to do this test?

Are any water jets hitting each other before they reach the fruit surface? For example, nozzles might interfere with each other above the fruit and thus reduce cleaning efficacy. Note: these observations must be made with fruit under the nozzles.

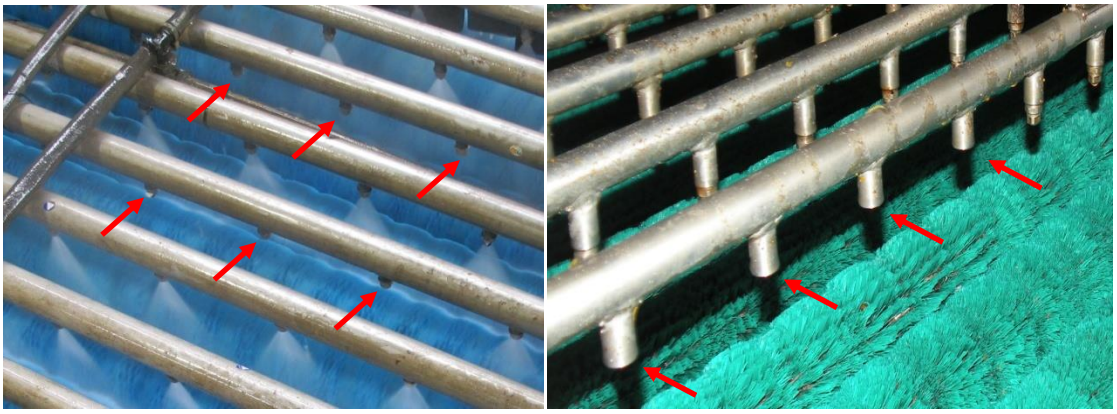

Figure 5. Completely blocked (A) or missing nozzles (B) in high pressure citrus washing systems.

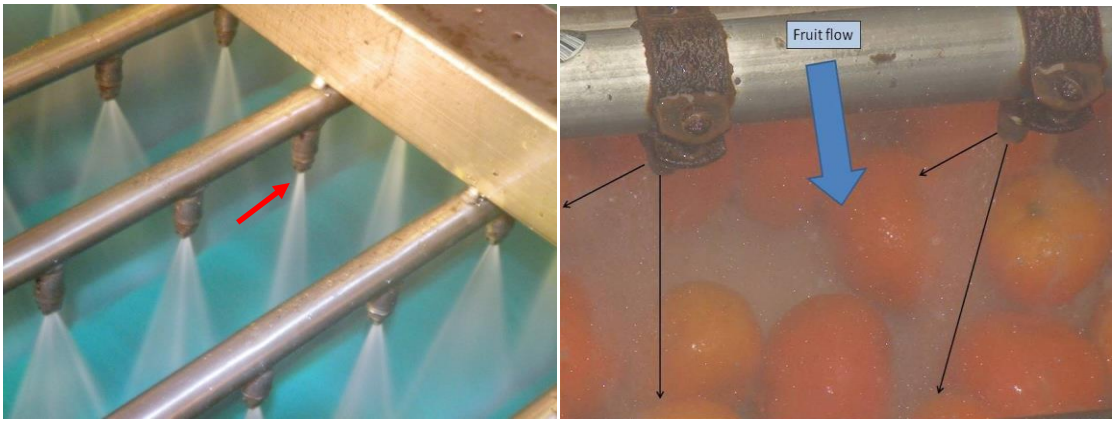

Figure 6. (A) Partially blocked nozzles in high pressure citrus washing systems not delivering a distinct 'fan' jet of water for maximum coverage. (B) Nozzles orientated incorrectly (rotated 90°, spray pattern indicated by arrows) and only hitting a small fraction of the fruit (this will also cause damage to the brush bed).

4 FLOW RATE

4.1 What is this test for?

To measure the flow rate of each nozzle to determine if there has been significant wear, or blockage, and whether the nozzle type is correct.

4.2 Why should we do this test?

Flow rate is a key component of high-pressure washing efficacy since it plays a significant role in determining the impact of the droplets on the fruit, and thus the removal efficacy. Nozzles wear over time, particularly if water quality is poor, and may need replacing. While complete blockage of nozzles is easy to note visually, partial blockage can be surprisingly difficult to see, and flow rate is an objective means to determine this. Finally, when nozzles are replaced or cleaned, they might be replaced in incorrect positions or at incorrect angles.

4.3 How to do this test?

Each packhouse should construct a system that allows easy fitting of a water-collection pipe over the nozzle outlet. Flexible plastic hose or PVC pipe is commonly used. Place one end of the pipe over each nozzle and place the other end of the pipe over a graduated measuring container (e.g. 5 L jug), start the pump/water flow, and, using a timer (set on “countup”) time how many seconds it takes to fill to a reasonable volume (e.g. 1.5 L; Figure 7). This is a balance between achieving accuracy (short times will be less accurate) and having enough time to carry out the tests. Note the time and volume collected for each nozzle and repeat. Where foaming of the water occurs, simply remove the jug (after stopping the stopwatch), allow the foam / bubbles to subside, and read the volume of water delivered.

We have found this to take about 40 minutes. This is good point at which to note that having a system (e.g. a plan/diagram, or labelling system) for individually numbering the nozzles makes this work much easier and less prone to errors. Similarly, appropriate platforms / walkways that give good access to the washer unit are important here from both efficiency and health and safety perspectives. Finally, appropriate PPE (Personal Protection Equipment) should be employed including gloves and eye protection where high pressures are employed.

To convert the time (in seconds) to litres per minute use the following formula:

Volume collected (in litres) x 60 = flow rate in litres/minute

Time to fill (in seconds).

Figure 7. Measuring flow rate. Time to fill to 1.5 L is measured for each nozzle. Hose should be fitted before turning the water on.

Frequency: Measure flow rate weekly or at least monthly.

5 FRUIT ROTATIONS

5.1 What is this test for?

To measure the number of fruit rotations under the washing treatment.

5.2 Why should we do this test?

A key factor in removal efficacy is that fruit rotate freely under the nozzles. If a fruit does not rotate freely during the time it passes under the nozzles, there is a significant increase in the likelihood that contaminants will not be removed. However, a balancing factor is that the fruit must rotate in a stable manner under the nozzles. Different sized fruit will rotate more or less times during the treatment period.

5.3 How to do this test?

Using a medium fruit size, apply a dark line across/around the fruit using a permanent pen system (Figure 8). Marked fruit can be placed on the washer (laterally) and the number of rotations counted as the fruit passes under the washer nozzles while the washer is under normal operating conditions. Fruit on a brush bed system should rotate and turn quite randomly due to movement of the following fruit. Use of a spiral-cut brush system can help ensure fruit move left to right, which should improve removal efficacy.

Figure 8. Medium sized orange with black line marked across/around it for counting rotations on the brush bed.

Frequency: Measure monthly.

6 CLEANING OF PAINTED FRUIT

6.1 What is this test for?

Checking that the entire fruit surface is being clean by the water jets.

6.2 Why should we do this test?

The ultimate way to measure high-pressure water washer efficacy is to use the target insect, i.e. FRW egg rafts, scale insects. However, that is both technically challenging and very expensive to carry out. Therefore, we consider that achieving thorough removal of a non-toxic white paint is a reasonable substitute that has been found to be an effective tool to visualise issues.

The method can be applied to any washer type. It can detect dead spots that the water jets are not reaching, but full paint removal should not be taken as a guarantee that the level of impact is sufficient to remove the target insects – i.e. paint will generally be easier to remove.

6.3 How to do this test?

6.3.1 The "PFR method": PVA and Surround®

A solution is made up of 4 g of PVA wood glue and 20 g of Surround® (Kaolin clay, AgNova Technologies Pty Ltd, Box Hill, Victoria) added to 100 mL of water. To achieve best results, mix the PVA with a small amount of water initially, then add the remainder of the water slowly with vigorous shaking until all dissolved (this takes some time). Finally, add the Surround and shake well to achieve a uniform solution. Fruit are then dipped in the solution (one end at a time), allowed to partially dry on their sides (on newspaper or similar), then rolled over after an hour or so (to avoid a "pooling" of solution at the base). Frequent stirring of the solution is required as settling occurs. After dipping, fruit should be allowed to dry for at least 2 days in an air-conditioned room at 20°C (Figure 9). Fruit should be kept dry until used for the washer tests, because exposure to dampness or even high relative humidity will make removal easier.

Figure 9. Oranges dipped in PVA/Surround® mixture and dried and then run over the washer.

In the examples below (Figure 10), oranges were put through the washer, allowed to dry, and the level of paint remaining used to determine areas of the fruit that were not being adequately cleaned, and thus not impacted by water jets.

Note that runs using painted fruit should be carried out at the end of a treatment day and the washer brushes and tanks thoroughly cleaned so that no residues of paint/PVA, etc. remain.

Figure 10. These oranges pictured indicate a range of paint removal from one pass under a citrus HPW. Clearly there are efficacy issues with this unit.

7 NOZZLE HEIGHT

7.1 What is this test for?

To measure nozzle height and distance from fruit.

7.2 Why should we do this test?

A key factor in the effectiveness of high-pressure washing is the distance between the nozzles and the fruit, because impact force declines exponentially with distance. If the distance is doubled, the impact will be four times less. Measuring the height of the nozzle to the brush-bed roller can be challenging as the nozzles are generally setup to pass between the brushes (to minimise damage). Because fruit size varies, a standard object needs to be used, and we have found a tennis ball to be both useful and readily available.

1. Use an old tennis ball (i.e. with minimal hair) and place between the rollers immediately below the nozzle to be tested. For a moving brush-bed, the bed may need to be advanced to the correct location.
2. Using a small ruler (best trimmed so that the start is 0 mm) measure distance between the tennis ball and each nozzle (Figure 11).
3. Distance should be ~110 mm for the top nozzle.
4. Adjust gantry/nozzles as appropriate.

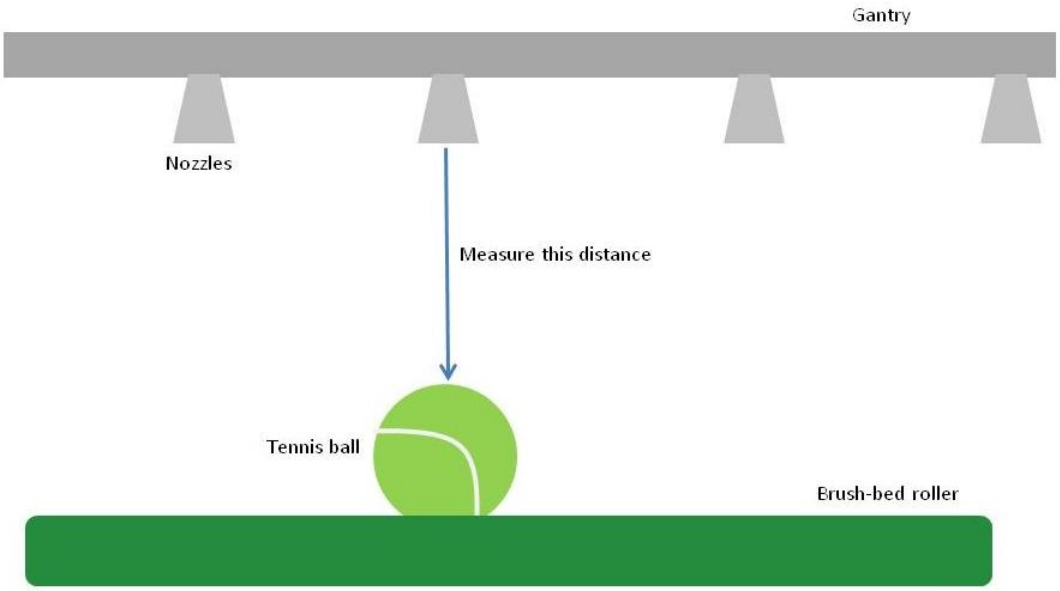

Figure 11. Diagram of how to check nozzle height (measuring distance from nozzle to a tennis ball) using a ruler.

8 WATER QUALITY/CLEANLINESS, AND FILTER MAINTENANCE

8.1 What is this test for?

Maintain a high level of water quality and cleanliness to maximise washing effectiveness, fruit quality, minimise fruit pathogens, and food safety.

8.2 Why should we do this test?

Water hygiene is influenced by a range of factors including the volume of fruit processed, cleanliness of the fruit (dust and dirt, bird guano, spray residues), volume of water in the system, water exchange rate, filter type and cleaning regime, and the use of sanitisers.

In terms of fruit rots, likely pathogens to build up in wash water include *Penicillium digitatum* and *P. italicum* (Green and Blue Mould) and *Geotrichum citri-auranti* (Sour rot). Use of sanitisers to minimise the build up of these spores is critical.

Potential sanitisers include, peracetic acid (Tsunami®), chlorine dioxide (Vibrex® Hortiplus), bromo-chloro products (Nylate®), calcium hypochlorite (Klorman®) and sodium hypochlorite (liquid pool chlorine). Using clean water that continually runs to waste would avoid most hygiene problems (assuming the water used is of high quality), but such volumes of water are generally either not available, too expensive or there are environmental limits on disposal.

The cleanliness of the wash water affects both the washer and the fruit. Sediments and small particulates will cause increased nozzle and pump wear, which will lead to changes to flow and pressure and reduce the effectiveness of the washer. Larger particles may cause partial or complete nozzle blockages. For citrus in Australia, the amount of dust on fruit results in significant contamination and buildup (Figure 12a), and when rotten fruit are processed fruit disintegrate resulting in large amounts of fruit material (Figure 12b).

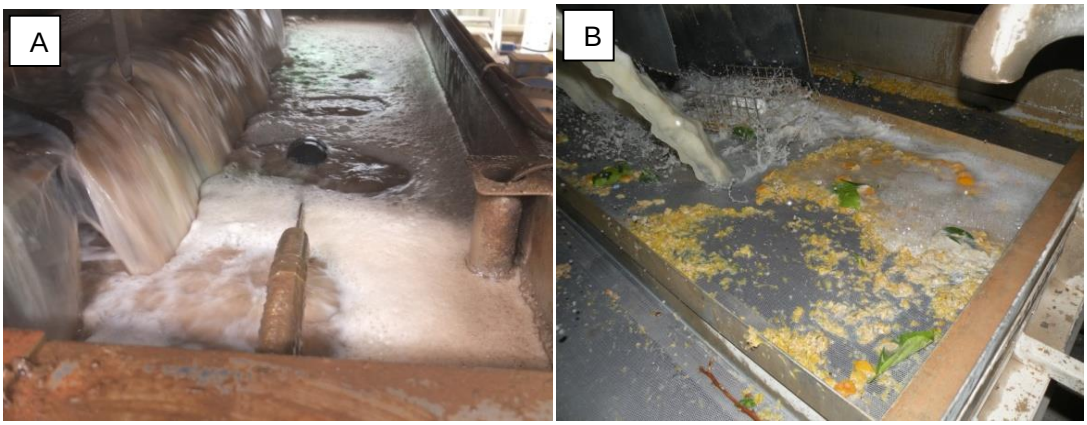

Figure 12. Challenges to water cleanliness: A. Dirt in the water tank. B. Rotten fruit that has disintegrated.

From a fruit perspective, not using a sanitiser will lead to increased levels of pathogenic fungi in the washer water system, and potentially to increased postharvest rots. A build-up in the washer system of agrichemicals (fungicides and pesticides) that are washed off the fruit could

potentially cross contaminate fruit, and we therefore recommend using a final row of clean water rinse nozzles after the high pressure washing system (Figure 13).

Build-up of organic matter washed from fruit, particularly bird guano, poses a risk of proliferation of bacteria that are a risk to human health. Bacteria such as *Escherichia coli, Salmonella,* and *Listeria* are all potential risks and the effect of the German *E. coli* O157:H7 outbreak on the Spanish vegetable sector in 2011 is a sobering example of potential impacts of food safety scares. In that case considerable economic damage was done even though Spanish produce was subsequently found not to have caused the outbreak. Controlling the microbial quality of water will ensure that contamination of fruits does not occur that is especially important when those are eaten with no or little further processing.

8.3 How to do this test?

This area is too complex for a detailed system to be described here, but the following factors are important to consider in the management of water cleanliness.

- Fruit volume. More fruit means more organic matter and other contaminants entering the washer water.
- Fruit cleanliness. The amount of dust, rotten fruit, bird guano and spray residues will all influence water cleanliness. Proximity to animals (e.g. cattle) and practices such as use of manure as a fertiliser will increase the chance that wind-blown dirt may contain *E. coli* and other faecally transmitted pathogens. The presence of particulate matter and soluble organic compounds generally decreases the efficiency of sanitizers on the elimination of micro-organisms.
- Water volume in the washer system. A small volume of water in the washer's tanks and piping will result in a more rapid build-up of contaminants.
- Water exchanges and dumping. Periodic water dumping and hosing out of tanks (e.g. at lunchtime and at the end of the day) is recommended as best-practice. Any hard-to-clean parts of the tanks need to be eliminated or given special emphasis during cleaning. To facilitate very rapid refilling of the washer tanks (e.g. at lunch time and before the night shift), an additional clean-water storage tank with large outlet pipe system is effective. This can be achieved by a tank on a stand so that gravity feed through the large pipe results in a fill of 10–15 min maximum, thus allowing cleaning and refilling over a typical lunch break.

As recommended below for fruit cleaning, a "clean water rinse" after high pressure washing can be used as a way of continually adding clean water to the system (Figure 13). This water can also provide top-up and dilution of the main water system. Clean-water storage tanks with large outlet pipes will facilitate rapid refilling of the washer system. Since dust and dirt can be a real issue here in Australia due to the conditions citrus are grown in, another option is to install a light brush and pre-rinse system which will remove some contaminates before fruit reaches the main high pressure washing unit.

Figure 13. Oranges exposed to a clean water rinse after HPW.

- Sanitisers. There are a wide range of sanitiser systems available for use in high pressure washer and flume systems.. Products include, peracetic acid (Tsunami®), chlorine dioxide (Vibrex® Hortiplus), bromo-chloro products (Nylate®), calcium hypochlorite (Klorman®) and sodium hypochlorite (liquid pool chlorine).

Consideration needs to be given to the following:

- Ease of use and maintenance of effective concentration.
- Effect of organic matter and pH on the sanitiser. This is particularly a problem for hypochlorite products, which rapidly loses efficacy in the presence of organic matter and in alkaline conditions.
- Health and safety: chemical exposure risks during mixture preparation, and for grading and packing staff who may be handling fruit soon after the washer.
- Sanitiser cost – This should include operating costs. For instance, the cheapest (sodium hypochlorite) product may not require very high doses &/or high monitoring costs to have sufficient efficacy with a high organic load. If possible, a fixed inline dosing system is recommended to ensure that effective concentrations of the sanitiser are maintained at all times.
- If sand filters are used, a glass bead media should be used.
- Cartridge filters. These are used in most washing systems and are an important part of the cleaning system. It is recommended to use a dual cartridge filter system assembly with a bypass so that flow can be switched between cartridges during cleaning. This will allow more time to correctly service the unused filter while the machine remains running. Auto back flushing systems are preferable.
- Flat screen or mesh filters. Most washers use first a course mesh filter (3–4 mm diameter holes), followed by very fine mesh (e.g. “100–42” mesh (100 meshes/inch) made of 304 or 316 grade stainless steel). Generally flat “trays” of these filters can be removed and rinsed periodically (Figure 14). If possible having two of the fine filters allows for removal and cleaning while maintaining filtration.

Figure 14. An example of a flat mesh type filter system in a high pressure citrus washer (A) and the nature of the material that blocks the filters (B) which is mostly fruit pulp from rotten fruit.

- We recommend that consideration be given to regular commercial analysis of washer water quality. This should be done at a NATA accredited commercial testing facility such as Envirolab and DMG Microlabs. Measurements should include Total Plate Count / Aerobic Plate Count (TBC/APC) (preferably incubated at 15–25°C), yeasts and moulds, and thermo-tolerant coliforms (or E. coli) to assess the efficacy of the treatment process (sanitizers, etc.) and to indicate possible faecal contamination (which would indicate the risk of human pathogenic bacteria being present). Sampling should at least be made under worst case" conditions, i.e. at the end of a run before water is dumped. The sampling frequency would depend on the amount of work carried out (e.g. volume of fruits processed a day or a week) but should be sufficient to establish trends and to notice aberrant samples. Sampling should be randomized and any results above the normal should be traced back to consider their cause. When high counts are found, close attention should be paid to the next sampling period in case they are repeated.

9 ACCESS TO THE WASHER

Ready access to the gantry and all nozzles is necessary to ensure staff safety, but more significantly so that regular checking and maintenance can be carried out. Many high pressure washers are poorly equipped in this area and improvements, or installation, of appropriate ladders and walkways is highly recommended. In addition, a system for lifting the nozzle gantry up and away from the conveyor would also be of benefit by making both the nozzles and conveyor more easily accessible. However, this would also require engineering of the supply piping.

10 PERSONNEL

Having a well-trained and diligent high pressure washer operator is likely to result in significant improvements. Consideration should be given to more training for this staff member and maintaining the same operator if at all possible over seasons. The significant investment in the machine and cost of running can be largely negated by poor operator skill and attentiveness. Consideration should also be given to instigating a regular meeting with the washer operator, site engineer, pack house manager, QC manager and other relevant staff (e.g. exporter/marketer). Ensuring that there are clear lines of communication and responsibility will also improve effectiveness.

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