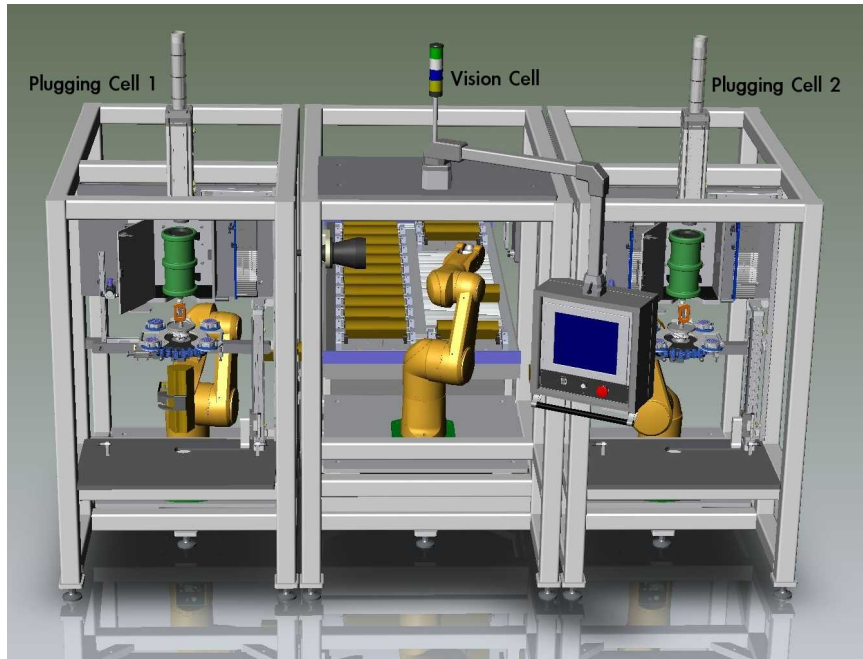


TRIBOT DPF PLUGGING SYSTEM



THROUGHPUT ESTIMATES

SIZE MM	SHAPE	CHANNEL DENSITY, CPSI	TRIBOT RATE DPFs/HR
80	ROUND	90	80 - 85
270 x 100	ANNULUS WEDGE	90	65 - 70
90 x 90	PIE	150	55 - 60
120	ROUND	150	35 - 40
144	ROUND	150	20 - 25
80 x 80	SQUARE	200	35 - 40
144	ROUND	200	14 - 16
203	ROUND	200	14 - 16 (SANS PERIMETER)
203	ROUND	200	8 - 10 (WITH PERIMETER)
103 x 56 x 64	ANNULUS WEDGE	200	35 - 40
70 x 90	PIE	200	55 - 50
48 x 48	SQUARE	300	85 - 90



20090910

Tribot Plugging Machine
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tribot@adaptiveequipment.com



Tribot Plugging Machine Description

20090615

This document describes the Tribot Plugging System's four major subsystems, profile compatibility, throughput estimates, and manual operations.

Pricing, options, and delivery information can be obtained by contacting Adaptive Equipment at tribot@adaptiveequipment.com.

Plugging videos and details of the Tribot vision system can be found at adaptiveequipment.com/dpfsystems/overview.html

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1. OVERVIEW

A Tribot plugging machine seals alternating channels on each face of a DPF substrate using a surface injection dispense technique. A Tribot plugging machine consists of four major subsystems:

1. Two plugging cells,
2. A vision and material handling cell,
3. A primary control system, and
4. A DPF infeed/outfeed system

An annotated schematic view of the Tribot pluggger is shown in Figure 1. An annotated, isometric view is shown in Figure 2 with guarding and frame details omitted. Complete system views from different perspectives are shown in Figures 3 and 4 and a dimensioned isometric view is shown in Figure 5.

Each plugging cell incorporates a 24 point, surface injection dispense system (see Figure 6). The dispense system consists of a four liter reservoir to hold the plugging media, a dispense valve assembly, a nozzle assembly, and 24 dispense tubes. A plugging cell robot (Staubli TX90) repeatedly engages a DPF face with the stationary nozzle assembly at locations established by the vision system.

This dispense system can simultaneously seal 24 channels and allows for any subset of tubes to dispense plugging media at any time. The volume of plugging media dispensed through each tube is independently regulated based on channel area to achieve a uniform plug depth. The 24 dispense tubes are fed through a nozzle body in a precise geometric pattern. The nozzle body is custom manufactured to match the channel density and geometry of DPF profiles. Profiles with different channel densities require different nozzle bodies for efficient operation.

The vision cell utilizes a high resolution grey level camera with a telecentric lens to provide accurate measurements of channel position and geometry. The camera is also used for quality control inspection of sealed DPFs. A Staubli TX90 robot is used in the vision cell to

- a) place and pick DPFs to and from the conveyors,
- b) present DPF faces to the camera for image acquisition, and
- c) place and pick DPFs to and from exchange nests for the two plugging cells.

The primary control system is a Linux based PC with a touchscreen display. This system, referred to as the vision PC or VPC serves multiple functions in a Tribot plugging machine. All image processing and plugging stratagem calculations are performed by the VPC. The VPC conducts each cell's operations and coordinates motion among the three robots. The VPC serves as an operator interface terminal (OIT) and maintains a production database that archives performance and QC data.

The DPF infeed/outfeed system consists of two power and free type conveyors. These conveyors transport nests that carry individual DPFs. The infeed/outfeed system has a 10 DPF queuing capacity. Nests can be loaded and unloaded manually or automatically.



FIGURE 1. Operational Schematic of the Tribot Plugging System.

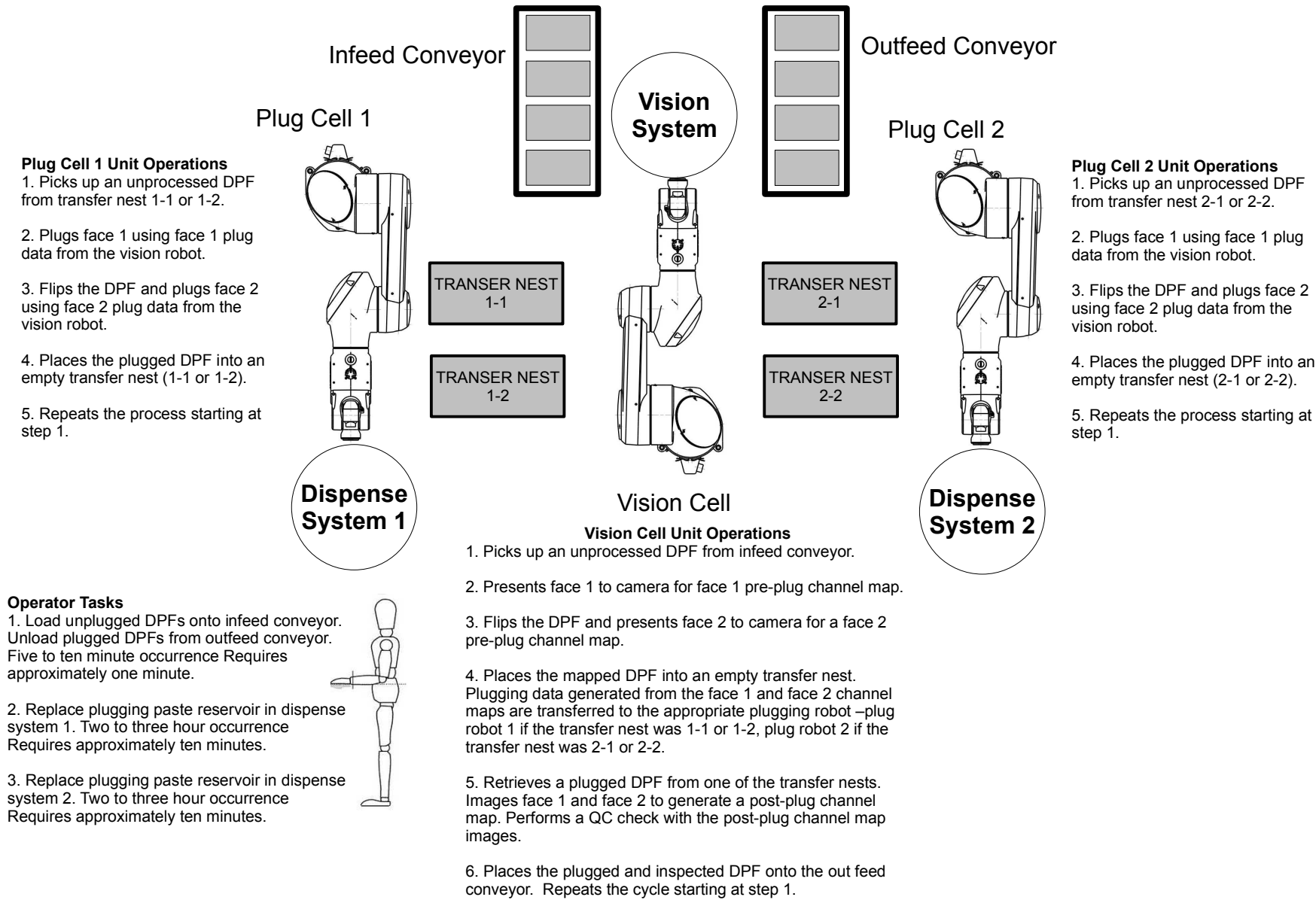


FIGURE 2. Tribot Exposed View.

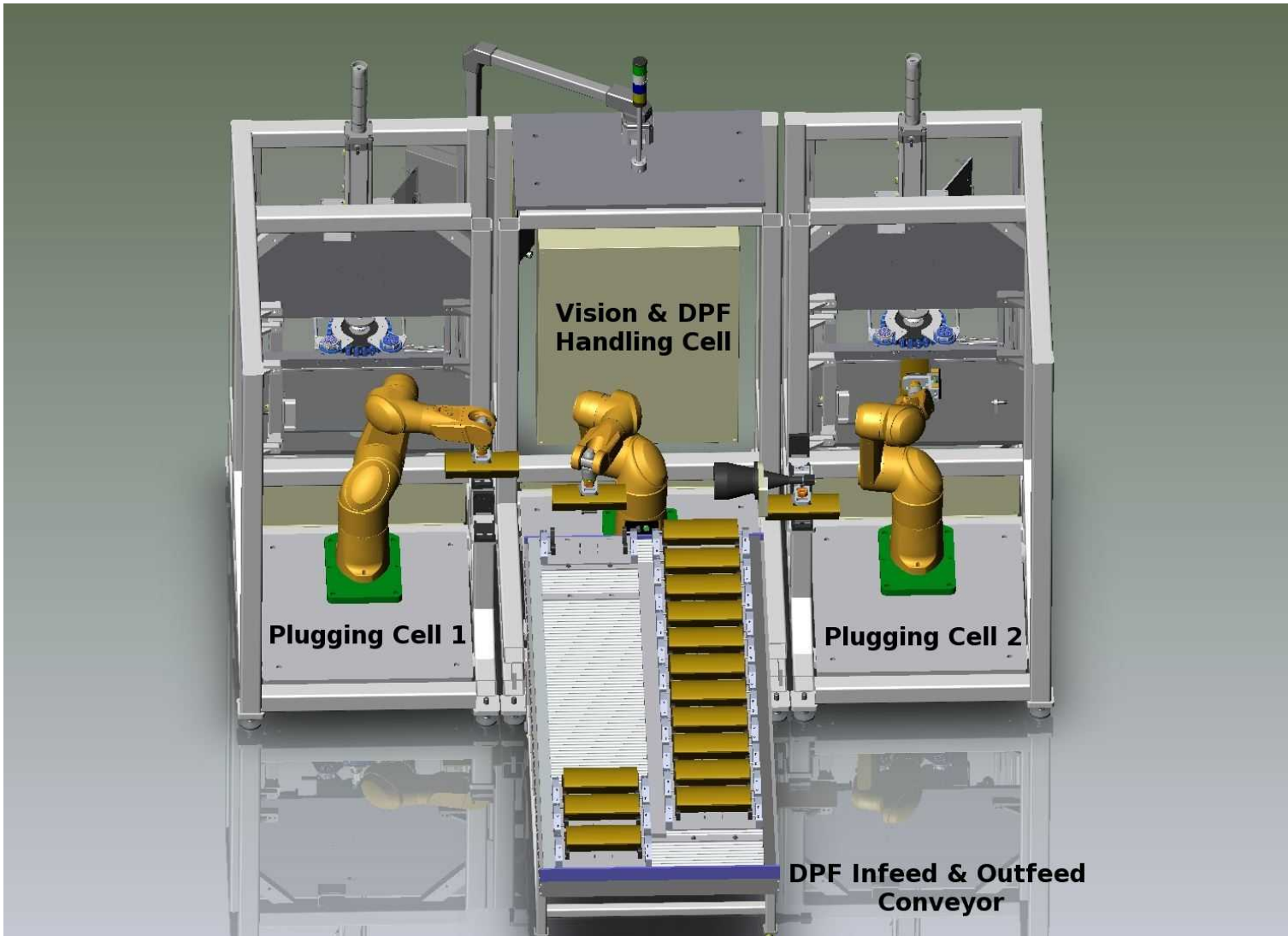
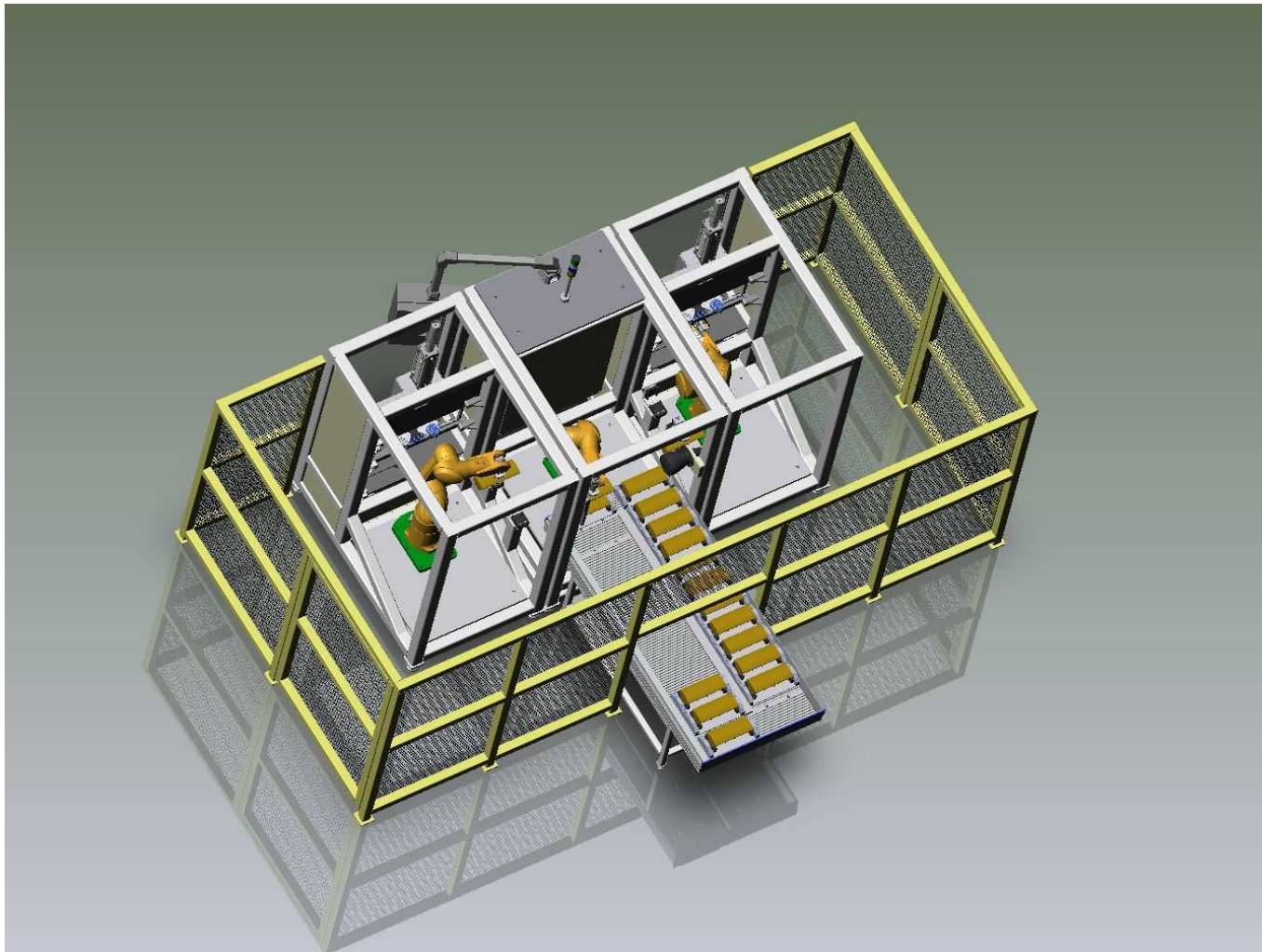


FIGURE 3. Tribot Full View, Conveyor Side.

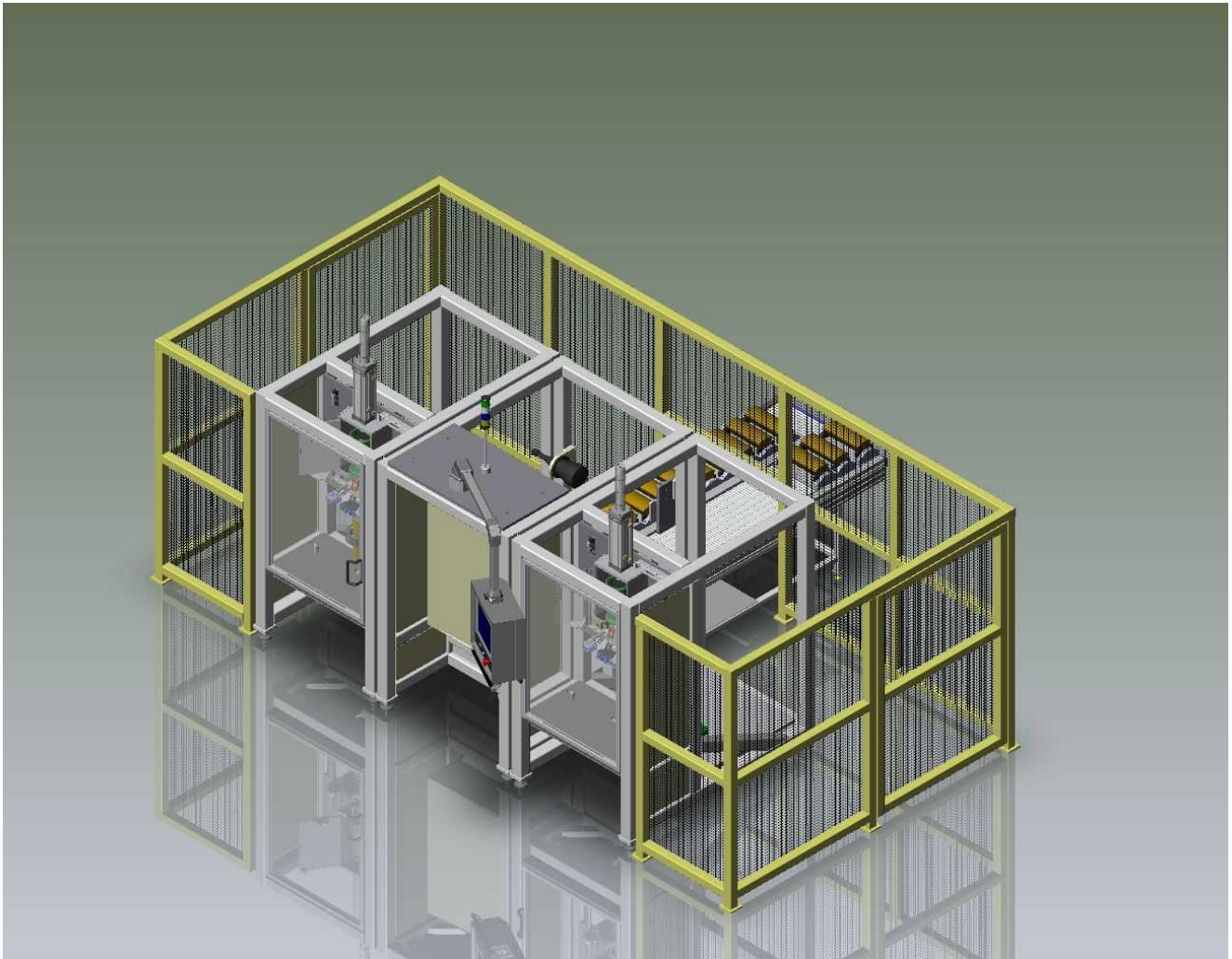


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FIGURE 4. Tribot Full View, Dispense Side.



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FIGURE 5. Tribot Overall Dimensions.

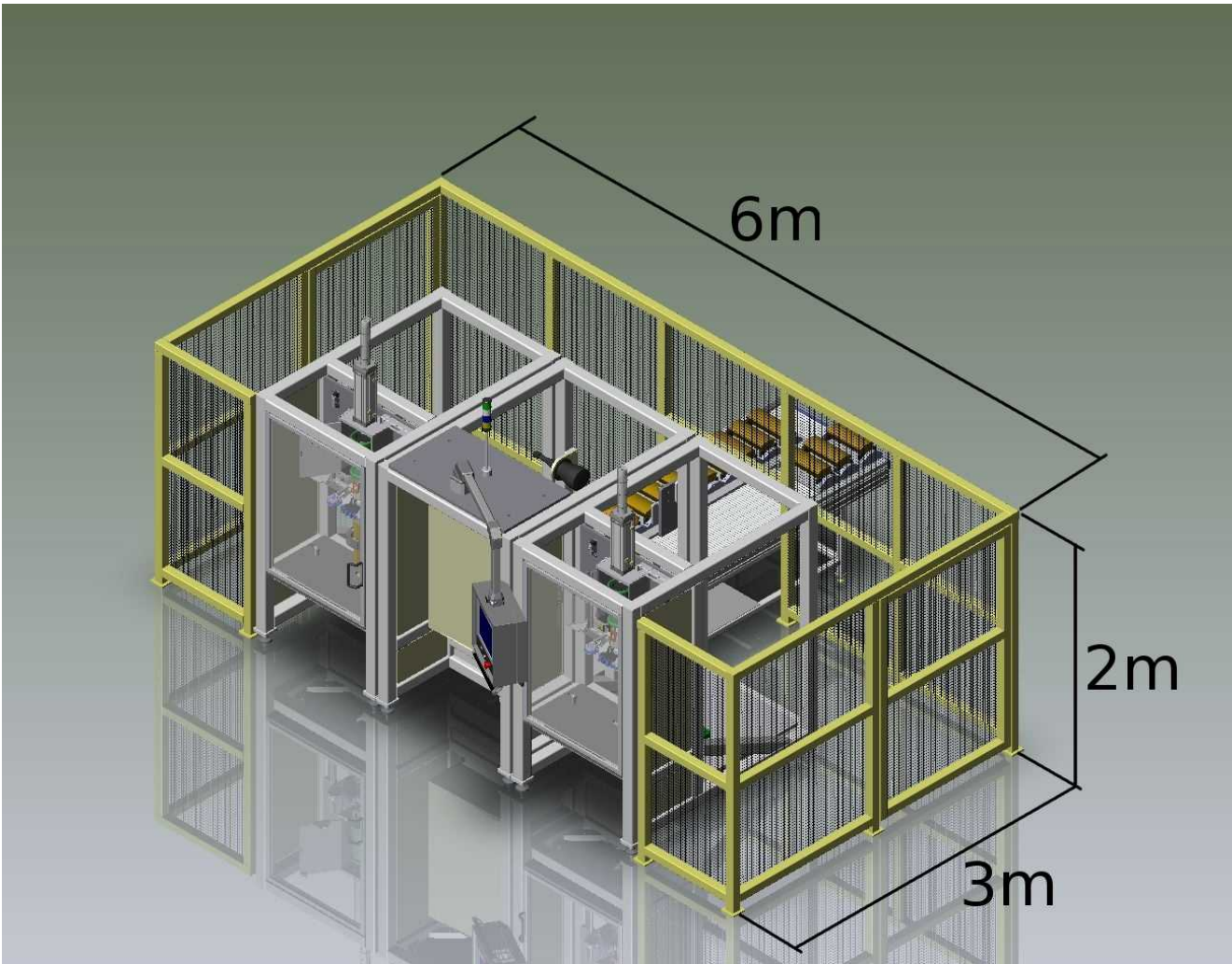
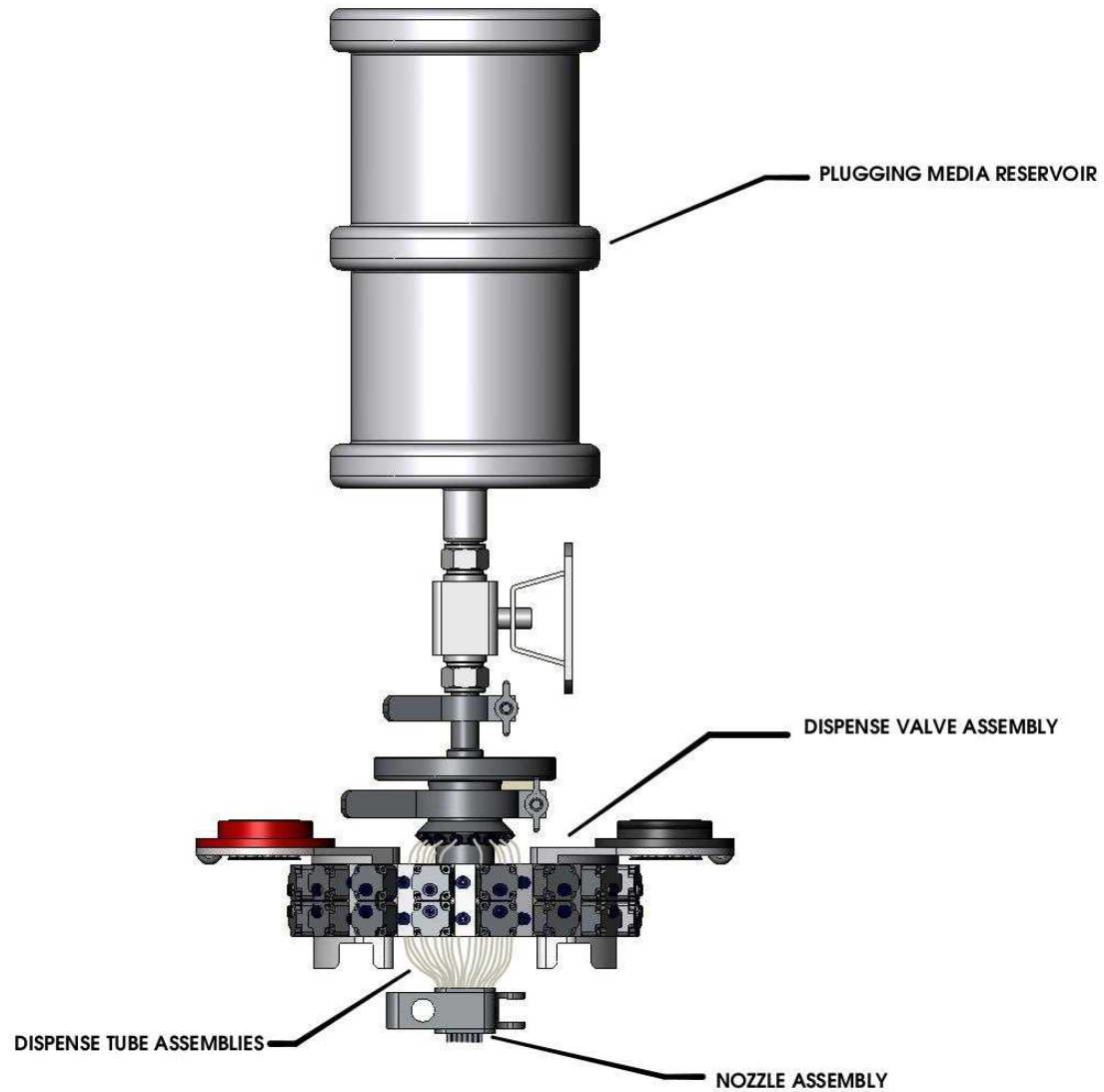


FIGURE 6. THE DISPENSE ASSEMBLY.
(some details are omitted for clarity)



2. SPECIFICATIONS

2.1 DPF Range

The Tribot plugging system can process DPFs within the size, mass, and channel density range shown in Table 1. Shapes that differ significantly from the standard round, rectangular, pie, or annulus wedge shapes (see Figure 7) may require specialized tooling.

Table 1. DPF Range

DPF CHARACTERISTIC	MINIMUM VALUE	MAXIMUM VALUE
LENGTH	150MM	350MM
FACE DIMENSION	25MM	150MM
CHANNEL DENSITY	90CPSI	300CPSI
MASS	NA	5KG

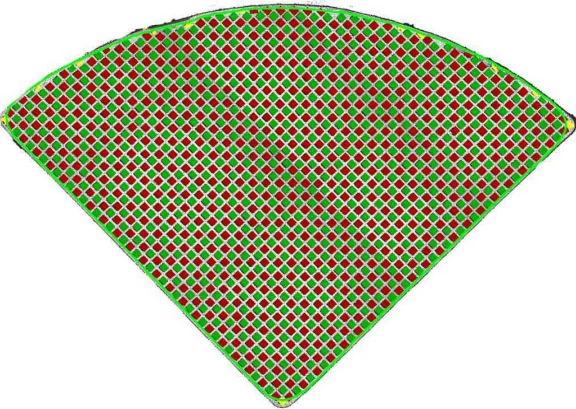
2.2 DPF Style Configuration

At delivery, each Tribot plugging system can be configured for up to five customer specified DPF styles conforming to the shapes shown in Figure 5 and the size, mass, and channel density range in Table 1. Each DPF style configuration may include unique conveyor nest tooling, robot gripper fingers, and dispense nozzle bodies.

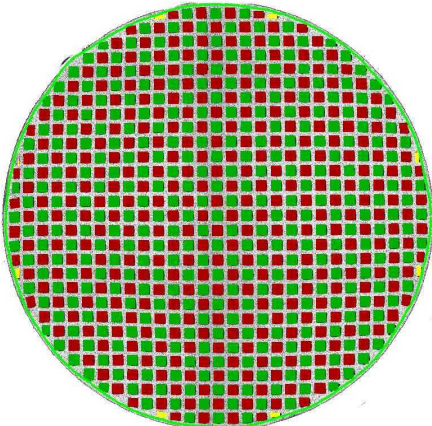
Configuration of the Tribot plugging system for additional DPF styles can be performed by the customer after completion of the one-week course, Configuration of the Tribot Plugging System for New DPF Styles. This course is included with the purchase of the Tribot plugging system. Alternatively, Adaptive Equipment can quote Tribot configuration for new DPF styles on request.



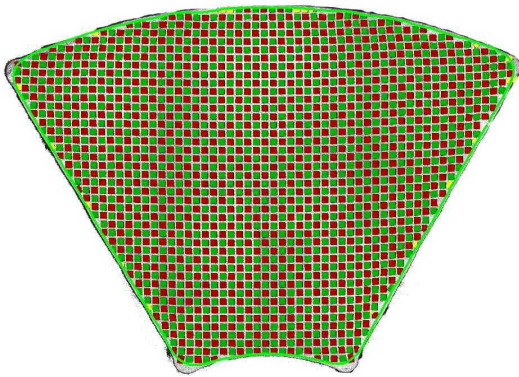
FIGURE 7. COMMON DPF SHAPES.



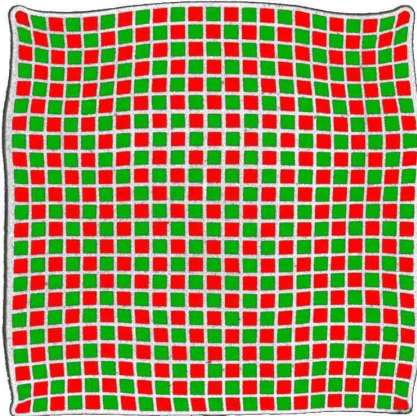
PIE



CIRCLE



ANNULUS WEDGE



RECTANGLE



2.3 Throughput Estimates

Throughput estimates for a Tribot plugging system are presented in Table 2.

Table 2. Tribot Throughput Estimates.

SIZE MM	SHAPE	CHANNEL DENSITY, CPSI	TRIBOT RATE DPFS/HR
80	ROUND	90	80 - 85
270 x 100	ANNULUS WEDGE	90	65 - 70
90 x 90	PIE	150	55 - 60
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103 x 56 x 64	ANNULUS WEDGE	200	35 - 40
70 x 90	PIE	200	55 - 50
48 x 48	SQUARE	300	85 - 90

2.4 Utility Requirements

Each Tribot plugging system requires the following utilities.

Electrical Power: 480VAC 3 phase, 15kVA, 50 or 60 Hz

Pneumatic Service: > 6 bar, 40 l/min



3. OPERATIONS AND MAINTENANCE ACITIVITIES

3.1 DPF Loading and Unloading

DPFs can be loaded and unloaded automatically or manually. The maximum throughput of the plugging machine is approximately 120 parts per hour. Therefore an automatic load unload system must complete it's cycle in 30s or less to prevent a backup at the plugging machine.

Manual load and unload intervals are dependent on two factors: the style of DPF and the number of DPFs that can be queued on the infeed/outfeed conveyor. We recommend a conveyor with a minimum queuing capacity of 10 DPFs. This provides an unattended operating time of approximately five minutes to 15 minutes, depending of the DPF style being plugged. Longer unattended operating times can be achieved by increasing the queuing capacity of the infeed/outfeed conveyor system.

3.2 Plugging Media Replenishment

An operator is needed to periodically replace the plugging paste reservoir. Reservoir replacement takes approximately 10 minutes and is performed every two to three hours. In addition, empty reservoirs must be cleaned and filled with fresh plugging mass. This is done off-line (e.g. in a plugging mass preparation area separate from the plugging machines) and is done in batches (many reservoirs cleaned and filled at the same time). Reservoir cleaning and filling requires approximately five minutes.

3.3 Periodic Cleaning

Cleaning the dispense areas of the machine is recommended after each eight hour shift. This involves vacuuming and damp cloth wipe down and takes requires five to ten minutes for each Tribot plugging machine.

3.4 Dispense Tube Replacement

The most frequent preventive maintenance task is the replacement of dispense tubes which are a wear item and should be replaced after one to two weeks of 24-7 operation. Replacing worn tubes takes approximately 45 minutes and requires the dispense valve assembly be removed from the machine. Utilization of a backup dispense assembly reduces machine downtime to approximately 10 minutes.

3.4 DPF Style Changeover

Product changeover requires from five to 65 minutes depending on the existing style on the machine and the new style being setup. The changeover operations are as follows:

- For most changeovers the conveyor pallet nest ends must be reconfigured. 15 minutes.

- For most changeovers the the gripper finger on the four robot DPF tools must be replaced. 15 minutes.

- If the new part style has a different channel pitch the nozzles must be replaced.

 - 5 minutes if two spare dispense assemblies are on hand.

 - 30 minutes if the nozzles must be swapped out of the dispense valves installed on the two plugging cells.

- The new part must be specified on the control system and the control system rebooted. 5 minutes.

