ORCHID ORTHOPEDICS – PROCESS FLOWS

Following are all primary process flows conducted at Orchid Orthopedics. Each step is briefly explained, followed by an assessment of the potential to emit constituents on the ODEQ Pollutant List (PTE), toxic emission unit (TEU) identifier (if applicable), and any further explanatory notes.

WAX Process Flow

**This is the only process that includes waxes and is the 'start' of product formation.*

Step # & Activity	***Room or Area***	***PTE***	***TEU***	***Notes & Methodology***
1) Wax Molding. Injection wax machines inject pattern wax into pattern tools. Gate wax is heated to 120°F and pattern wax is heated to 148°F for molding. The unique pattern tools are then combined into a mold assembly, called a 'gate'. Excess wax on molds is cut off, collected and combined with cooled wax from Step #4 and sent back to the manufacturer for re-use.	Wax	NO – *see notes*	NA PARTS CLEANING	The wax molding room has been identified as having no to negligible PTE. Logic: • Physical. This room is in the building interior and has no vents, windows or doors to the exterior. • Non-wax products. An SDS review of non-wax products in this room did not identify any ODEQ Pollutants with potential to emit. • Wax products: A review of emission reference documents did not identify any discussion or reference to emissions from low-temperature wax melt and injection into a pattern. This includes AP-42 (Section 13, Steel Foundries), or the RTI International *Emission Estimate Protocol for Iron and Steel Foundries* (RTI). Therefore, there are no identified stack or fugitive emissions. *Note that any general cleaning activities with acetone or isopropyl alcohol (IPA) in this room is still conservatively included as fugitive emissions in the material balance (MB) portion of AQ520 as their use was considered facility wide.*
2) Investing. Wax molds go through a repeated dipping in wet slurry, then sand application and then drying process to create ceramic forms around the assembled wax molds. Sub-processes: a. Slurry mixtures are created in large containers by pouring dry and wet products together to create slurry. b. After being dipped in a slurry, sand is applied either through a "Rainfall sander" that drizzles sand on the slurry-dipped mold, or in a "Sand bed" which blows compressed air up through the bed. c. The mold with the slurry and sand coating dries on an open rack prior to repeating the process as many times as is needed.	Investing	NO – *see notes*	NA	The investing room has been identified as having no PTE. Logic: • Physical. This room is climate controlled to specific temperatures and humidity, with no exterior vents. • Internal Dust Control: Ducting to the mixing and sand coating processes collects dust using a large blower motor (vacuum). The system sends the collected dust/air through a large array of 40 pleated filter cartridges in parallel (99.9% mass efficiency).* Filtered air is returned to the investing room through a large 'sock' to soften air flow and distribution. Therefore, there are no identified stack or fugitive emissions. *Dust Collector (DC) #7 (see Figure 3).

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
3) Drying Tunnels (2, 3 & Final Dry). A series of controlled environment curing rooms kept around 70 degrees. Recirculated air goes through a dehumidifier to lower humidity and dry molds.	Drying Tunnels 1, 2 & Final Dry	NO – *see notes*	NA	The drying tunnels have been identified as having no PTE. Logic: • Physical. These rooms are climate controlled to specific temperatures and humidity, with no exterior vents.
4) De-wax. Dried molds are placed in a furnace powered by natural gas. The furnace operates at 1,500F (main burner) and 1,600°F (afterburner). Wax melts out of the molds and the drippage is collected, cooled and sent back to the manufacturer for re-use. Air emissions are controlled with an afterburner on the furnace stack.	Dewax	YES – Fugitive (natural gas) & Point (flashfire dewax afterburner)	NATURAL GAS & FLASHFIRE DEWAX	Pacific Kiln FlashFire Dewax system is fueled by Natural Gas (NG). According to manufacturer: • Approx. 10 - 20% wax is burned off as smoke during the process. The average of 15% is used for emission calculations. This is considered conservative since wax purchase amount is being used and does not account for wax that is cut off during the process, collected and sent for recycling. • Afterburner has a minimum 99% efficiency rate for VOCs and PM. Wax Products with PTE ODEQ Pollutants: Emissions from wax with ODEQ pollutants are calculated using MB (15% of wax purchased) and a 99% control efficiency (afterburner).

CASTING Process Flow

**In this process the ceramic molds are used to create metal castings.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
5) Pre-Heating. Ceramic molds are wrapped in fiberglass insulation and pre heated in open ovens (fueled by natural gas) to prepare for receiving metal (casting). Batches are heated to 1600-1900°F depending on part design.	Foundry (Casting)	YES – Fugitive (natural gas)	NATURAL GAS	The only PTE identified are fugitive natural gas emissions. Heat from the ovens is collected and vented. Fiberglass insulation is used to protect the ceramic molds (reduces cracking). A review of the SDS (M-414 Inswool Moldable) did not identify any ODEQ Pollutants in the fiberglass binder.
6) Casting. Metal is heated to 2,900°F in electric induction furnaces (EIFs). Molten metal is then manually poured into the pre-heated ceramic molds. Freshly cast molds are placed on pallets and allowed to cool for 45-60 mins. Sub-processes: a. F75 alloy is melted and argon gas (used as shielding gas to prevent rust by blocking oxygen) is dripped into the crucible. b. 17-4 alloy is melted with argon (gas) and hexamethylenetetramine (powder) placed on top of mold to create a reaction for an oxygen free environment (drum placed over mold to preserve the environment).	Casting	YES-Fugitive	F-75 CAST & 17-4 CAST	Casting emissions are fugitive. Orchid's engineering department reviewed the RTI document and identified the following (uncontrolled) alloy Emission Factors (EF) are used. Updated to reflect the sum of both filterable PM (PM-FIL) and condensable PM (PM-CON) and only RTI as reference; emission factors provided by CAO: *Melting*: - ~~AP-42 (Table 12.13-2): 0.1 lb.~~ RTI (Table 3-3): 1.55 lb. PM / ton metal poured *Induction Charging and Tapping:* - RTI (Table 3-3): 0.51 lb. PM / ton metal poured *Pouring and Casting:* - RTI (Table 5-4): ~~0.087~~ 0.317 lb. PM / ton metal poured *Cooling*: - RTI (Table 5-4): ~~0.29~~ 1.06 lb. PM / ton metal poured **<u>Alloy Casting EF</u>** <u>(uncontrolled)</u> combines above EFs: ~~0.1 + 0.087 + 0.29 = 0.477 lb. PM / ton metal poured~~ 1.55 + 0.51 + 0.317+ 1.06 = 3.437 lb. PM / ton metal poured This process occurs early in the morning in a large, enclosed, unvented room. This space is under negative pressure. Process instructions require all doors to be closed during casting to prevent a draft which could introduce dust or debris to the alloy. Any PM emissions would settle on surfaces. A building control efficiency of 99% has been applied.

KNOCK OUT AND CUTOFF Process Flow

**In this process the ceramic molds are removed from the castings, which are then cut into individual parts.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
7) Knock out. After cooling, molds are placed one by one into a pneumatic jack hammer tool "knockout booth" to break and crack shell off the casting.	Knock Out and Cutoff (KOCO)	YES- Point	KNOCKOUT	Control Device: The knockout booth is connected to Dust Collector #2 (DC2). **Ceramic Knockout EF** (uncontrolled): ~~- RTI (Table 5-4): 79.3 lb. PM / ton metal poured (described as "shakeout" in RTI, aka "knockoff")~~ - EPA AP-42 (Chapter 12, Table 12.10-7): 3.2 lb PM / ton metal poured The PM is generated from breaking the ceramic molds. The estimated percentage of each ODEQ pollutant present in one pound of ceramic material is calculated in the excel file *Supporting Calcs for Emissions*.
8) Cutting. Two AW Bell power saws are used to cut off individual parts from the gate assemblies.	KOCO	YES - Point	F-75 CUT & 17-4 CUT	Control Device: Dust Collector #1 (DC1) collects dust from both saws. **Alloy Cutting EF** (uncontrolled): - RTI (Table 6-2): 6 lb. PM / ton metal produced

CELL 1 and CELL 2 Process Flow

**In this process the rough parts are taken through an initial series of steps to take any remaining ceramic mold off the part, grind down the gate connection point, inspection for flaws, and rework of fixable defects.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
9) Sandblast. Parts are sandblasted to remove residual amounts of remaining ceramic shell.	Cell 1 Sandblast	YES - Point	CELL 1 SANDBLAST	Control Device: Dust Collector #3 (DC3) collects the air from the sand blast operations. PM generated is predominantly sand, with small amounts of alloy and residual ceramic mold. **PM Emissions** from sandblast are calculated using Material Balance. Sandblast also occurs in Cell 2 using two Goff tumble blasters using the same grit material. Estimates assume 75% of material is used in Cell 1 Sandblast and 25% in Cell 2 Sandblast.
10) Gate Grind. The remaining gates on each part are ground down to prepare for machining in CNC machine cells. Predominantly this is an auto gate grind, but some hand grinding on a belt is also done.	Cell 1 Gate Grind	YES - Point	CELL 1 GATE GRIND	Control Device: DC3 collects the air from the alloy grinding operations. The emissions from this and rework grinding operations are calculated using the following EF: **Alloy Grinding EF** (uncontrolled): - RTI (Table 6-2): ~~16~~ 8 lb. PM_{10} / ton metal produced Risk modeling will estimate ~~assumes~~ 95% of Alloy Grinding emissions go to DC3. Hand grind activities described in the Steps #12 (Hand Grind) and #14 (Rework) are each assumed to have 2.5% of total alloy grinding emissions.

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
11) Tumble Blasters. Parts are sandblast using two Goff tumble blasters.	Cell 2	YES - Point	CELL 2 SANDBLAST	Control Device: Dust Collector #4 (DC4) collects emissions from the tumble blasters and the downdraft tables. **PM Emissions** from sandblast are calculated using Material Balance. Sandblast also occurs in Cell 1 using the same material (method of estimation is described in Step #9, above).
12) Hand Grind. As needed, druml-sized dies are used to hand grind parts at four down draft tables.	Cell 2	YES - Point	CELL 2 HAND GRIND	Control Device: DC4 collects emissions from the tumble blasters and the downdraft tables. Risk modeling will estimate Alloy hand grinding emissions ~~are assumed~~ to be 2.5% of total (using EF described above in Step #10).
13) Straightening. Parts are inspected using Go/NoGo gauges and manually straightening with hammers and presses.	Cell 2	NO	NA	
14) Rework. Parts are manually inspected, and small defects are ground out using small die grinders.	Cell 1	YES - Point	REWORK GRIND	Control Device: Dust Collector #6 (DC6) is a roof top collection unit that collects emissions from each booth's down draft table. Risk modeling will estimate Alloy hand grinding emissions ~~are assumed~~ to be 2.5% of total (using EF described above in Step #10).
15) Penetrant inspection. Parts are soaked in fluorescent penetrant fluid. The parts are then inspected under a blacklight to identify any flaws, cracks or defects	Cell 1	YES - Fugitive	PARTS CLEANING	The penetrant inspection has been identified as having no PTE. Logic: • An SDS review of the penetrant and developer used did not identify any ODEQ Pollutants with potential to emit. *Note that parts cleaning with acetone (sharpie marks, degrease, etc.) is included as fugitive emissions in the material balance portion of AQ520 as their use was considered facility wide.*
16) Rework welding. Parts that are found to have fixable defects are repaired by welding in a weld booth. Welding is TIG welding.	Cell 1	Yes- POINT (Welding) & YES - Fugitive	WELD (F-75), WELD (17-4) & PARTS CLEANING	Control Device: DC6 collects welding emissions from each booth's down draft table. *Note that parts cleaning by hand with isopropyl alcohol is included as fugitive emissions in the material balance portion of AQ520 as their use was considered facility wide.*

Heat Treat

**All products go through a heat treatment (including products shipped unfinished).*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
17) Heat Treat. Castings are placed in heat treat and heated up under vacuum to enhance metallurgical properties.	Heat Treat	YES - Fugitive	NATURAL GAS	Natural gas is used for heating. The process might produce minimal emissions of Argon gas (not an ODEQ pollutant).

**** At this point over 90% of the castings are sent off site for finishing. In 2023, 6.5% of castings were finished at the Oregon City facility (16,599 pounds of finished products produced).****

~~Kolene~~

~~**This is a specialty cleaning process conducted for one client. Frequency of use is approximately 2x per month, but the system is always kept heated and ready.*~~

~~*Step # & Activity*~~	~~*Room or Area*~~	~~*PTE*~~	~~*TEU*~~	~~*Notes & Methodology*~~
~~**18) Kolene.** Parts are cleaned in a Kolene process tank. This step is to remove small amounts of residual ceramic shell that are lodged in hard-to-reach nooks and crannies of parts. The process takes parts through a series of baths: a Sodium hydroxide bath heated to 1,000°F, a water bath, and then a hydrochloric acid bath to neutralize.~~	~~Kolene~~	~~YES – Point~~	~~KOLENE~~	~~Control Device: Viron Horizontal Scrubber~~ ~~The Kolene system emits a sodium hydroxide (NaOH) mist that is captured by the Viron scrubber. According to Viron's industry knowledge we can expect ~10% of NaOH to be 'spent' during etching, leaving ~90% emitted as mist. According to Viron, when operating as designed the scrubber will have a 98.5% to 99.5% control efficiency.~~ ~~This information also presented in the excel file *Supporting Calcs for Emissions*.~~

Machining

**In this step parts are milled closer to finished dimensions and then cleaned.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
19) Machining. Parts are placed into a CNC machine and milled to bring it much closer to finished dimensions. Each mill is equipped with a mist buster to eliminate aerosolized coolant escaping the machines. There is no direct dust collection.	Machining	YES-Fugitive	MACHINING OIL	This process is not anticipated to produce PM emissions. Fugitive emissions from one product with ODEQ Pollutants are estimated based on Material Balance.
20) Auto Chlor. Parts are cleaned after machining to remove any coolant and machine oil. An industrial dish-washer style machine is used to clean the parts.	Machining	NO – *see notes*	NA	SDS review of the cleaning product Mach Endurance identified sodium hydroxide (CAS 1310-73-2) as the only ODEQ pollutant. Sodium hydroxide (also known as caustic soda) is highly soluble in water and will discharge with wastewater. Therefore, there is no PTE for the Auto Chlor process.

Finishing / Polishing

**In this step parts are polished in a variety of ways.*

Step # & Activity	***Room or Area***	***PTE***	***TEU***	***Notes & Methodology***
21) Belting/ Polishing. Parts are manually belted and polished on buffing wheels and polishing belts. Polishing compounds are used in three different varieties.	Finishing/polishing	NO – *see notes*	NA	Control Device: Dust Collector #5 (DC5) is currently collected at machine sources, filtered and recycled back into the controlled environment room. No emissions from the room.
22) Robot polish. Same as manual polish only these parts are supported by an automated robot that completes the same belting and polishing task with a preprogramed robot arm. Work is conducted in an enclosed booth.	Robot Polish	YES – Point	ROBOT POLISH	Control Device: Dust Collector #9 (DC9) collects emissions from the robot polish booth. **PM emissions** from the polishing compound used in this room are estimated based on Material Balance.
23) Drag finish. Parts are fixed to a rotating arbor that drags them through a trough of media that creates a highly polished surface	Drag	~~NO – *see notes*~~ YES-Fugitive	NA	Wet process (no PM emissions). Revised to include one TAC in a regulatory section of SDS.
24) Vibratory mill. Parts are placed in a large container of media and vibrated to achieve a high polish finish.	Drag			
25) Sandblast. Parts are sandblasted manually in sandblast cabinets. Using a finer media than previous sandblast treatments	Finish Sandblast Room	YES – Point	FINISHING SANDBLAST	Control Device: Dust Collector #6 (DC6) collects PM from the sandblast cabinets. **PM emissions** from sand included under Material Balance.
26) Polishing water treatment. Water used in polishing processes is treated to remove polishing compound in preparation for water treatment disposal.	WW Pre-Treat	~~NO – *see notes*~~ YES-Fugitive	NA	A review of products used in water treatment shows that they either don't contain ODEQ pollutants or don't have PTE (coagulants and pH balancers). Revised to include one TAC in a regulatory section of SDS.

Cleaning/ESMA

**In this step parts are cleaned and a protectant sealant applied.*

Step # & Activity	***Room or Area***	***PTE***	***TEU***	***Notes & Methodology***
27) Parts Cleaning. Parts are placed in a dishwasher style machine to clean and disinfect the parts. Each machine is equipped to plumb in and out each liquid component.	ESMA	NO – *see notes*	NA	Emissions vent out of the room unfiltered through ducting. The equipment uses MC 518 Solution, RO water and Citric Acid. Products used in this step do not contain ODEQ pollutants.
28) Dip Seal. Parts are dipped into a dip seal solution that quickly hardens to protect the parts surface during additional process.	ESMA	NO – *see notes*	NA	Dip seal (M-2175 Evans Stripcoat Type II) does not contain any hazardous ingredients per SDS. Dip seal media is kept heated and ready at roughly 180°F. (Crockpot sized.). Lid kept on when not in use. Wax consistency.
29) Final Clean. Hand inspecting and cleaning parts and then packaged in protective packaging.	ESMA	YES-Fugitive	PARTS CLEANING	*Note that parts cleaning by hand with isopropyl alcohol is included as fugitive emissions in the material balance portion of AQ520 as their use was considered facility wide.*

NDT

**In this step parts undergo non-destructive testing (NDT).*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
30) Digital X-ray. Parts are inspected using digital x-rays.	NDT	NO	NA	
31) Fluorescent penetrant. A second location for penetrant inspection. Same process in a second location	NDT	NO	NA	
32) Manual Inspection. Personnel use black lights and minimal touch up grinding on parts using die grinders in a booth setting (for using the black lights).	NDT	Yes - POINT	NA (de minimis)	Control Device: The small filter behind the building (DC8) collects emissions from booths. *PM emissions at this location are assumed to be <1% of the emissions from all grinding activities are therefore not shown on AQ520. Note that grind emissions in Steps 10 -12 are included on AQ520 assuming 100%.*

Coating

**In this step specialty parts metal beads applied.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
33) Coating. Specialty parts have metal beads manually applied and glued into place. Parts are subsequently cured in an electric oven.	Coating Room	NO – *see notes*	NA	None. Heat (and emissions) from the electric oven vent to the roof. No ODEQ pollutants in adhesives. *Note that parts cleaning by hand with isopropyl alcohol is included as fugitive emissions in the material balance portion of AQ520 as their use was considered facility wide, however the air in this room is recirculated.*

Waste Water Treatment

**Parts are not involved in this step.*

Step # & Activity	*Room or Area*	*PTE*	*TEU*	*Notes & Methodology*
34) Water Treatment. Plant process water is collected in tanks and processed in 1,000-gallon batches. The solids are removed, and the water is measured for pH before discharge to sewer line.	Waste Water Treatment Room	None (see Notes)	NA	A review of products used in water treatment shows that they either don't contain ODEQ pollutants or don't have PTE (coagulants and pH balancers).