

Appendix A - Tables

Bill of Materials - BOM	A1
Quality Function Deployment - QFD	A3
Failure Modes and Effects Analysis - FMEA	A4
Design Verification Plan - DVP	A5

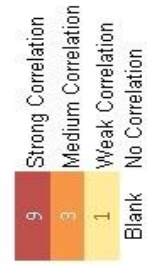
Bill of Materials

Part #	Description	Supplier	Mfg part #	Quantity	\$/item	Total Cost	Shipping
1	Carriage	McMasterCarr	9246K13	1	\$30.39	\$30.39	\$0.00
2	Carriage Linear Slides	McMasterCarr	5708K25	2	\$189.20	\$378.40	\$14.00
3	Carriage Linear Rails	McMasterCarr	5708K99	2	\$112.20	\$224.40	\$0.00
4	Support Bracket	Home Depot	15442	2	\$1.99	\$3.98	\$0.00
5	Actuator Mount (see part#1)	----	---	1	\$0.00	\$0.00	\$0.00
6	Stand	McMasterCarr	89015K37	2	\$16.85	\$33.70	\$0.00
7	Needle Stepper Actuator	Anaheim Automation	23AV104DX12-AB	1	\$195.00	\$195.00	\$10.30
8	Frame	McMasterCarr	9246K33	1	\$42.71	\$42.71	\$0.00
9	#10-24 X 3/8 SHCS	Fastenal	73436	4	\$0.16	\$0.64	\$0.00
10	#10-24 X 1/2 SHCS	Fastenal	73437	6	\$0.22	\$1.32	\$0.00
11	#10-24 X 2 SHCS	Fastenal	73444	4	\$0.56	\$2.24	\$0.00
12	#10-24 X 1 SHCS	Fastenal	73440	6	\$0.26	\$1.56	\$0.00
13	3/8 tube strap	Fastenal	450437	2	\$0.79	\$1.58	\$0.00
14	M4 X 12mm SHCS	Fastenal	MS2530012A4000	16	\$0.14	\$2.24	\$0.00
15	M4 X 25mm SHCS	Fastenal	MS2530025A4000	8	\$0.24	\$1.92	\$0.00
16	#10-24 nuts	Fastenal	1170707	10	\$0.06	\$0.58	\$0.00
17	Multiplexor Breakout	Sparkfun	BOB-09056	4	\$5.00	\$20.00	\$5.00
18	Shift Register Breakout	Sparkfun	BOB-10680	2	\$3.00	\$6.00	\$0.00
19	Analog to Digital Converters (ADC)	Digikey	AD7892ANZ-1-ND	2	\$30.00	\$60.00	\$7.63
20	Linear Comparator	Digikey	497-6993-5-ND	2	\$2.50	\$5.00	\$0.00
21	ZIF Connector (28 position)	Newark	17R8729	1	\$2.00	\$2.00	\$0.00
22	Power Supply	Jameco	2115240	1	\$95.00	\$95.00	\$0.00
23	Stepping Motor Driver	Gecko	G213V	2	\$170.00	\$340.00	\$13.75
24	Heatsink	Heatsink Factory	AK-210	2	\$10.00	\$20.00	\$7.25
25	Thermal Paste	Newegg	N82E16835186020	1	\$8.00	\$8.00	\$0.00
26	MicroController	Atmel	XMEGA-A1	1	\$30.00	\$30.00	\$0.00
27	Jumper Wires	Sparkfun	PRT-09140	2	\$4.00	\$8.00	\$0.00
28	Schmitt Trigger	Digikey	296-17840-ND	1	\$2.00	\$2.00	\$0.00
29	Limit Switch	Digikey	SW776-ND	2	\$1.00	\$2.00	\$0.00
30	Plastic Retaining Ring 1/4" thick	McMasterCarr	8560K359	1	\$11.00	\$11.00	\$0.00
31	Ring Linear Bearings	McMasterCarr	6255K32	4	\$42.00	\$168.00	\$0.00
32	Ring Linear Actuator	anaheimautomation	11AV102CX06-SB	1	\$148.00	\$148.00	\$0.00
33	Al. Shaft Diam3/8" L12"	McMasterCarr	5911K22	2	\$15.00	\$30.00	\$0.00
34	Sensor Mount Plate	McMasterCarr	9037K51	1	\$72.92	\$72.92	\$0.00
35	Sensor Cover Plate	McMasterCarr	9037K11	1	\$43.76	\$43.76	\$0.00

36	Sensor Protection Pad	Reynold's Adv. Materials	Custom	1	\$31.85	\$31.85	\$0.00	
37	1.5in Pins	Beverly's	N/A	350	\$0.01	\$3.99	\$0.00	
38	Aluminum Brackets	McMasterCarr	88805K56	1	\$26.82	\$26.82	\$0.00	
39	1/4-28x0.5 18-8 Stainless Steel Screw	Fastenal	70039	4	\$0.24	\$0.96	\$0.00	
40	1/4-28x0.625 18-8 Stainless Hex CS	Fastenal	70040	6	\$0.26	\$1.55	\$0.00	
41	1/4-28 NE 18-8 Stainless Hex Bolt	Fastenal	70880	10	\$0.20	\$2.01	\$0.00	
42	#8 X 3/8 SHCS Stainless	Fastenal	73421	2	\$0.19	\$0.38	\$0.00	
43	#4 X 1/4 SHCS Stainless	Fastenal	73410	1	\$0.07	\$0.07	\$0.00	
44	#2 X 1.5 SHCS Stainless	Fastenal	171030	4	\$5.70	\$22.80	\$0.00	
45	Pressure Sensor	Sensing Tex	N/A	1	\$77.38	\$77.38	\$95.00	
46	10x10x10 Acrylic Box	Collecting Warehouse	AD0704	1	\$48.77	\$48.77	\$23.92	
47	ZIF Connector (24 position)	Newark	30K5817	1	\$1.00	\$1.00	\$0.00	
	Sales Tax	1.085						
					Total	\$2,208.92	\$176.85	
						Total Cost	\$2,573.53	

Customer Requirements

Customers					Engineering Specifications															Benchmarks					
					Bill	Operator	Consumer	Average	% of Pit Fragments Found	Fruit per minute	% Fruit Damaged by Sorting	Operating temperature range	Peach Size Range	Pit Size Range	Power Consumption	Material & Material Cost	Usability (Learning Time)	Setup Time	Dangerous Mechanisms Exposed?	Unsafe Chemicals or Processes in Sorting?	Size	Operating Time	Assembly Time	Optical	Laser
No Fruit Damage	9	8	9	8.5		6	9		3							9					3	5	3	5	
Accurate Sorting	9	9	9	9	9	6	9	6	6	9								6	6		4	4	4	4	
High Speed	9	9	5	9		9	6				6							3			5	5	5	3	
Operator Safety	8	9	5	8.5							6				9	9	9				5	5	5	4	
Food Safety	9	9	9	9	3		6			3		6									5	5	5	5	
Ease of Use	6	9	5	7.5									9	9				3			3			3	
No Environmental Damage	3	3	6	3							3		9			6					5	5	5	5	
Low Initial Cost	5	5	1	5		3		3			3							6	6		2	2	2	4	
Low Operating Cost	8	5	1	6.5		3	3	3			9	9		3				6	6		4	4	4	2	
Long Lifespan	7	7	5	7		3		3		3	6	9						3			4	4	4	2	
High Device Reliability	8	8	5	8		3		3				9									4	4	4	5	
Small Device Size	1	1	1	1					6			6	6	3		3		9	6	3	4	4	4	4	
Ease of Maintenance	8	9	6	8.5		3		3				6	6		6	6	6	6	9		4	4	4	3	
Ease of Disposibility	1	1	6	1								9						6	6	9	2	2	2	5	
Units					%	F/min	%	C	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	
Targets					99	2160	0	-10 to 50	2 to 4.5	1 to 1/8	1.5	10k	1	15	no	no	no	10x6x8	21	1		9	3	1	Blank
Benchmark #1 (Optical)						2160			1 to 1/8	1.5					no	no	no			N/A		9	3	1	Blank
Benchmark #2 (Laser)									1 to 1/8	3 (W/kg)					no	no	no			N/A		3	1	Blank	No C
Benchmark #3 (X-ray)						2160			1 to 1/8						no	no	no			N/A		Blank	Blank	Blank	No C
Benchmark #4 (Human)					95	2160	0	0 to 43	2 to 4.5	1 to 1/4	salary	1	1	1	no	no	no			0		Blank	Blank	Blank	No C



Engineering Specifications Benchmarks

No Fruit Damage Accurate Sorting

High Speed

Operator Safety

Food Safety

Ease of Use

No Environmental Damage Low Initial Cost

Low Operating Cost Long Lifespan

High Device Reliability Small Device Size Ease of Maintenance Ease of Disposability

Benchmark #1 (Optical) 2160 1 to 1KB 1.5 no no NIA -Medium Correlation Benchmark #2 (Laser) 1 to UB 3 (Wfkg) no no NM
1 Weak Correlation Benchmark #3 (X-ray) 2160 1 to UB no no NIA Blank No Correlation Benchmark #M (Human) 95 2160 0 0
to 43 2 to 4.5 1 to 1M salary 1 1 no no 0

FMEA NO.:
Machine Name :
Design Responsibility:

1
Pit Detector

Prepared By :
Product/Service Application :
Review Date :

Pit Crew

Page 1 of 1
FMEA Date:
Core Team :

Function and Performance Requirement	Potential Failure Mode	Potential Effects of Failure	Severity	Potential Cause of Failure	Occurrence %	Current Design and Machinery Controls	Detection	RPN
Needle	Break	Needle embedded in peach	8	embrittlement	2	Temperature control/ material selection		40
		short circuit electronics	7	overstress	2	controls design		
				vibrations	5	vibrations analysis		
				Fatigue	2	Larger Diameter/ Stronger Material		
				tip chip	5	contact stress analysis		
				hits a material other than pit/peach	3	foreign body detection		
	Pit sticks on it	Needle no longer functions	3	force too high	3	controls design		35
		False readings	5	oddly shaped pit	7	needle cleaning/ lubrication		
				Pit jammed between	6	needle cleaning/ lubrication		
	Peach sticks to it	stops next peach from operation	4	cold peach	7	device placement on line		48
		shuts down that line	6	hard peach	8	device placement on line		
		produce false readings	5	unripe peach	7	device placement on line		
				ejection force too low	3	spring design		
				dry needle	2	lubrication		
				sticky needle	1	lubrication		
	Hit conveyor	breaks needle	8	absence of peach	5	peach sensor		50
		puncture/tear conveyor material	#	Electronics glitch/bug	2	code design		
		conveyor flow stops	6	limiting control failure	3	code design		
	Contact each other			peach misaligned	5	peach sensor		
		scrapping of needles	1	Deflection	3	needle design		35
		missing pits	5	Jam	4	needle cleaning		
	Sensor	inaccurate readings	5	Misalignment	7	manufacturing design		
		false readings	5	Force exceeds safe limit	2	controls design		40
		missed pits	5	Controls failure	2	thorough testing		
		rejects good peaches	5	Cold/Hot operating conditions	4	environment control/ heat dissipation		
				Gets wet (water damage)	8	waterproofing		
				Sudden impact	6	controls design		
	false reading	reject good peaches	5	Obstruction	3	pre-test sensing		35
		allows pits to pass through	5	hysteresis	7	recalibration plan		
				overstress	2	controls design		
				manufacturing	6	inspection before assembly		80
Electronics	Exposed wire	electronics damage	#	fatigue on wires	8	stress analysis		
		water damage	#	code error	2	testing		16
	overshoot	damage of sensors	7	Electronics glitch/bug	2	testing		

ME428/ME481 DVP&R Format															
Report Date		12/12/2013		Sponsor	Wawona Frozen Foods						Component/Assembly				REPORTING ENGINEER: Elliot Wenzel
TEST PLAN												TEST REPORT			
Item No	Specification or Clause Reference	Test Description	Acceptance Criteria	Necessary Hardware	Location	Test Responsi	Test Stage	SAMPLES TESTED		TIMING		TEST RESULTS			NOTES
								Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	
1	# of Fragments Detected	Use Device to test various peaches with and without peach fragments and pits and record detection rate	99% of pits > 0.125in	Testing peaches	Bonderson Project Center, Room 210	Colby	DV	50	peaches	12/6/2013	12/9/2013	Did not meet acceptable criteria	1/8in-50% 1/4in-90% 1in-100%	see left box	Mainly due to needle slop (see Recommendations)
2	Fruit Per minute	Find time per one test cycle, then find how many peaches can be tested in one minute	60 peaches/min	Testing peaches, stopwatch	Bonderson Project Center, Room 210	Cobly	DV	1	machine	12/9/2013	12/9/2013	Did not meet acceptable criteria (see notes)	0	1	Intentionally kept prototype slow to avoid damage
3	% Fruit Damaged	Repeated testing on multiple peaches using device and inspection/taste test	<1% of peaches damaged	Paper Towels, Testing peaches	Bonderson Project Center, Room 210	Elliot	DV	20	peaches	12/10/2013	12/10/2013	Not Performed	no data	no data	No peaches availabe at time of testing
4	Electronics Operating Temperautre Range	Subject electronics to hot and cold temperatures	10 to 50 C	hairdryer, freezer packs	Bonderson Project Center, Room 210	Hamilton	DV	1	machine	12/9/2013	12/11/2013	Met required critera	1	0	
5	Power Consumption	Use multimeter to test power usage	<1.5kW	Multimeter	Bonderson Project Center, Room 210	Elliot	DV	1	machine	12/11/2013	12/11/2013	Met required critera	1	0	Operates at 0.03KW for one unit
6	Set Up Time	Measure time to set up and use machine	<15 min	stopawtch, assembly tools	Bonderson Project Center, Room 210	Hamilton	DV	1	machine	12/10/2013	12/10/2013	Not Performed	no data	no data	
7	Operating Time	2 hours continuous operation	2 hours	stopwatch or timer	Bonderson Project Center, Room 210	Rick	DV	2	hours	12/11/2013	12/11/2013	Met required critera	2	0	
8	Water Loss	Test with device and measure weight difference with a scale against control fruit	<1% loss of weight	scale, testing peaches	Bonderson Project Center, Room 210	Rick	DV	1	peaches	12/9/2013	12/9/2013	Met required critera	1	0	
9	Foreign Object Safety	While device is running insert foreign object and record damage and device reation	No damage to user, and proper machine response	gloves, "foreign objects"	Bonderson Project Center, Room 210	Rick	DV	10	objects	12/11/2013	12/11/2013	Met required critera	10	0	
10	User Safety	While device is unpowered, test accessibility to dangerous systems of the machine	No access to dangerous systems, clear and visible warnings	gloves	Bonderson Project Center, Room 210	Elliot	DV	4	people	12/11/2013	12/11/2013	Met required critera	4	0	