

N F P A

**Fluid Power**

**VEHICLE**

**Challenge**



NFPA  
Education and  
Technology  
Foundation

FINAL PRESENTATION  
University of Utah  
Advisor: M Dillon  
April 12, 2024

  
THE  
UNIVERSITY  
OF UTAH

# Progress Since Midpoint

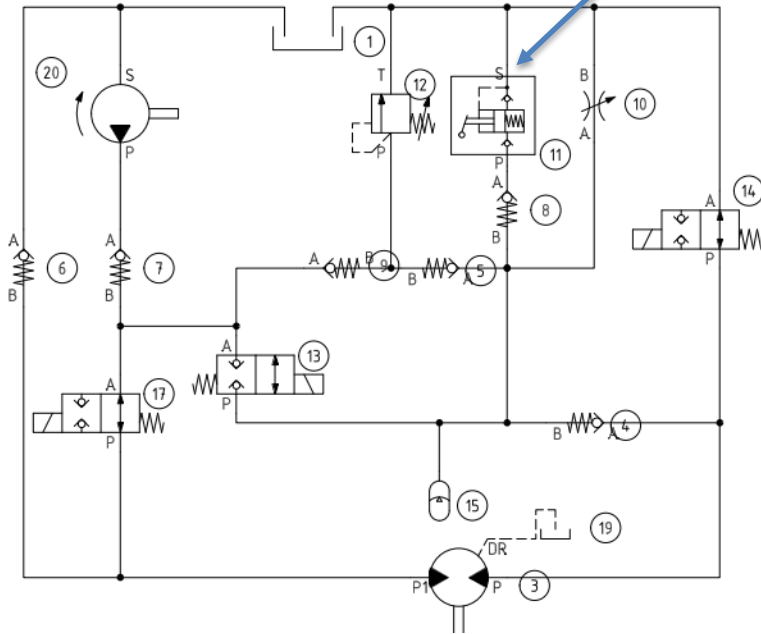


1. Fully installed motor, pump, reservoir, manifold, clutch on bike, screen, and control system.
2. All hoses and hydraulic parts installed and no leaks.
3. Installed a chain tensioner and chain guard with no binding.
4. Control system went from nothing to fully operational.
5. Designed pump and motor mounts, chain guard, chain tensioner, a way to fix sprocket to back wheel.
6. Got bike to be operational.
7. Built crate for bike shipment.

# Hydraulic Circuit Change

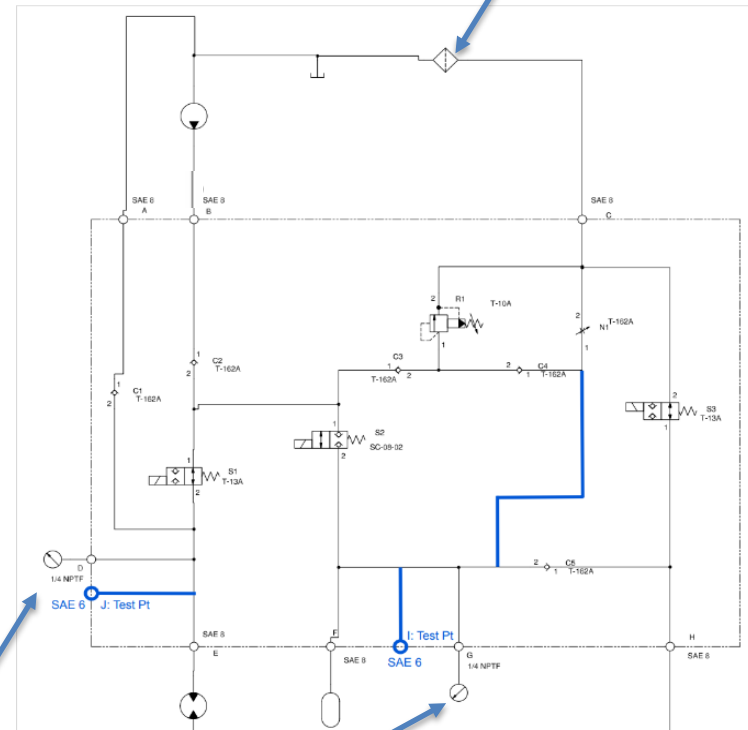
Old Circuit

Removed  
Mechanical Pump



New Circuit

Oil Filter



Included 2 pressure checks

NAME	SIZE
A, B, C, E, F, H	SAE 8
D, G	1/4 NPTF

# Pump and Motor Specs

## Motor

	Old Motor	New Motor
CIR	0.31	1.04
Type	Bent Axis	Gear
Manufacturer	Hydro Leduc	Danfoss
Output Shaft	Keyed Shaft	Keyed Shaft

## Pump

	Old Pump	New Pump
CIR	0.24	0.39
Type	Bent Axis	Gear Pump
Manufacturer	<u>Hydac</u>	Danfoss
Output Shaft	Keyed Shaft	9 Tooth Spline

# Pump Mount

- Two big iterations, final iteration shown
- Flexible coupler in between 2 plates



# Chain Tensioner

Two iterations, three  
different locations

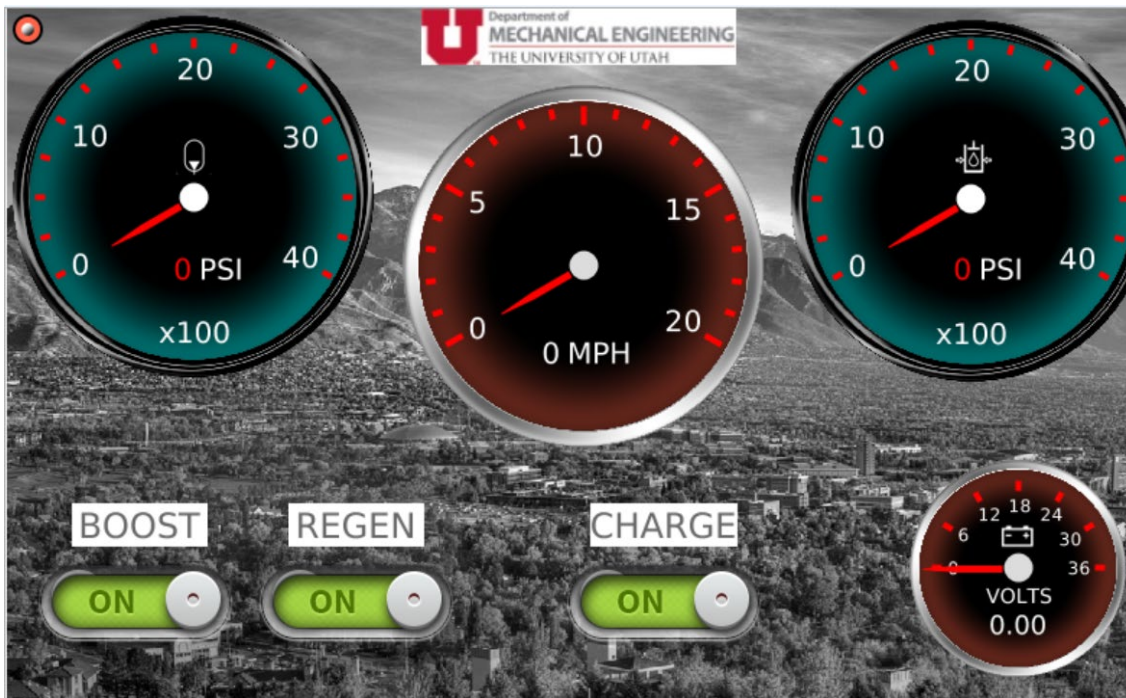


# Chain Guard

- Creating an exact shape was an iterative process due to weird geometry of the gear box.
- Used a laser cutter to cut cardboard to iterate.



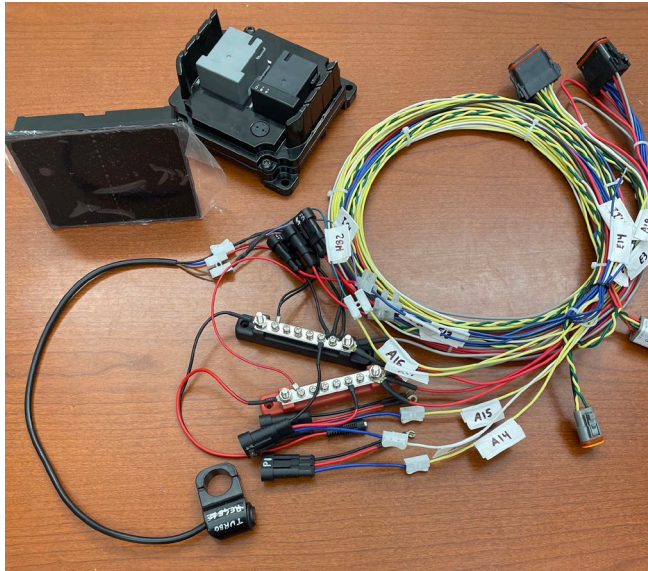
# Control System



Current layout of our PV500 screen which includes the accumulator pressure, mph, motor pressure, 3 separate modes, and the battery voltage.



# Control System Testing



Starting with the basics from what was ordered from IFP, we wired the bus bar to a wall adapter for initial powerup. Using the basic program from Josh Scarbrough, we were able to gain a basic understanding of how the program worked in order to improve and adapt our program. The inductance sensor had to be mounted on the bike to test the speedometer.

# Switchable Modes



We are able to switch between Direct Drive, Boost, and Regenerative with the flip of a switch. To enter into the fill accumulator mode, we use the touch screen.

# Pneumatics / Clutch

- Clutch allows the rider to switch between coasting and regeneration modes.
- Clutch is actuated by a single acting pneumatic cylinder.
- Pneumatic circuit consists of a pressure reservoir, hoses, switch, and cylinder.
- Custom shaft adapter and mounting brackets were required to connect the motor and clutch.
- Pneumatic circuit required troubleshooting.



# Clutch System Specifications



- System was designed to work with decreasing air pressure over time.
- Threads had to be locked to prevent sprocket from unscrewing during regeneration.
- Pneumatic actuation allows rider to continue to control bike with 2 hands vs manual actuation which requires 1 at all times.
- Clutch requires rear sprocket to be fixed instead of free-wheeling.

Clutch actuation force	19 lbf
Cylinder pull force (80 psi)	70 lbf
System working pressure	60-80 psi
Cylinder Stroke length	1.5 in
Max Clutch Torque	25 lb-ft

# Full CAD Model



# Lessons Learned

- Iterations take time
- Good designs usually are not on the first try
- Tool directions are hard to determine in CAD
- Account for lead times to not have an abundance of down time
- Leak tight welding is extremely difficult for new welders

# Lessons Learned



- Double check your orders for accuracy
- Make a list when you go shopping
- Manufacturing goes faster when you can do it yourself

# Back Up Slides





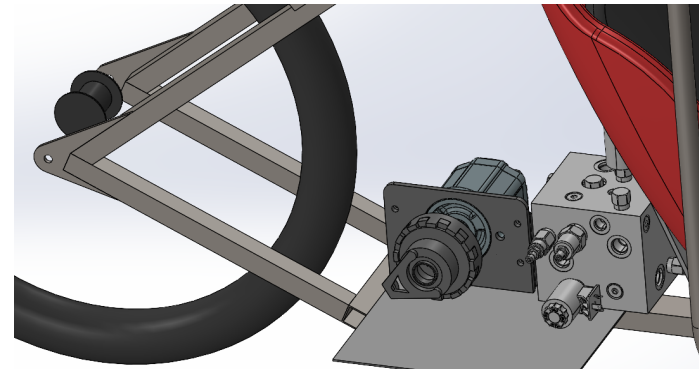
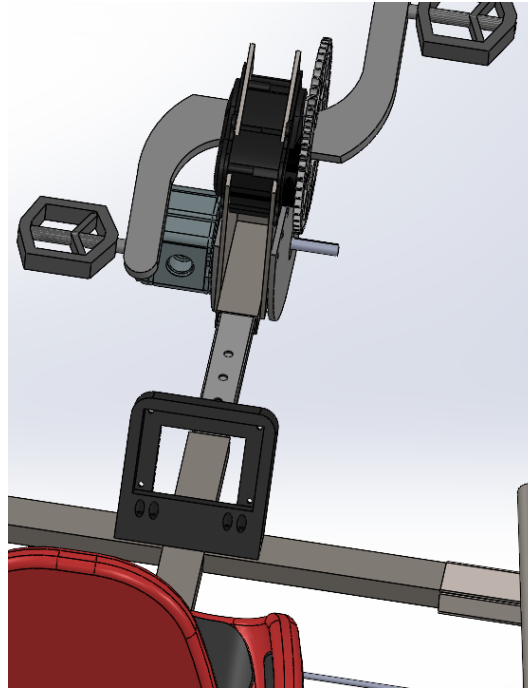
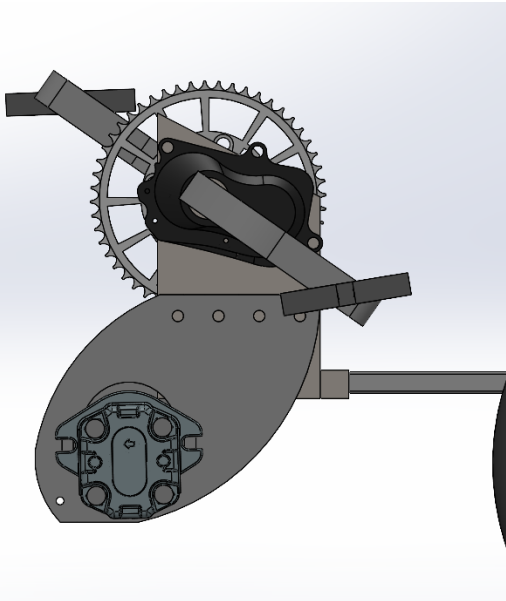
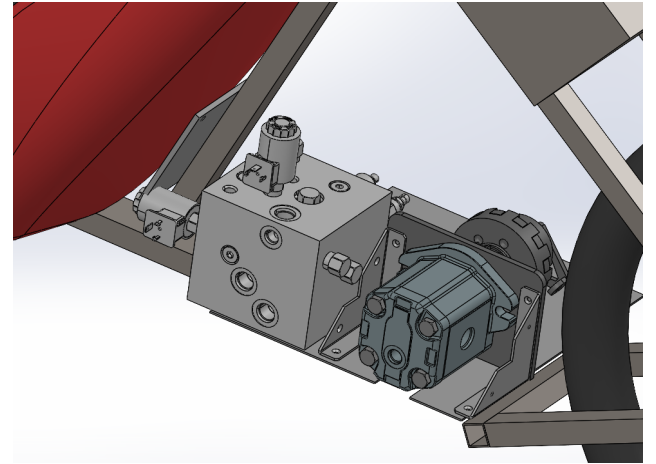
N F P A  
**Fluid Power**  
VEHICLE  
*Challenge*

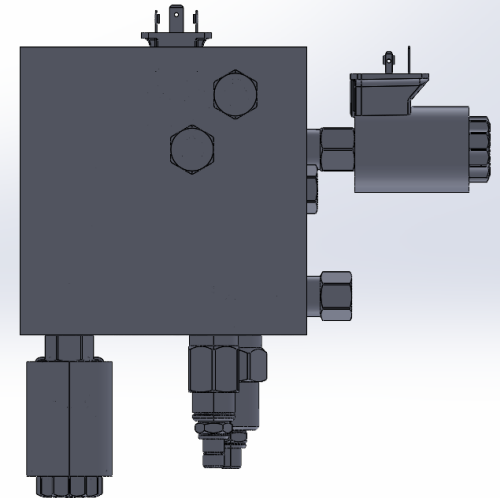
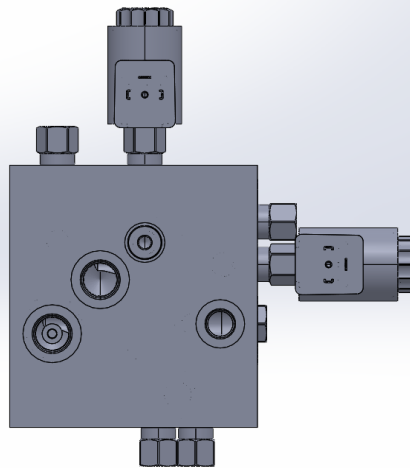
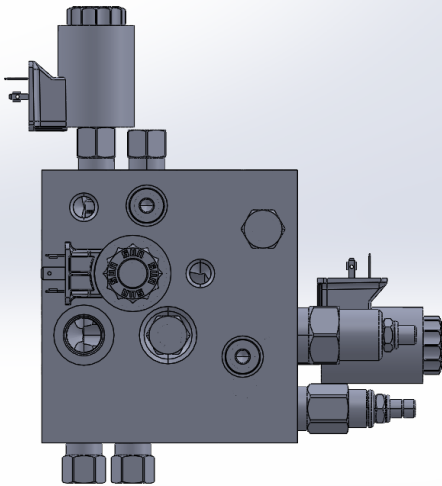
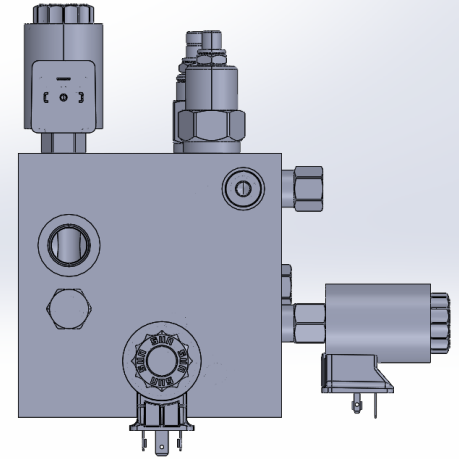
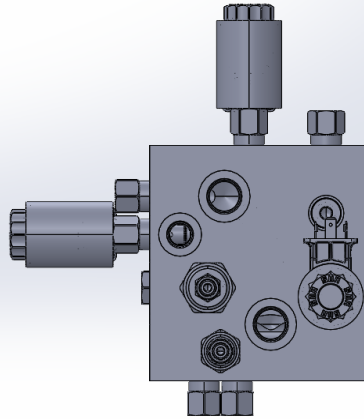
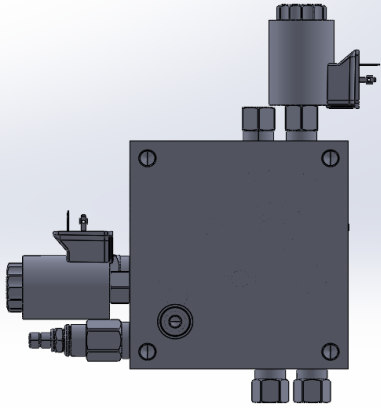


N F P A  
**Fluid Power**  
VEHICLE  
*Challenge*



N F P A  
**Fluid Power**  
**VEHICLE**  
*Challenge*







# Budget



## University of Utah FPVC Budget 2023-24

Date	Quantity	Part #	Description	Vendor	Purchaser Name	Item Cost	Sub-Total
1/18/24	1	<a href="#">B0B17Z1V</a>	ALITOVE 24V 8A Power Supply Adapter	Amazon	M	\$39.99	\$39.99
10/30/2023	1		Initial Tool Order	Amazon	Isaac		\$278.94
11/14/2023	1		Clutch	3D Motorsport Engineering	Isaac		\$280.50
11/15/2023	1		Team tools and equipment (drill, grinder, etc)	Amazon	Isaac		\$300.46
11/15/2023	1		Initial Tools and Supplies	Walmart	Isaac		\$46.60
11/30/2023	1		Sprocket for clutch	Structure Mechanics Corp.	Isaac		\$57.75
1/4/2024	1		Hydraulic fittings	Brennan Industries	Isaac		\$55.25
1/10/2024	1		shim stock, tools and hardware	McMaster-Carr	Isaac		\$205.65
1/16/2024	1		Battery adapter and tank cap	Amazon	Isaac		\$43.00
1/16/2024	1		Splined Coupling	Fayette Trailers LLC.	Isaac		\$32.87
1/19/24	1	<a href="#">B09XS36QFD</a>	18 Gauge 2 Conductor Electrical Wire	Amazon	M	\$20.79	\$20.79
1/20/24	1	<a href="#">B07JLCSTNX</a>	Sdoot auto Motorcycle Headlight Switch, 2 Pack 7/8" Handlebar	Amazon	M	\$12.99	\$12.99
1/21/24	1	<a href="#">B0CKH298H4</a>	BBus Bar 130A AC/ 150A DC, 300V AC/ 48V DC, 6 Terminal Power Distribution Block with 12 Wire Lugs	Amazon	M	\$21.99	\$21.99
1/23/24	2	<a href="#">B08579V5ZJ</a>	2 Pin Connector Waterproof Connector, Male and Female	Amazon	M	\$12.99	\$25.98
1/23/24	2	<a href="#">B08DLJK8XW</a>	3 Pin Connector Waterproof Connector, Male and Female	Amazon	M	\$14.99	\$29.98
1/29/24	1		Steel for mounting brackets	Wasatch steel	Chris		\$30.08
1/30/2024	1		Batteries and tank cap	Amazon	Isaac		\$153.72
1/30/2024	1		Splined Coupling	Findynamica	Isaac		\$81.16
1/30/2024	1		Machine tools for shaft adapter	MSC Direct	Isaac		\$61.71
2/5/24	1		More steel	Wasatch steel	Chris/M	\$70.00	\$70.00
2/6/24	1		order for frontend shaft coupler	Surplus Center	M	\$67.05	\$67.05
2/6/2024	1		Switches, screws, and supplies	McMaster-Carr	Isaac		\$74.24
2/12/2024	1		Hobby wire	Amazon	Isaac		\$6.18
2/12/2024	1		Hydraulic fittings and sprockets	Misumi	Isaac		\$57.25
2/20/2024	1		Sheeting and discs for paint	Amazon	Isaac		\$24.08
3/4/24	1		Hydraulic hoses and fittings	Hose and Rubber	Alex	\$423.63	\$423.63
3/26/24	1		New pedals with straps	Amazon	Isaac	\$66.06	\$66.06
3/27/24	1		Gearbox and cables from utah trikes	Utah Trikes	Isaac	\$148.91	\$148.91
4/2/24	1		Material for crate	Home Depot	Alex/M	\$169.40	\$169.40
<b>TOTAL:</b>						<b>\$2,886.21</b>	

# Cont.



### MANIFOLD + VALVES

Quantity	Part Number	Description	Unit Price	Subtotal	Type	Manufacturer	Vendor	Link	Comment
1	---	Custom Manifold	\$350.00	\$350.00	Credit	Hydac	Hydac	---	
1	CXBAXZN	Free flow nose to side check valve (1 PSI to open)	23.94	\$23.94	Credit	SunHydraulics	IFP		
1	AAJ	Line Body - 90 Degree - SAE -8 Ports - T-162A	28.60	\$28.60	Credit	SunHydraulics	IFP		
1	DTBFXCN	2-way, solenoid-operated directional spool valve (Normally Closed)	52.82	\$52.82	Credit	SunHydraulics	IFP		
2	DTBFXHN	2-way, solenoid-operated directional spool valve (Normally Open)	52.82	\$105.64	Credit	SunHydraulics	IFP		
3	740224D	24 VDC coil with ISO/DIN 43650, Form A connector with TVS Diode	26.41	\$79.23	Credit	SunHydraulics	IFP		
1	NFDCLAN	Fully adjustable needle valve	42.66	\$42.66	Credit	SunHydraulics	IFP		
4	CXBAXAN	Free flow nose to side check valve (4 PSI to open)	27.74	\$110.96	Credit	SunHydraulics	IFP		
1	RDDALAN	Direct-acting relief valve	119.23	\$119.23	Credit	SunHydraulics	IFP		
3	7000-180201-6160300	Meter, DIN A to Flying Lead with LED and Voltage Suppression (Works with 12VDC and 24VDC Coils)	16.40	\$49.20	Credit	SunHydraulics	IFP		
2	2-1/2IN-1/4NPT-3000PSI-LM	Pressure gauge	0.00	\$0.00					will supply w/out charge
				\$0.00					

TOTAL (MANIFOLD): \$962.28

### HYDRAULICS

Quantity	Part Number	Description	Unit Price	Subtotal	Type	Manufacturer	Vendor	Link	Comment
1	121.20.045.00	Motor, Gear, 1.025 CID, Keyed Shaft .625", Bi-rotation, external drain	\$405.00	\$405.00	Credit	Danfoss	SunSource	<a href="https://www.sunsource.com/Products/238491">https://www.sunsource.com/Products/238491</a>	page 55 SunSource Spec Sheet
1	111.20.346.00	Pump, Gear, 0.39CID, 9 tooth spline, CW rotation	\$281.00	\$281.00	Credit	Danfoss	SunSource	<a href="https://www.sunsource.com/Products/238497">https://www.sunsource.com/Products/238497</a>	page 37 SunSource
1	D1620-01-06SAE	Fitting, Test Point - Accumulator Side. SAE -6 Male	\$18.00	\$18.00	Credit	Dynamic FCI	SunSource		
				\$0.00					
				\$0.00					
				\$0.00					

TOTAL (HYDRAULICS): \$704.00

### CONTROLS

Quantity	Part Number	Description	Unit Price	Subtotal	Type	Manufacturer	Vendor	Link	Comment
1	78700664	PowerView500, 5" TFT Projected Capacitive Touchscreen, 8GB Flash	\$598.54	\$598.54	Credit	Enovation	IFP	Specifications	
1	78090104	Programming Kit, PV450/PV500	\$379.48	\$379.48	Credit	Enovation	IFP	Specifications	
1	58700010	(MC-2-18-6) Mobile PLC/Controller with integrated valve driver (PWM and On/Off Solenoid)	\$339.59	\$339.59	Credit	Enovation	IFP	Specifications	Control Kit 1
1	58700011	Programming Kit, MC3 and MC4	\$434.93	\$434.93	Credit	Enovation	IFP	Specifications	
1	38000009	MC2 Programming Adapter Harness	\$206.24	\$206.24	Credit	Enovation	IFP		
2	BSP B250-FV004-A04A1A-S4	Pressure Sensor, 250Bar, 0-10, 3W	\$146.93	\$293.86	Credit	Balluff	IFP	Specifications	
2	7000-12221-6140500	Cable -M12 Connector -4 Wire - 5 Meters Long	\$15.16	\$30.32	Credit	Murr	IFP	Specifications	Sensors
2	BES M12MG-PSC80F-BP05	Inductive Sensor - 8 MM Distance - 3 Wire - NO contact - PNP - 5M - Non Flush Mount Style	\$25.10	\$50.20	Credit	Balluff	IFP	Specifications	

TOTAL (CONTROLS): \$2,333.16

Total: \$3,999.44