Rough Estimate of Gas-handling Components Required: Short list

**Compressor**: Contacted KNF 30 Sept. ‘12

 FORMERLY: *GAST* MAA Diaphragm, Two-Stage ($386.90 for 1)

**Mass Flow Controller**: *MKS* πMFC PFC-50 or PFC-60 Quote Requested (Option2 price: $6672 for 3)

**Purifier/Filter**: *Systems Specialties* Gaskleen II Purifier ($3320 for 2)

**Pump**: *Edwards* XDS10 ($6,257 for 1)

**Mixing Baffle**: *McMaster-Carr* 12 blade Inline Pipe Mixer ($350-$880 for 1)

**Molecular Sieve**: *Scientific Instrument Services* MT-752K Adsorption Trap ($325 for 1)

**Cold-Trap**: NSCL can build one, according to J.Yurkon, but I haven’t contacted Jay Pline

 FORMERLY: *Scientific Instrument Services* LN2 Cold-Trap ($1060 for 2)

**Regulators**: : *McMaster-Carr* Gas Pressure Control Regulator CGA 7897A16&17 ($1325.80 for 5)

**Pressure Transducers**: *MKS* 622B 13TDE Baratron ($2208 for 2)

**Differential Pressure Transducers**: *MKS* 226A(21MGAGAFB1T1) ($1376 for 2)

**Automated Valves**: *Swagelok* IGC-II Pneumatic-Actuated Low-Pressure Valve

 FORMERLY *Kurt J. Lesker* Bellows Sealed Angle Valve (SA0100EVQF) ($2180 for 5)

**Manual Valves**: *Swagelok* IGC-II Toggle-actuated Low-Pressure Valve

 FORMERLY *Kurt J. Lesker* Bellows Sealed Angle Valve (SA0100MVQF) ($3360 for 12)

**Storage Tank:** *McMaster-Carr* High Pressure Inert Service HP80 (7822A14) ($303.63 for 1)

**Gas Analyzer**: *MKS* Cirrus 2 continuous gas analyzer ($44K for 1)

 Or *Extrel* MAX300 LG Gas Analyzer ($66K for 1)

**Heat Exchanger**: Necessary? If so, *Exergy* Sanitary 17 Series ($1800 for 1)

**Ballast Tank**: *McMaster-Carr* ASME-Code Horizontal Pressure Tank 9426K14 ($1148.45 for 1)

Total Price, minus gas analyzer & minus connecting components: $31,917

…with gas analyzer: **$76-98,000**

Rough Estimate of Gas-Handling Components Required: Full List of Options

**Compressor**

 ~~Option1~~*~~: Cal Supply Company~~* ~~Low Pressure Oil Free Rotary Claw Compressor~~

* ~~Operates at 0-30psi~~
* ~~Dry-running~~
* ~~Requested more information (March 13) as it’s not clear this compressor can be used with recirculating gas~~
	+ **Response: What we want is too small. Directed me to GAST**

Option2: *Fluitron Inc* Unsure of model

* Dry-running
* Leakage (using metal seals): 1e-9 scc/s = 4e-9 standard liters per hour
* Requested more information (March 13) as only general qualities of their compressor models are quoted
	+ Response: 1 stage unit can take 0.2 atm (160 torr) input at 0PSIG output for $14,000; 2-stage unit can take 0.1 atm input at 0PSIG output for $28,000. No model # quoted
* Cost: Ana’s spreadsheet (no model quoted) says $15,300 (including metal seals)

Option3: *GAST* (gastmfg.com)

* Need to contact these guys to see what they think is best. First need to find out a likely pressure drop across other components.
* Requested manual on their line of compressors:

<http://www.gastmfg.com/catalogs/rotaryvane_catalog.pdf>

<http://www.gastmfg.com/catalogs/diaphragm_catalog.pdf>

* Closest to meeting our needs: (Unsure about DAA & 15D(DC)
	+ **Two-Stage MAA Diaphragm**:3.5bar max press, 48mbar min pres, max flow 2.4m3/hr; Noise: 69-83dB (85dB for 8hrs a day is max allowed w/out ear plugs)
	+ $386.90



* + DOA Diaphragm? ….didn’t show-up on search by specifications we require



**Mass Flow Controllers**

 Option1: *MKS* Type 1479A Metal-Sealed

* Analog control
* Full scale range anywhere from 10sccm to 20slm
* Accuracy:±1% Full Scale
* Repeatability ±0.2% Full Scale
* Leak Rate: <1e-10 scc/sec = 4e-10 standard liters per hour
* Calibrated for a SPECIFIC GAS
* “Normal Operation Pressure Differential: 10-40psig” ?? (Contacted MKS about this)
* Two year warranty
* Cost: The *Kurt J. Lesker* catalog quotes the price at $1,594 + $300 for surface mount seal + $330 for the electrical connector (RS 485) 🡪$2224 each

Option2: *MKS* πMFC Model PFC-50 or PFC-60

* 50: “Multi-Range”
* 60: “Pressure Insensitive”
* Digital or Analog Control
* Calibrated for a specific gas, but the current gas being used can be programmed in
* Otherwise, specifications same as for 1479A
* Contacted MKS (March 13) for comparison between above 3 devices & cost estimate
	+ Reminder sent april 8th. Received reply that they’d “get back to me” on Mar 13

**Purifiers**

 Option1: *Matheson Tri-Gas* PUR-Gas Cartridge Purifier System

* Max Flow rate is 3 liters per minute, so perhaps not compatible with our system
* Clean gases to 99.9999% purity
* Cartridge installed on a base-plate so as to be replaceable (without tools)
	+ Check-valve closes upon cartridge replacement
	+ 1,2,or 3 cartridge base plates available
* Can either get Moisture, Oxygen, Hydrocarbon, a combination of the two, or all three
* Color indicator for purity for Moisture & Oxygen purifiers
* Seems to assume inert carrier gas. Not sure if this is for example, or the only kind of gases they recommend using this purifier system with
* See pgs. 333-336 Matheson Tri-Gas manual

Option2: *Matheson Tri-Gas* PUR-Gas In-Line Purifier System

* Max flow rate is 25 liters per minute
* Clean gases to 99.9999% purity
* Can either get Moisture, Oxygen, Hydrocarbon, a combination of the two, or all three
* H2O capacity of 6grams, O2 capacity of 1000grams, & Hydrocarbon capacity of 12 grams
	+ Estimated life-span: >2 years
	+ Higher capacity for single in-line purifiers
* Seems to assume He carrier gas. Not sure if this is for example or really the only gas they recommend using this purifier system with
* Proper orientation is Vertical
* See pgs. 337-339 Matheson Tri-Gas manual

Option3: *Entegris* Inert Gas Purifier

* Meant for: N2, He, Ne, Kr, Ar, Xe, Halocarbons, Light Hydrocarbons
* Purity: <100ppb H2, CO, CO2; <100ppt H2O O2
	+ Assumes <10ppm concentration of contaminants; <1ppm moisture
* Leakage: 1e-9 scc/sec = 4e-9 slm
* Must operate above 1atm, but perhaps this is ok, as we could purposely have a pressure-drop across the mass flow controller & the mixing baffle will have some pressure drop
* ~1year estimated lifetime at nominal flow rate
* Several models available for various flow ranges; pressure drops vary for each
	+ 70KF: 3slm max, 1slm nominal; with 0.7psid pressure drop
	+ 100KF: 20slm max, 2slm nominal; with 4psid pressure drop
	+ **300KF**: 50slm max, 7slm nominal; with 5psid pressure drop
		- This would be my choice. Quote requested 8 April ‘12

Option4: *NuPure* UltraPure PF Series Point-of-Use UHP Gas Purifier Model 600PF

* Max Flow (at 150psig): 30slm
* Liftetime: 1 year at nominal flow of 6slm
* Leak Rate: <2e-9 scc/s = 8e-9 slm for He
* Fittings: ¼”” VCR
* Used for flow gases: Ar, Ar/CH4, He, CH4, Ne, CF4, Xe, Kr, SF6,N2
* To remove impurities: H2O, O2, CO to <10ppb
* Filters contaminants above size: 0.004micron
* Requested (Mar 14) quote & pressure-drop information

Option 5: *Systems Specialties* Gaskleen II Purifier

* Inert Gases: GLP2INPVMM4; Flammable: GLP2SIPVMM4
* Removes H2O,O2,CO2,CO to <1ppb
* 1x109 retention of particles >0.003μm up to 5slpm
* $1660 each



**Filters**

 Option1: *Matheson Tri-Gas* Model 6164-T 316 Stainless Steel High Purity Depth Filter

* Microporous fiberglass used for filtering
* 100% filtration efficiency at 0.2 micron level
* Swagelok tube fittings (VCR, VCO fittings also available (6164-V)
* Various diameters available (1/8”, ¼”, 3/8”, ½”)
* Not sure if this will work at our pressures & pressure drop.

Option2: *Matheson Tri-Gas* Model 6190 0.01 Micron Membrane Gas Filter

* Teflon media used for filtering
* 100% efficiency at 0.01 micron
* Swagelok tube fittings (VCR MxM fitting also available)
* Not sue if this works at our pressures & pressure drop

Option3: See Purifier Option 4

Option 4: See Purifier Option 5

**Mixing Baffle (a.k.a. Static Mixer)**

 Option1: *KoFlo* Stainless steel static mixer

* $1,071 for six-blade stainless steel mixer w/ 0.37” ID, 4” length
* …overkill

Option2: *McMaster-Carr* Inline Pipe Mixers

* Stainless steel
* Come with 6 or 12 blades in diameters from ½” to 2” diameters
* Cost: $240-580 for 6-blade, $350-880 for 12-blade
	+ Price is pipe-diameter dependent
* More blades required for lower viscosity, but perhaps our fluid is too low of viscosity for this type of mixer to be effective

**Vacuum Pumps**

Option1: *Edwards* XDS10

* Does an excellent job thus far. I see no reason not to get another one, unless the cost ($6,257 on website) is prohibitively high
* Since shield gas (N2) won’t be recirculated, perhaps a dry pump in unnecessary. Though I would recommend one so that there are not back-streaming concerns.

**Molecular Sieve**

* Option 1: *Scientific Instrument Services* Model & Price dependent on Pipe-diameter
	+ MT-752K:
		- Traps hydrocarbons & H2O
			* NEED TO MAKE SURE CO2 is purified!
		- NW16-NW16 flange
		- 5cfm maximum flow
		- $295 for the trap + $30 for replacement zeolite charge
		- Bakeable

**Cold Trap**

* Option 1: *Scientific Instrument Services* LN2 Cold Trap
	+ NW25 flanges
	+ NEED TO MAKE SURE CO2 is trapped….though it should be at this temperature
	+ 4” diameter, 11.5” height
	+ $530. We need two: $1060

**Differential Pressure Transducers**

* Option 1: *MKS* 226A Differential Capacitance Manometer
	+ Available for several Full Scale Ranges: 0.2-1000 Torr
	+ Resolution: 0.01% of Full Scale
	+ Accuracy: 0.5% of Full –sacle
	+ Maximum Overpressure: 120% of Full Scale
	+ Maximum Line Pressure: 40psig
	+ Fitting & Full-scale range depend on model #, prices vary between $605-688
	+ I think we’d like the 20mbar version with bi-directional calibration
		- NW16-KF flange fitting
		- Terminal adaptor block electrical connection
		- $688 -🡪 Wee need two: $1376

**Pressure Transducers**

* Option 1: *MKS* Type 622B Baratron
	+ More or less equivalent to the 622A we already have (622A no longer made)
	+ Full Scale Ranges between 1 and 1000 Torr
		- Accuracy 0.25% of reading for 1-1000 Torr (Model: 622B13TDE)
		- 0.15% for 10-1000 Torr optional upon request
			* Seemingly unnecessary as our 622A does the job just fine
	+ NW16KF flange
	+ 622B13TDE price: $1104. Counting the ballast tank, we need 2: $2208 (though maybe we don’t need something so accurate for the ballast tank)

**Automated Valves**

* Option 1: *Kurt J. Lesker Company* Bellows Sealed Angle Valves
	+ Stainless Steel
	+ High Conductance
	+ Good to 10-9 torr; Leak less than 2e-9 scc/sec
	+ 24V DC
	+ KF16 or KF25 size
	+ Assuming KF25: $436, Part number SA0100EVQF
		- We need 4: 🡪$1744
* Option 2: *McMaster-Carr* Sure-Seal Stainless Steel Solenoid Valves
	+ NOT SURE WHAT VACUUM THEY’RE GOOD TO
	+ Used for inert gases
	+ For “low flow”
	+ Buna-N seal
	+ Connection type: NPT female
	+ Pipe Size: 1/8” or ¼”; 1-5/8” x 2-7/8”
	+ 120V AC or 24V DC
	+ Price: $82.36-90.27 depending on details
	+ Max PSI: 10-450 depending on details
	+ Assuming we’ll use ¼ 24VDC 10PSI max: Product # 4639K163: $84.05
		- We need 4: $336.20
* Option 3: *Swagelok* Pneumatic-Actuated Low-Pressure valve with VCR fitting (free-floating)
	+ For normally open, add –O to product # or –C for normally closed
	+ All options have ¼” fitting:
		- Female VCR: 6LVV-DPFR4-
		- Male VCR rotatable: 6LVV-DPMR4-
		- Male VCR integral: 6LVV-DPVR4-
* Option 4: *Swagelok* IGC-II surface mount Pneumatic-actuated low-pressure valve
	+ For normally open, add –O to product # or –C for normally closed
	+ 1/8”-27 NPT inlet
	+ 2-port normally opened: 6LVV-MSM-DP-2-P-O
	+ 3-port normally opened: 6LVV-MSM-DP-3-P-O
	+ ADD Indicator Switch:
		- 24” wire with in-line clip
		- Add M to product # for normally open, M-2 for normally closed

**Manual Valves**

* Option 1: *Kurt J. Lesker Company* Bellows Sealed Angle Valve
	+ Stainless steel
	+ High conductance
	+ Good to 10e-9 torr; Leak less than 2e-9scc/sec
	+ KF10 up to KF50 size
	+ Assuming KF25: $280, Part number SA0100MVQF: We need 13: $3640
* Option 2: *Swagelok* IGC-II surface-mount toggle-actuated low-pressure valve
	+ 2-port: 6LVV-MSM-DPT-2-P
	+ 3-port: 6LVV-MSM-DPT-3-P

**Regulators**

* Option 1: *McMaster-Carr* Gas Pressure Control Regulator CGA 580:0-100 & CGA320:0-125
	+ 580: 0-100: Product Number 7897A16
		- “Standard Duty”: steel & brass w/ two 2” diameter gauges & neoprene diaphragm
		- Two-Stage: Ensures a constant, steady delivery pressure, despite inlet fluctuation (One-stage is a little more than half the price)
		- 5/8”-18 right hand female
		- For Argon, Helium, Nitrogen
		- $265.16 each. We need two --🡪$530.30
	+ 320: 0-125: Product Number 7897A17
		- Same as above, but for Carbon Dioxide
		- $265.16 each. We need two 🡪 $530.30
	+ For all 4 required: $1060.60 ….5th required for storage tank?: $1325.80

**Storage Tank**

* Option 1: *McMaster-Carr* High Pressure Inert Service HP80 (Product No. 7822A14)
	+ 2,265 liter capacity (at stp)
	+ Used for Argon, Argon/CO2 blends, nitrogen, and helium
	+ DOT 3AA-2015 standards: Max pressure 2,015PSI
	+ $303.63

**Heat Exchanger**

* Option 1: *Xchanger* Model LC-12-1, ref data sheet #107241
	+ 22”x25”x27”; 200lbs
	+ …gave us quote assuming 300l/min flow instead of 5 as requested!!!!
	+ Cost: $4,470
* Option 2: *Exergy* Sanitary 17 Series Shell & Tube
	+ 0.12psi (6 torr) pressure drop
	+ Cost: $1,800
* Option 3: Couldn’t we just get away with running the gas through a helical tube?

**Gas Analyzer**

* Option 1: *Extrel* MAX300 LG Gas Analyzer
	+ Mass Range: 2-250amu
	+ 165lbs (75kg); 60cm x 49cm x 68cm
	+ NW 100CF (6 inch) flange!!!!!
	+ Dual Faraday/Electron Multiplier detector
		- Upper Detection Limit: 100%
		- Lower detection limit: 10ppm Faraday, 10ppb Electro Multiplier
	+ Communication via RS232
	+ Software 1 (Merlin): Run in scan mode or single-ion monitoring mode
		- 80 microseconds per sample in scan mode
			* “Up to 72 ions with 20 scan segments”
		- 5ms per ion in single-ion mode
	+ Software 2 (Questor 5): Analysis Rate: 400ms per component
	+ Precision: ±0.0025 absolute; 30 Day Stability: ±0.005 absolute
	+ Calibrated at factory with SF6 & again on-site with gases of our choosing
	+ $66 minimum (see full quote)
	+ Requires “very little gas”
* Option 2: *MKS* Cirrus 2 continuous gas analyzer
	+ Continuous analysis
	+ <100ppb detection of contaminants
	+ 250 data points per second
	+ 64.5 cm x 41 cm x 35cm; 34.5kg
	+ 0.2sccm gas-consumption
	+ $44,000
		- Includes travel, installation, + 1 day of training
* Option 3: *SRI Instruments* Multiple Gas Analyzer Gas Chromatograph
	+ <100ppb detection for most contaminants
	+ (Would need to be calibrated b/c a gas chromatograph)
	+ $16,275

**Ballast Tank**

* Option 1: *McMaster-Carr* ASME-Code Horizontal Pressure Tank 9426K14
	+ Need 340 liters worth of storage
		- P1V1=P2V2, P1=550torr V1=500liter, P2=800torr 🡪V2=340liter
	+ ..so we go for tank with 120gallons internal volume: 454liters
	+ Choose epoxy-lined steel: Model 9426K14
	+ 24”x67”x31”
	+ 7 openings, NPT Female type
	+ Good for down to 270torr
	+ Cost: $1128.45