The Daya Bay RPC Gas System

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Princeton U.

Daya Bay Collaboration Meeting

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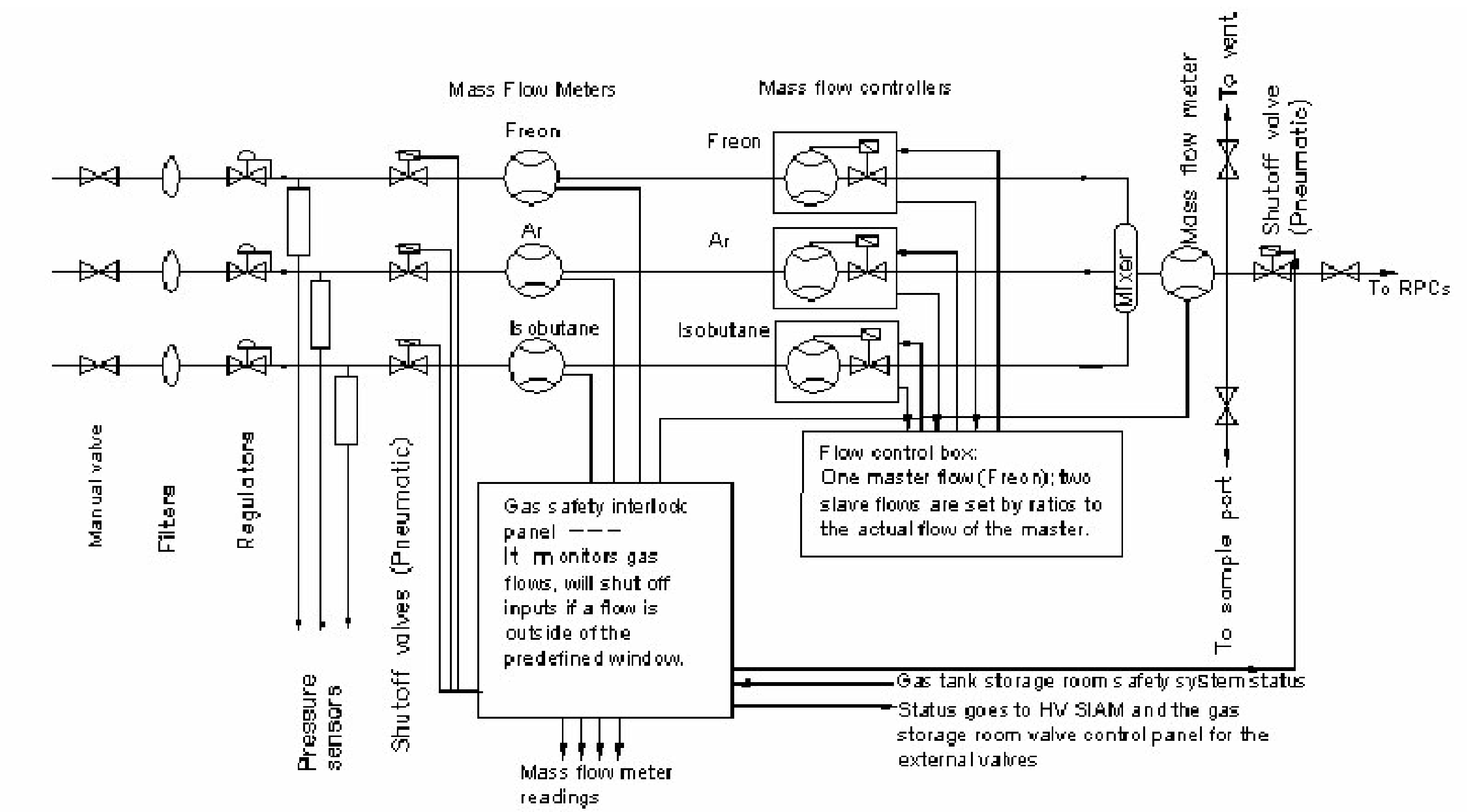


(Based on DYB-doc#743)

Introduction

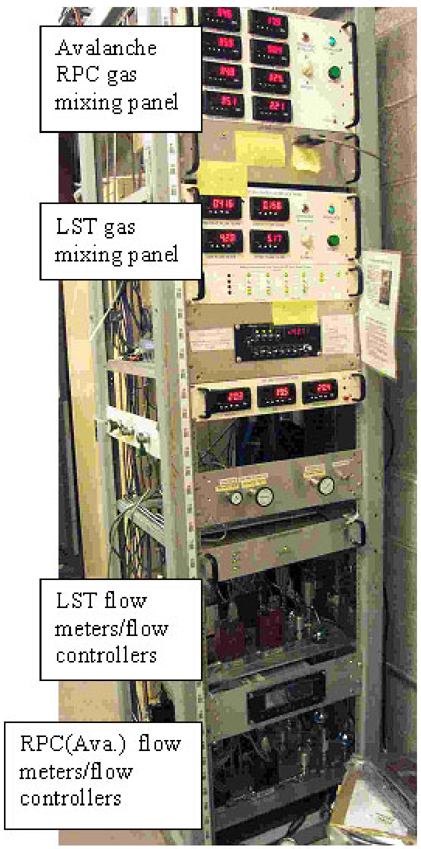
- The Daya Bay Experiment needs three identical RPC gas stations, one each for the Far Hall and the two Near Halls.
- The proposed Daya Bay gas system is based on the BaBar RPC/LST system and the Belle RPC system (both built by Princeton U).
- The first prototype proposed here can be used at any one of three sites.
- We wish to build this prototype as soon as funding permits so we can test its stability and explore its long term operational behavior.

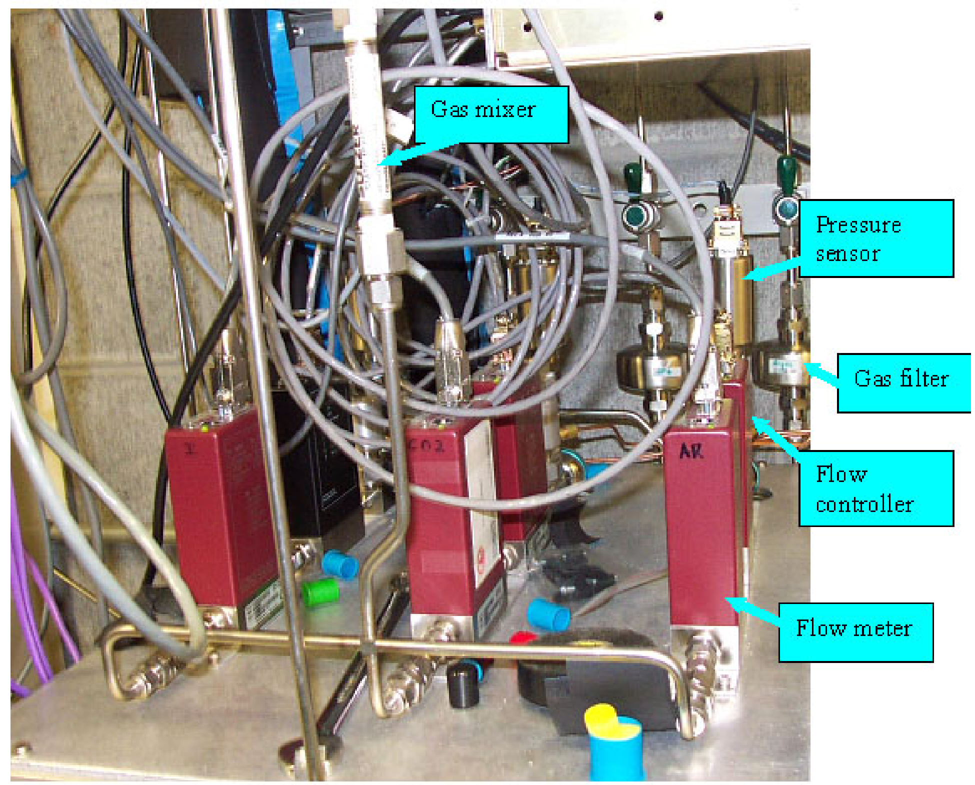
The BaBar RPC/LST Gas System

Some component redundancy to protect against equipment failure.

Three mass flow controllers which can set and display the actual flow rates for all three gas components.

Three additional gas flow meters also show the flow rates and control the shutoff valves in case any of the gases flow rates wanders outside its predefined range.





The BaBar RPC/LST Gas System, II

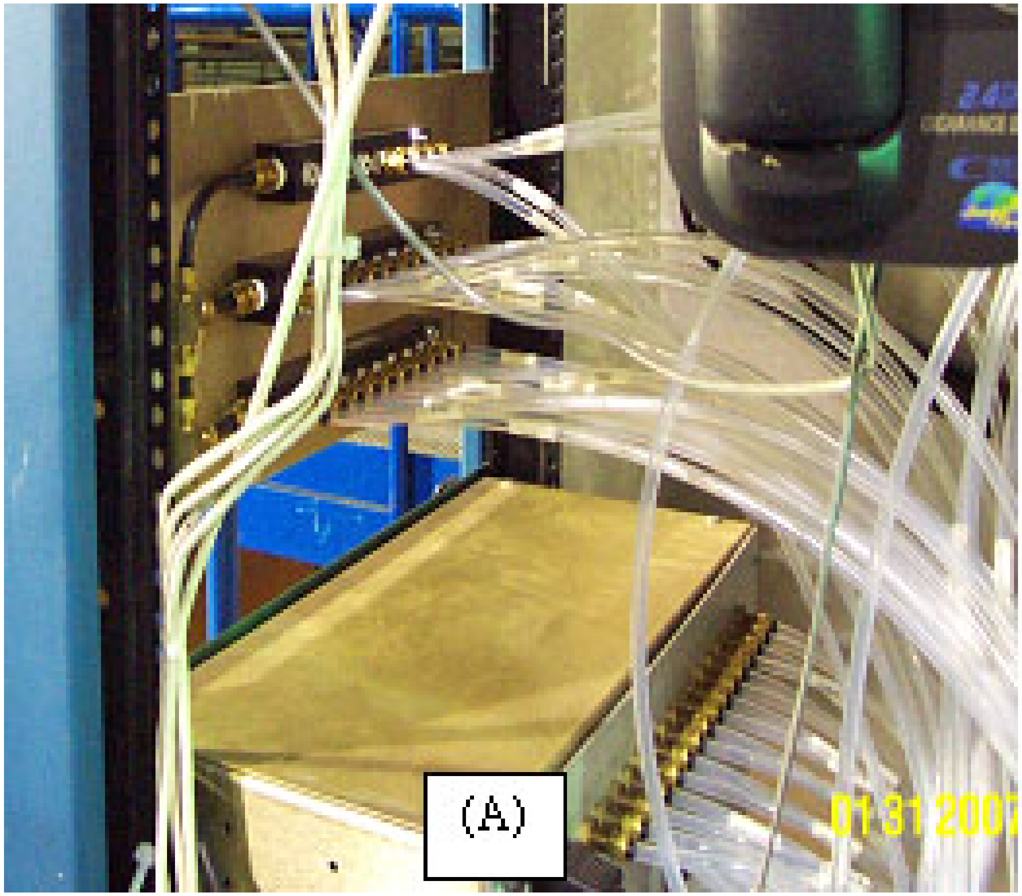
(1) Gas Safety Interlock Panel: displays flow rates and interlock status.

(2) Gas Shack Valve Panel: shuts off gas flow if fault in gas shack.

(3) Gas Mixture Control Panel: sets the desired gas mixture and flow rate.

(4) Gas Pressure Panel: shuts off gas flow if pressure outside range.

The BaBar RPC/LST Gas System, III

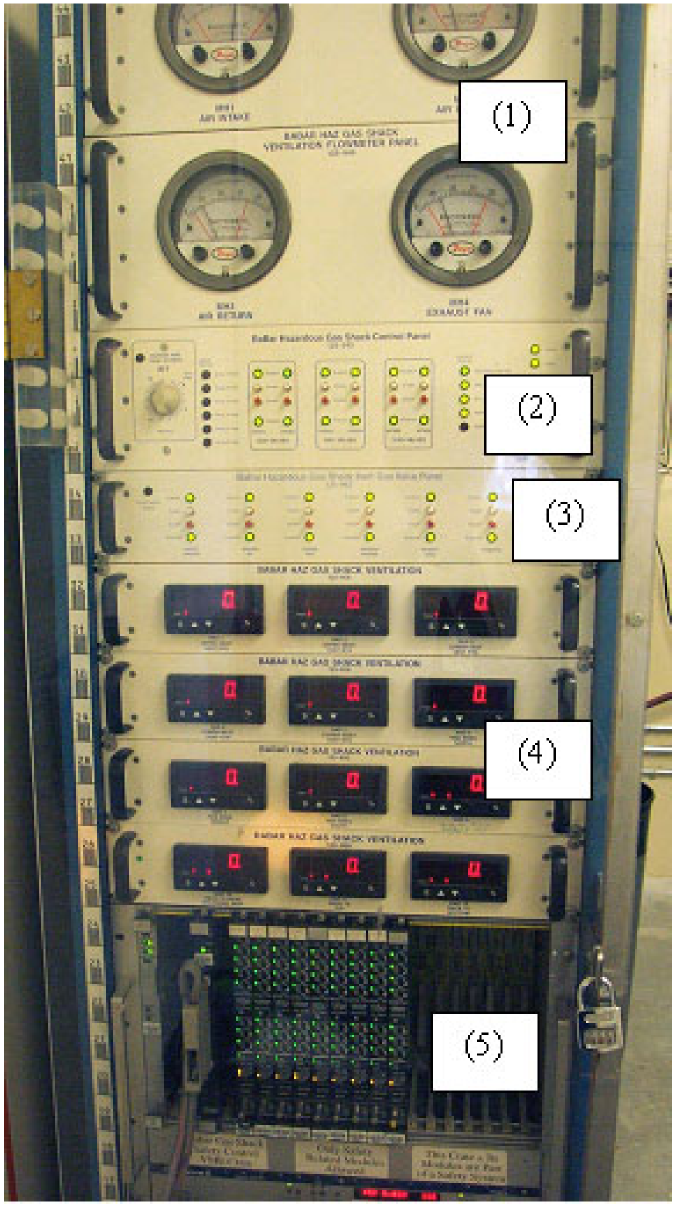


Inlet gas manifolds.

Outlet gas bubblers.

The BaBar gas system exhausted the gas into the experimental hall. We propose to do the same in Daya Bay as well.

The BaBar RPC/LST Gas System, IV



Gas Shack Control Panel: safety system independent of experimental control system.

Gas Shack Ventilation Flowmeter Panel.

Hazarous Gas Valve Panel.

Inert Gas Valve Panel.

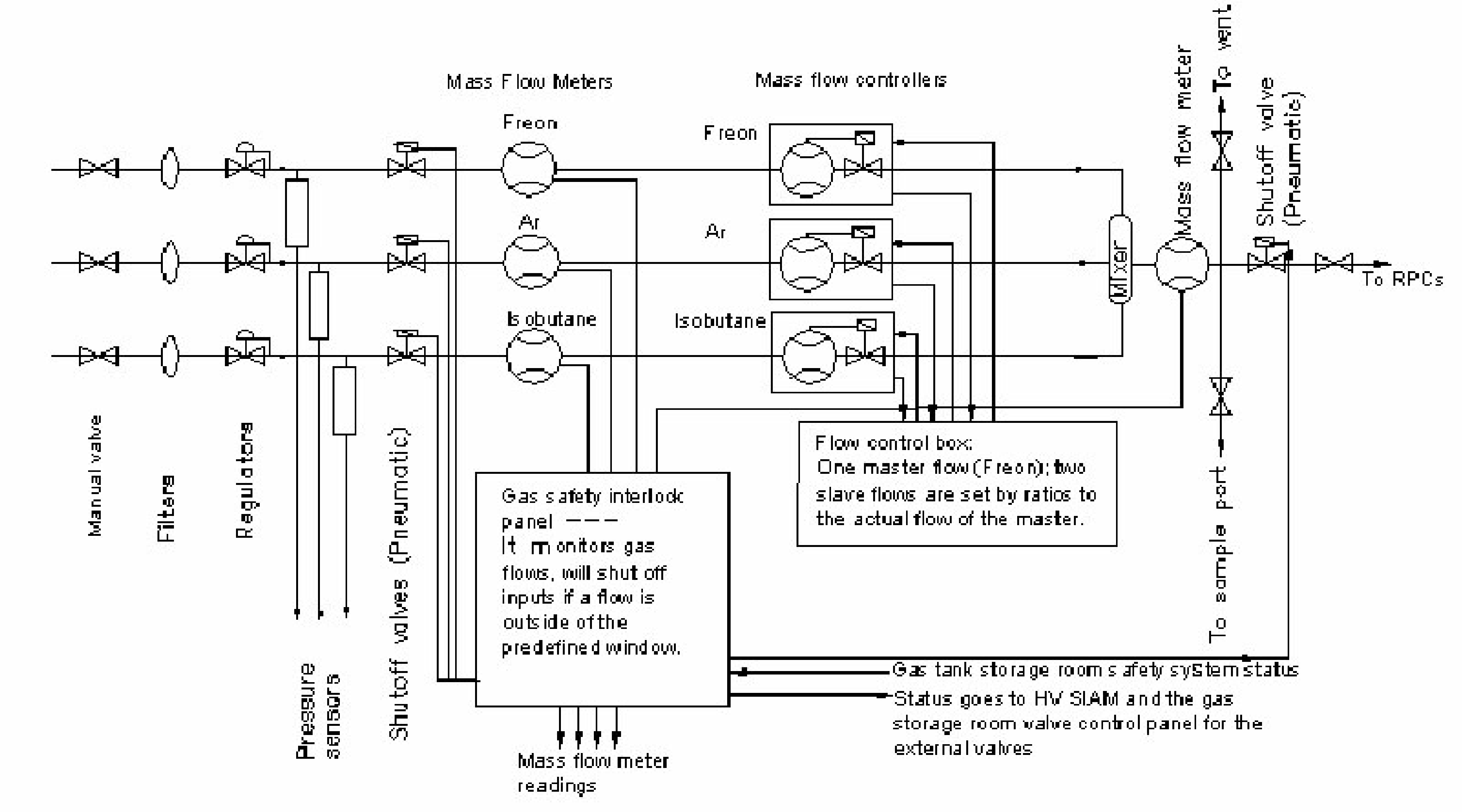
Gas Flow and Pressure Display Panel.

SIAM electronics modules.

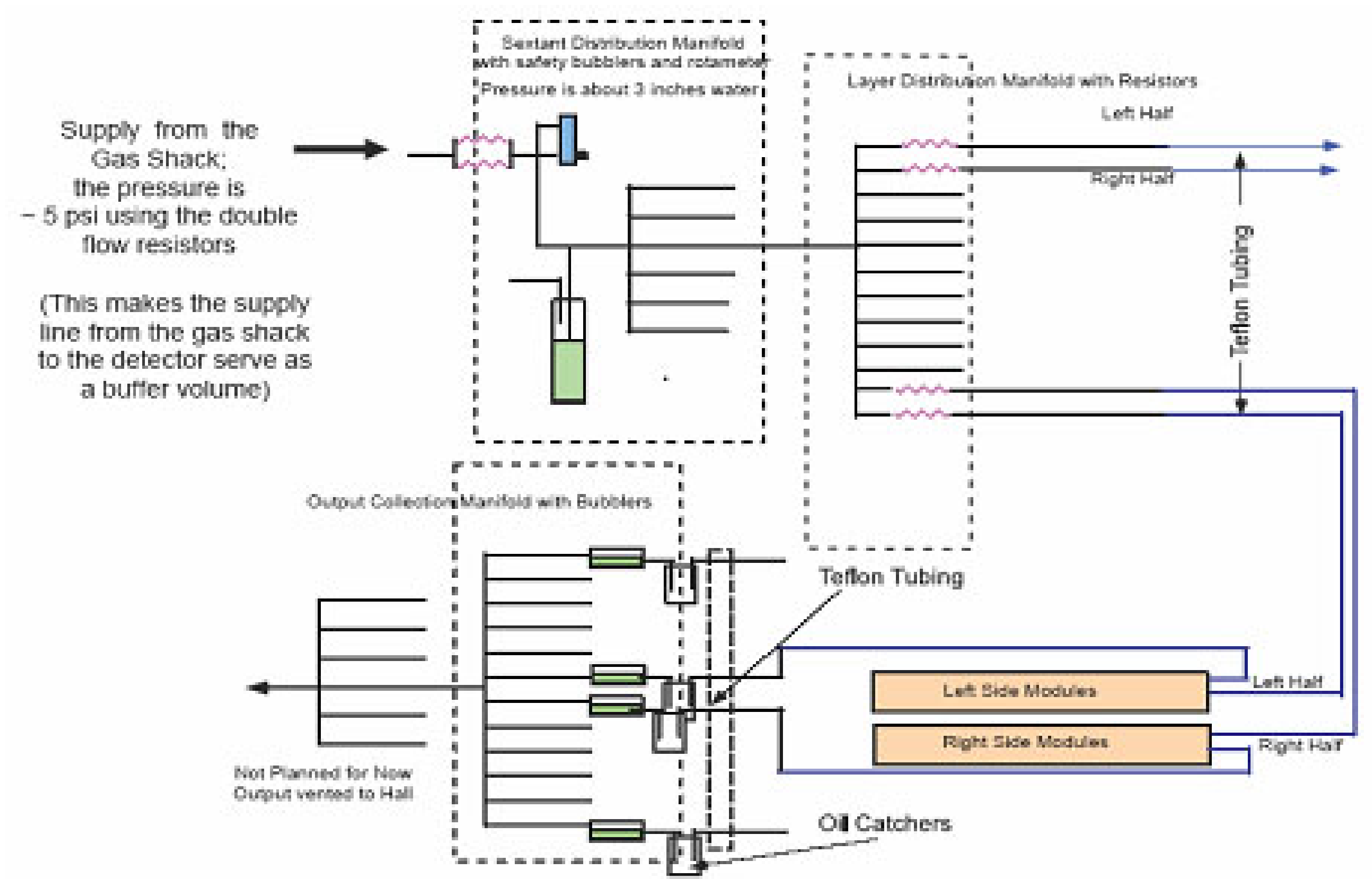
Daya Bay RPC Gas System

- $\approx 800\ 2 \times 2$ m^2 RPC modules.
- Total gas volume ≈ 7 m^2; ≈ 3 m^2 in Far Hall, ≈ 2 m^2 in each Near Hall.
- Low flow rate, ≈ 1 chamber volume/day, so can exhaust gas directly into the detector halls.
- Parallel gas distribution, to minimize effect of chamber outgassing.
- Gas mixture: R134A/Ar/Isobutane (44/50/6%), $\Rightarrow$ gas flow rates of 0.9, 1.0 and 0.12 SLM, respectively.
- Gas system based on experience of BaBar and Belle.
- Some redundancy in flow monitoring and control in primary gas system.
- Separate monitoring and shutoff control in the gas safety system.
- Evaluate use of Integrated Gas System, rather than fabrication from "discrete" components.

Overall Scheme

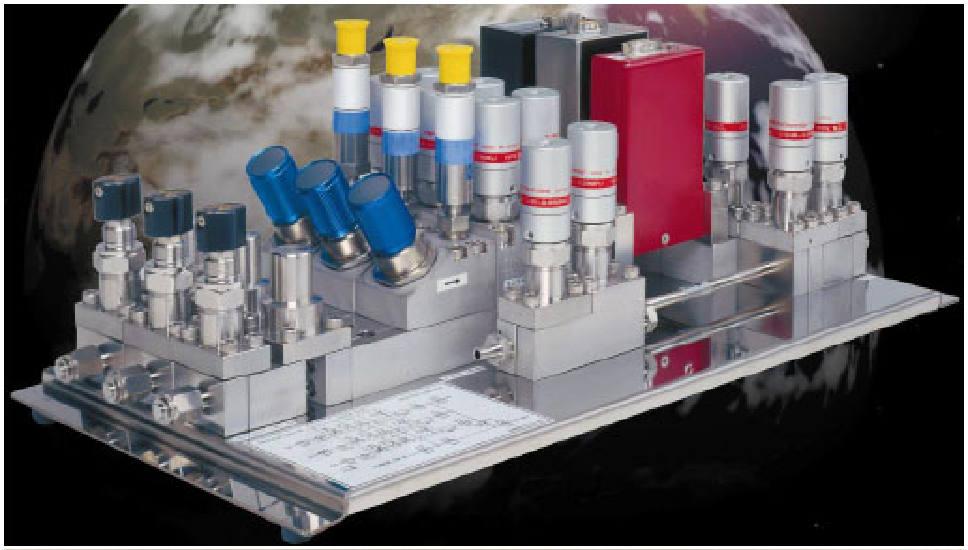


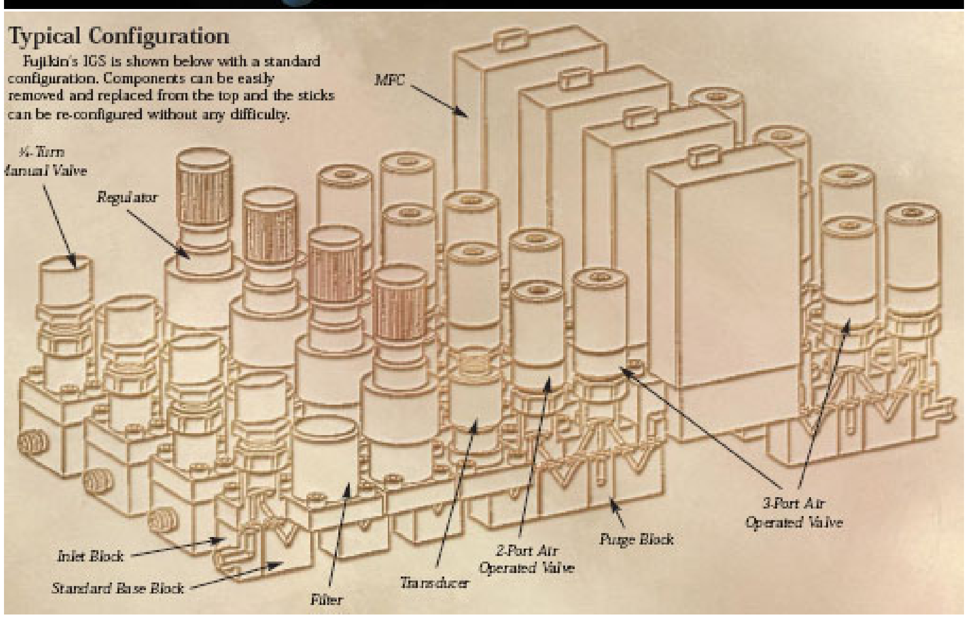
Overall Scheme, II



Fujikin Integrated Gas System

http://www.technofittings.com/pdf/igs/igsbroc.pdf





Also consider use of flow control devices based on upstream pressure control, rather than on rate of heat transfer.

Theory of Operation

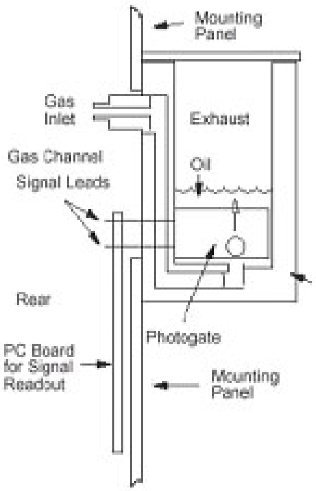
The FCS - unlike conventional mass flow controllers - is a sonic pressure flow control system.

How does a pressure-based flow control system control flow? If the absolute pressure upstream of an orifice (P_1) is at least double that of the pressure immediately downstream of the orifice (P_2), the flow rate (Q) of the gas through the orifice will travel at the speed of sound (sonic flow). Even if P_2 is decreased further - so that the differential across the orifice is even higher - the flow velocity will never exceed the speed of sound - which is a natural boundary. Therefore the flow rate Q is determined only upon upstream pressure P_1.

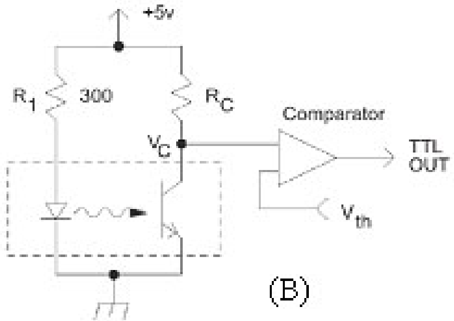
Since the gas velocity through the orifice always remains at sonic velocity, the flow rate is proportional to P1 only.

This principle is known as critical expansion, and is the principle under which the FCS is able to provide ultra-high flow control accuracy despite its amazingly simple design.

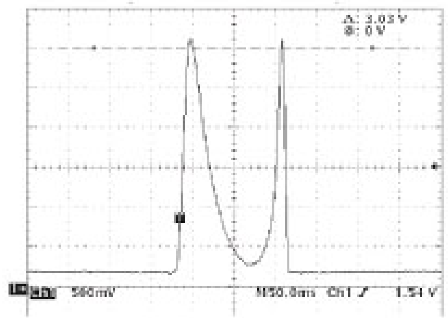
Electronic Bubblers



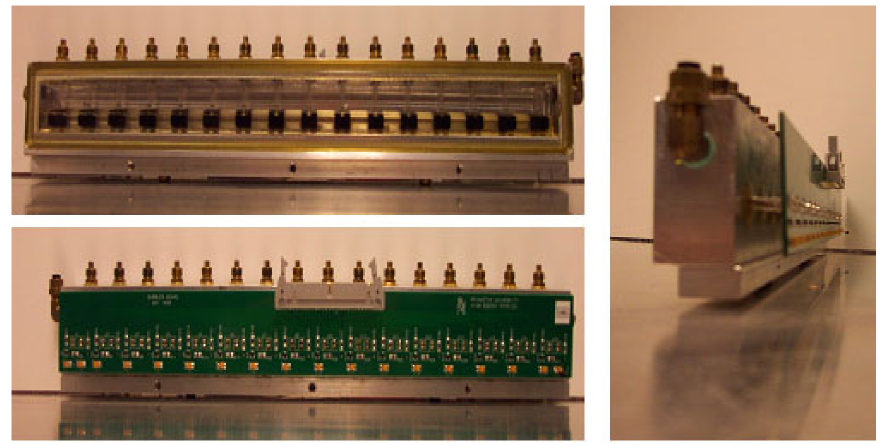
(A)

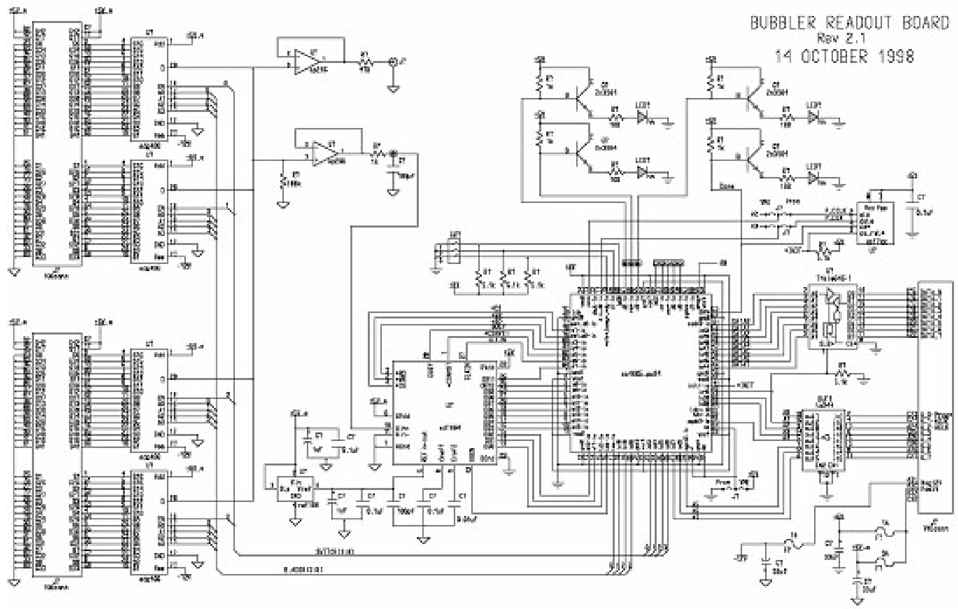


(B)



(C)





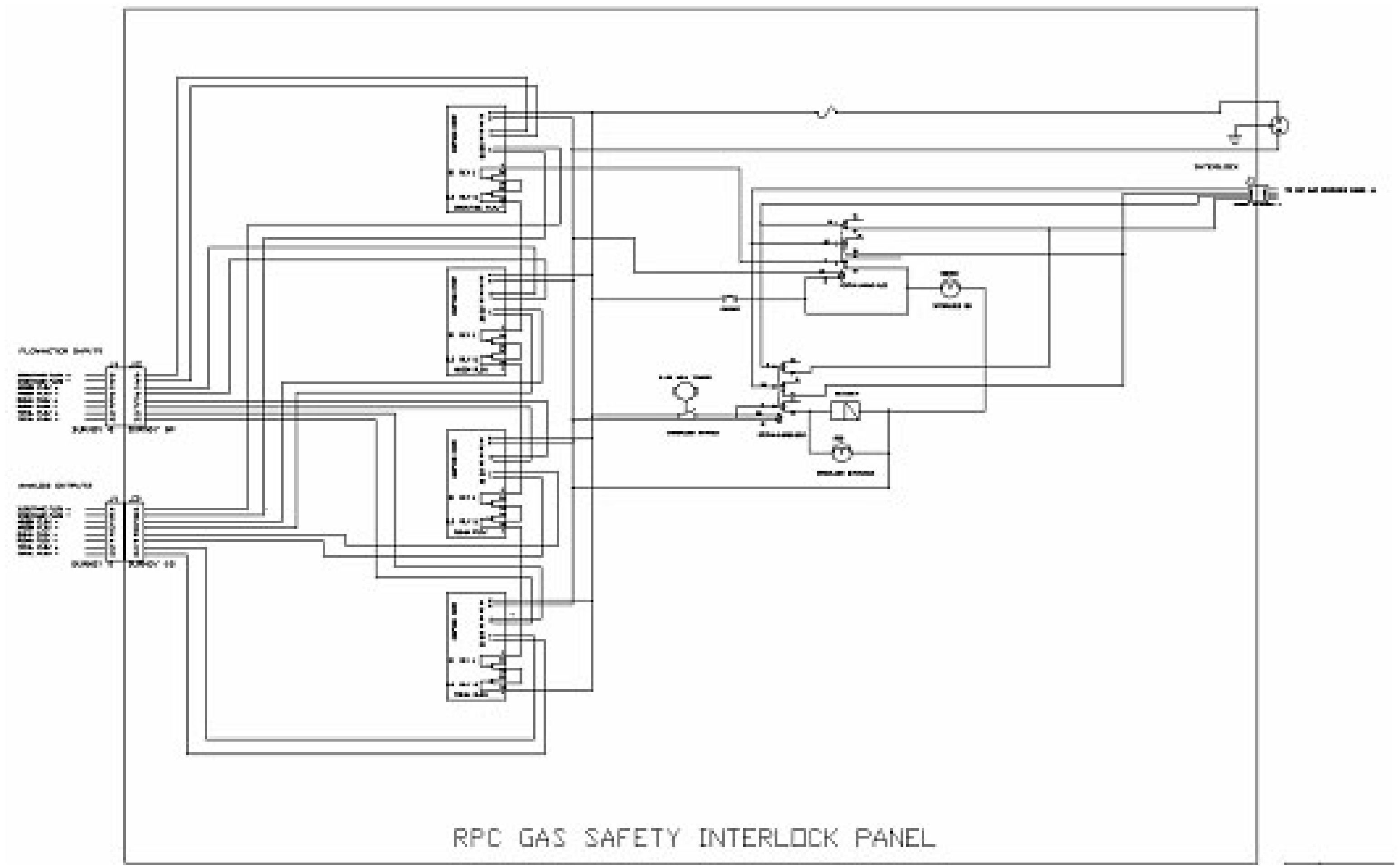
Preliminary Cost Estimate for One of Three Gas Systems

Subsystem		Item	Specs	Price/unit	# of unit	Cost/item	Subsyster
Gas mixing Rack							19058
	Components						
		1479 Mass Flow Controller	Full range 3.0	1503	1	1503	
		1479 Mass Flow Controller	Full range 1.0 SLM	1503	1	1503	
		1479 Mass Flow Controller	Full range 0.5 SLM	1503	1	1503	
		179A Mass Flow Meter	Full range 3.0 SLM	983	1	983	
		179A Mass Flow Meter	Full range 1.0 SLM	983	1	983	
		179A Mass Flow Meter	Full range 0.5 SLM	983	1	983	
		Gas Pressure Sensor	Type 890 single-ended, absolute	556	3	1668	
		247D four channel Power Supply/Readout		1482	1	1482	
		Line gas regulator		400	3	1200	
		Line gas filter		200	3	600	
		Manual shutoff valve		150	3	450	
		Solenoid shutoff valve		150	4	600	
		Gas mixer		600	1	600	
		Heaters(isobutane and Freon)		400	2	800	
		Gas regulator for gas tank		400	3	1200	
		Valve power supply		100	1	100	
		Line check valves		150	3	450	
	Rack construction						
		Swagelok/VCR fittings ($10-20/fitting)				1500	
		S.S. tubing ($8/ft)				750	
		Rack		200	1	200	
Safety system							15539
	Gas flow Interrupt Box (include Simpson controllers)						
		Simpson controller		313	3	939	
	Power Supplies for Flowmeters, pressure gauges, shutoff valves					600	
	Pressure Monitoring Box (with Simpson monitors)					1200	
	HAD sensors			1400	2	2800	
	Control Chassis & Crates					5000	
	VME crate					5000	
Fire system							
	Sprinkler, water hookup					1000	1000
Gas system Monitoring							14978
	Safety Status Monitoring						
		SIAM		1200	1	1200	
	Digital gas bubbler system						
		Bubbler board		56	23	1288	
		VME readout board		165	6	990	
		Bubbler (labor)		500	23	11500	
Gas supply site							3860
	Argon						
		Gas regulator, tubing					
		Backup 6-packs regulators		400	6	2400	
	Isobutane						
		Electric weight scale					
		Gas regulator, tubing					
		Backup tank gas regulator		400	1	400	
	Freon						
		Electric weight scale					
		Backup tank gas regulator		400	1	400	
		Gas regulator, tubing					
	Manual shutoff valves						
		Sample, Vent, Output to expeirmental hall		200	3	600	
	Flexible hose of teflon						
		1/4" I.D. braided nylon tubing, 100 ft long		0.6	100	60	
Miscellaneous							
	Various small parts not listed in the table					500	500
Grand total						54935	54935

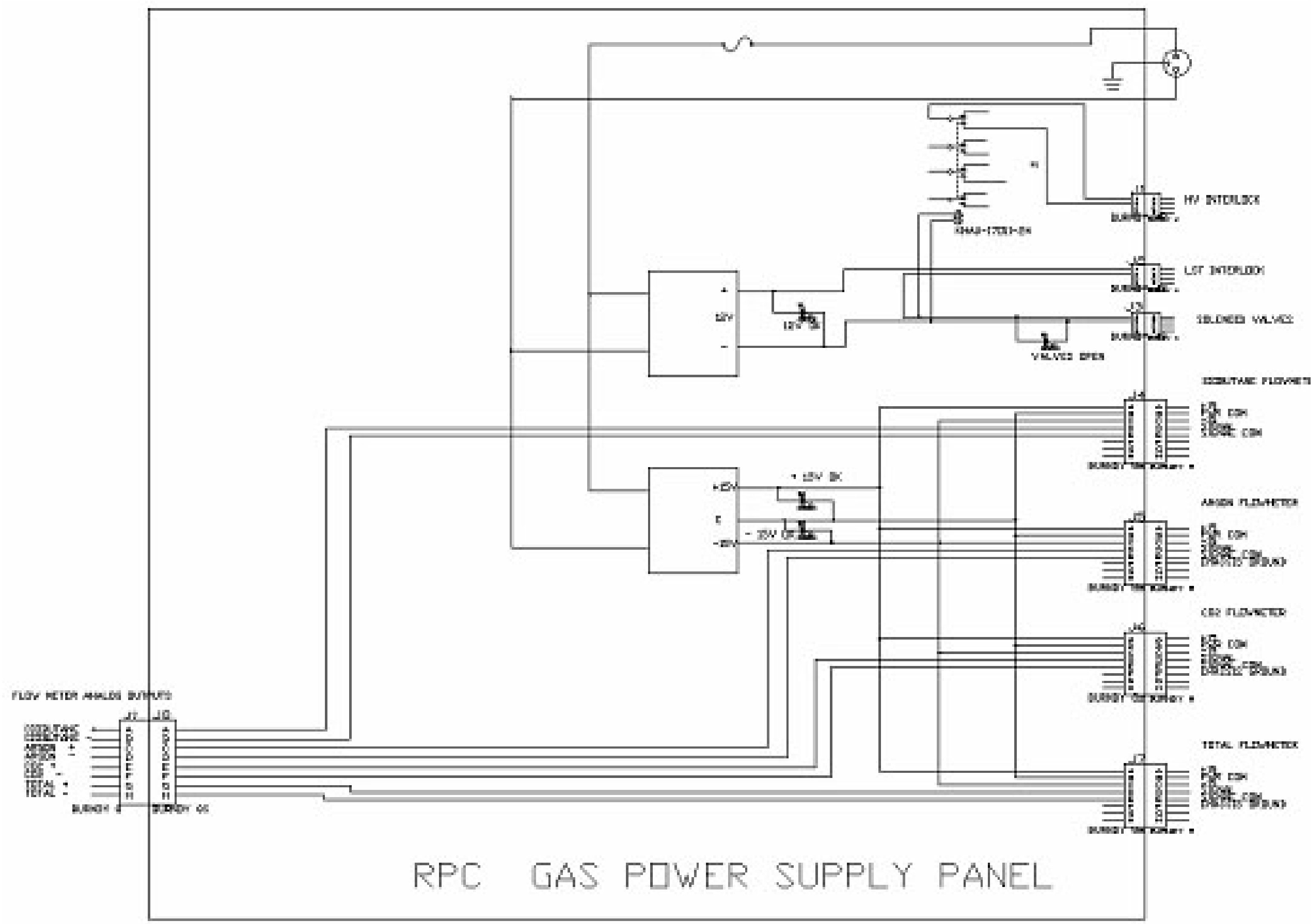
Disclaimer: This cost estimate is for a prototype system without full implementation of underground safety features.

Appendix

Gas Safety Interlock Panel



Gas Power Supply Panel



Gas Pressure Monitor Panel