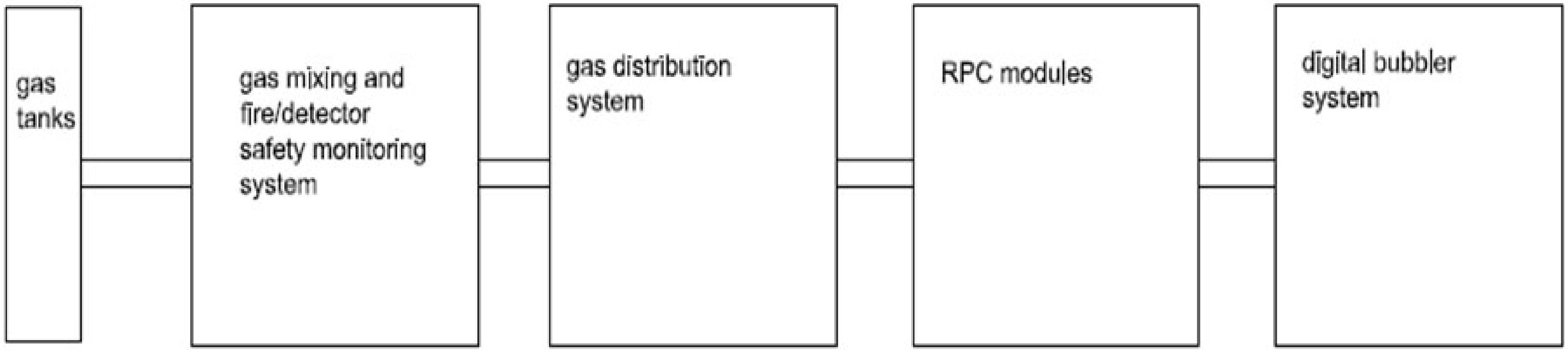
Outlines

- Gas system overview;
- Location of gas system;
- Plan view of gas/gas mixing room;
- Daya Bay RPC gas mixture flammability analysis;
- Gas cylinders underground;
- Isobutane gas cabinet, HAD sensor; air flow sensor and controller, cylinder switchover panels;
- Gas pressure rating of tubing and fitting used in gas system;
- Schematic diagram of gas system plumbing.

Overview of the RPC Gas System

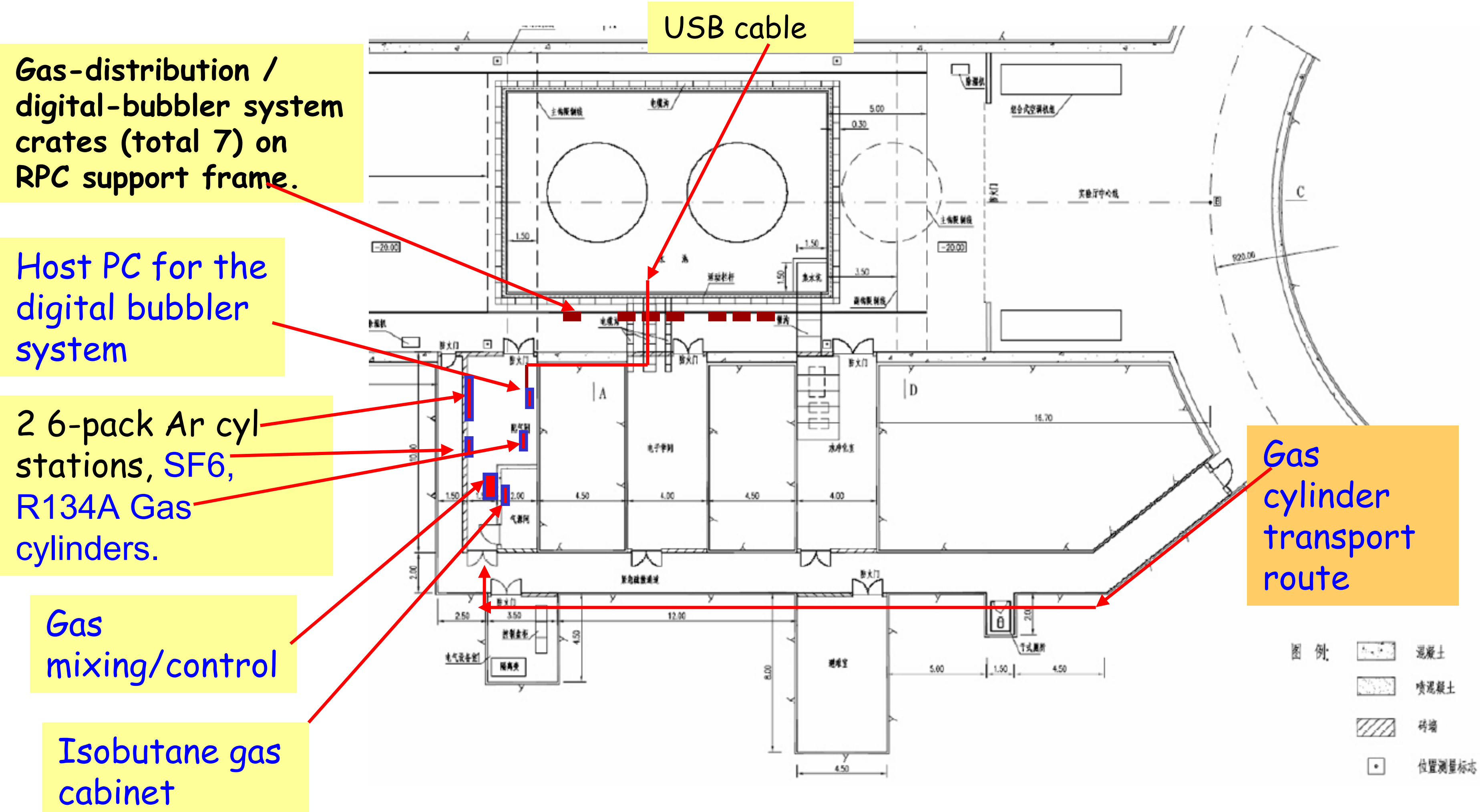


The RPC gas system has five major components:

- The gas storage bottles, including the bottle changeover system
- The gas mixing and fire/detector safety monitoring system
- The gas distribution system
- The RPCs
- The gas exhaust system, including the output bubbler system.

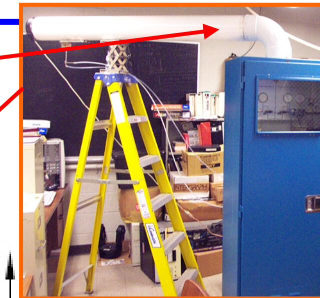
The hazardous gas safety system. but not the ODH system, is part of the RPC gas system scope.

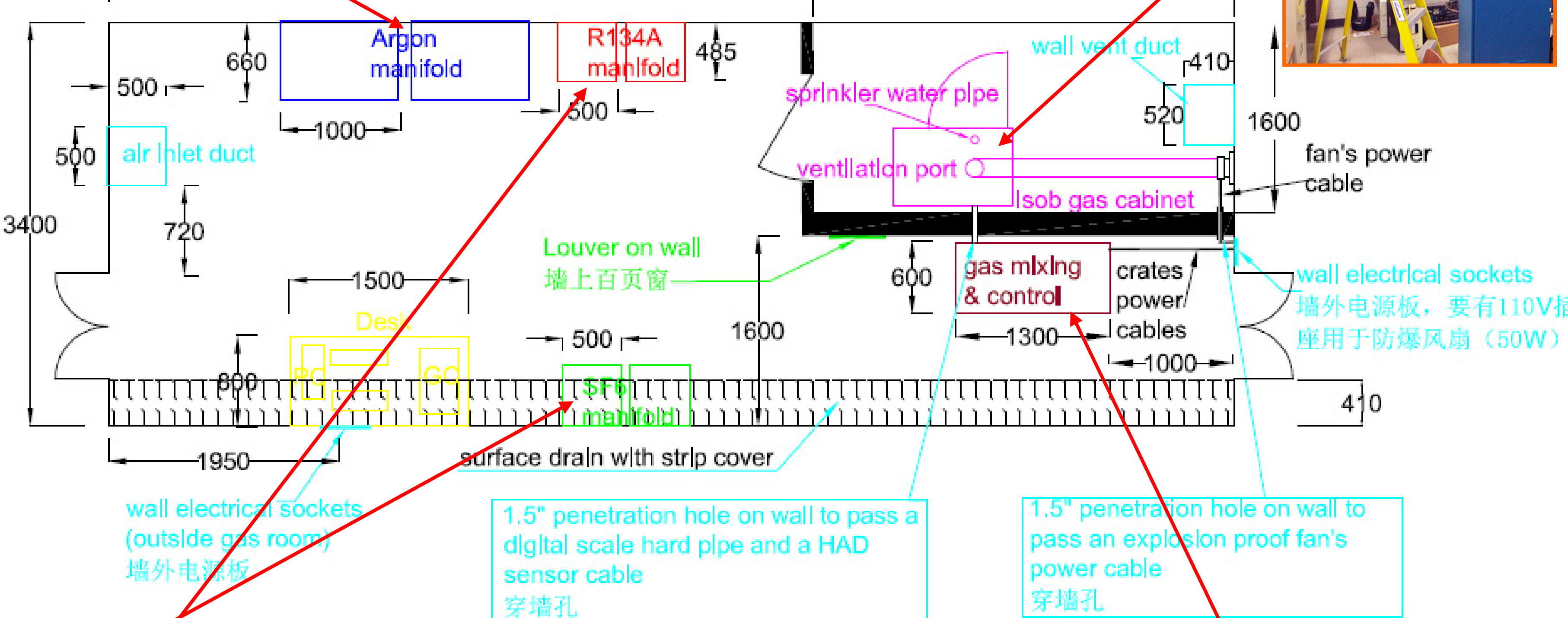
Location of the Gas System in the Daya Bay Near Hall (#1)

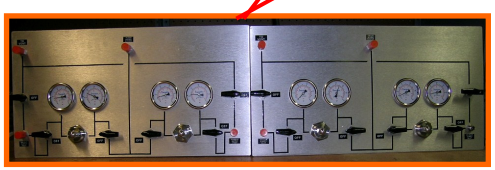


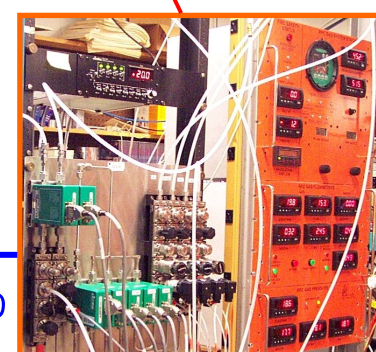
Layout of the gas/gas mixing rooms

Galvanic 6" pipe and elbow









RPC Gas Flammability Analysis

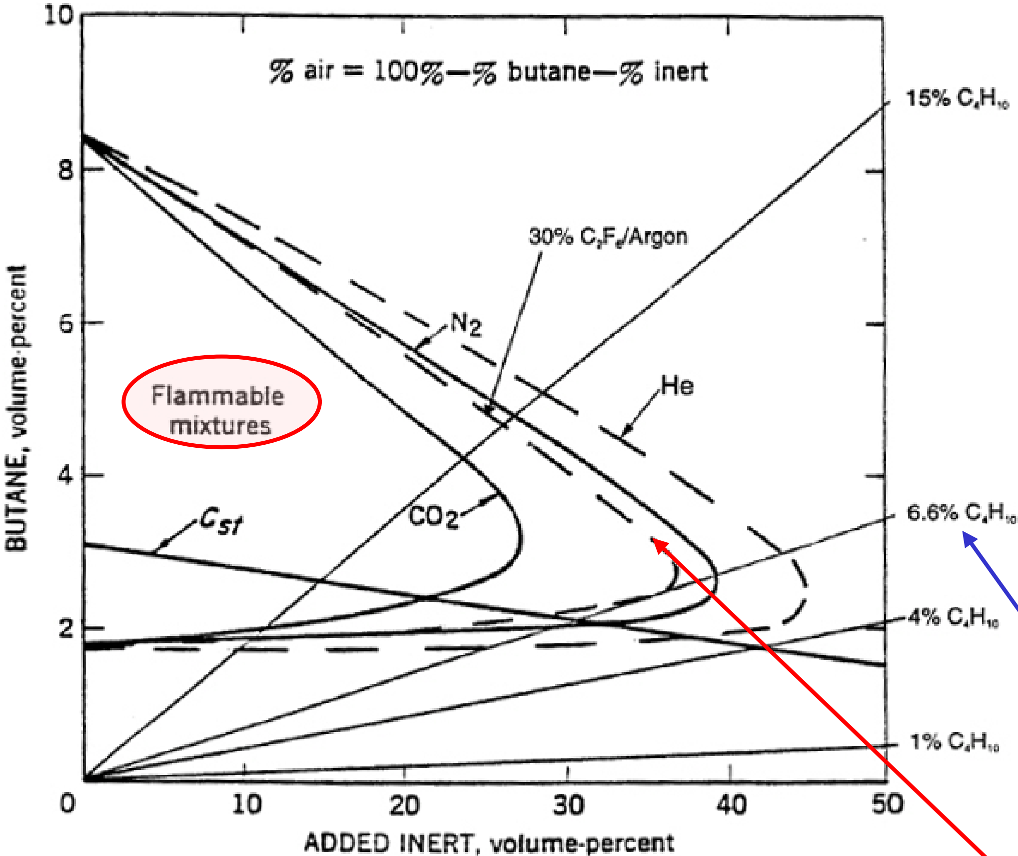
During the BaBar detector construction SLAC hired Hughes Associates, Inc. to perform an analysis of flammability hazards for the entire detector.

The fire hazard associated with the use of butane (C_4H_{10}) gas mixtures in BaBar was one of the analyzed items. (Hughes report: Doc-DB #574)

http://puhep1.princeton.edu/~mcdonald/dayabay/BaBar_gas_system/SLAC-FHA.pdf

Here we shall briefly mention the main conclusion that is relevant to our assessment.

Flammability Diagram for Butane with Argon/C_2F_6 in Air



The figure shows the flammability regions for several butane/inert gas mixtures in the air.

The curves for butane/N_2 and butane/CO_2 are from lab tests by the, Bureau of Mines (Zabetakis, Bulletin 627).

Any point in the plot corresponds to a gas mixture of **butane/inert gas/air** with the mixing ratio of **y/x/(100-y-x)**.

If the point falls into the corresponding flammable region, this mixture is flammable.

Hughes **calculated** the gas mixture of 30% C_2F_6/balance Ar with Isobutane, because C_2F_6 is very similar to R134A ($C_2H_2F_4$), especially in heat capacity.

The flammability limit of Isobutane in this gas mixture is 6.6%.

Daya Bay Gas Mixture Flammability Analysis

- To be conservative we could use an alternative gas mixture: Ar/R134A/Isobutane/SF_6 (65.5/30/4/0.5).

  The previous slide shows this to be non-flammable.

  Recent tests done by OPERA RPC group (DocDB #2278) show a very similar gas mix with good performance and ~1000V HV plateau higher than original OPERA gas mix.

  Since our HV supply can provide +/- 4000V, this gas mixture won't call for any modification to the present RPC and HV design.

  http://puhep1.princeton.edu/~mcdonald/examples/detectors/paoloni_lnf-08-14.pdf

- The advantage of this gas mixture is obvious: the RPC system downstream from gas mixing panel won't need to be categorized as a flammable gas control area.

Number of Cylinders Underground

There is a tradeoff between frequency of transport/changeover of bottles *vs.* degree of oxygen deficiency hazard and flammable gas hazard from leaks at bottles.

In addition to bottles in use, a second set of bottles should be underground at all times.

The following configuration ⇒ 60 bottles underground

[plus 3 more argon bottles for the Emergency Purge System (slides 24-26)].

Exp. Hall	Gas	Cylinder	Location	Days/90% of cylinder used
Near Hall	Ar	6 cyl. @1800psi	Mix. Room	30
	R134A	100kg	Storage Room	39
	Isobutane	9kg	Mix. Room	43
	SF_6	4kg	Storage Room	61
	He	Cyl. 80, 85 ft^3	Mix. Room	➢180 days
	N_2	Cyl. 80, 85 ft^3	Mix. Room	> 1 year
Far hall	Ar	6 cyl. @1800psi	Mix. Room	19
	R134A	100kg	Storage Room	25
	Isobutane	9kg	Mix. Room	27
	SF_6	4kg	Storage Room	38
	He	Cyl. 80, 85 ft^3	Mix. Room	➢180 days
	N_2	Cyl. 80, 85 ft^3	Mix. Room	> 1 year

Isobutane Gas Cabinet

As suggested by D. Beavis, isobutane cylinders will be stored in a gas cabinet, which incorporates Class I, Div. 1 electrical devices, such as gas sensors, sprinklers, and solenoid valve.

In each gas cabinet we'll install two HAD sensors (one inside and the other outside), one air-flow sensors, an electronic digital scale, a manual scale, and cylinder changeover panel.

In addition, the cabinet volume must accommodate two 9-kg Isobutane cylinders.

Water sprinklers will be installed inside of the gas cabinet and in the gas room.

Isobutane Gas Cabinet (cont'd)

Features:

- All welded construction using 11-gauge steel, epoxy painted. Texture finish on outside, smooth finish on inside of cabinet.
- Exhaust vent located on top of cabinet is 6" diameter x 3" high.
- 165°F sprinkler head on top of cabinet is coated with bees wax.
- Removable white back panel mounts to inside rear cabinet.
- Cylinder brackets or lecture bottle brackets are adjustable for precise pig-tail alignment.
- Door and window will close and latch automatically.
- Window is 1/4" thick clear wire glass.
- Louvers at bottom of door.
- Flush mounted stainless steel paddle latch.
- All stainless steel fasteners.

Options:

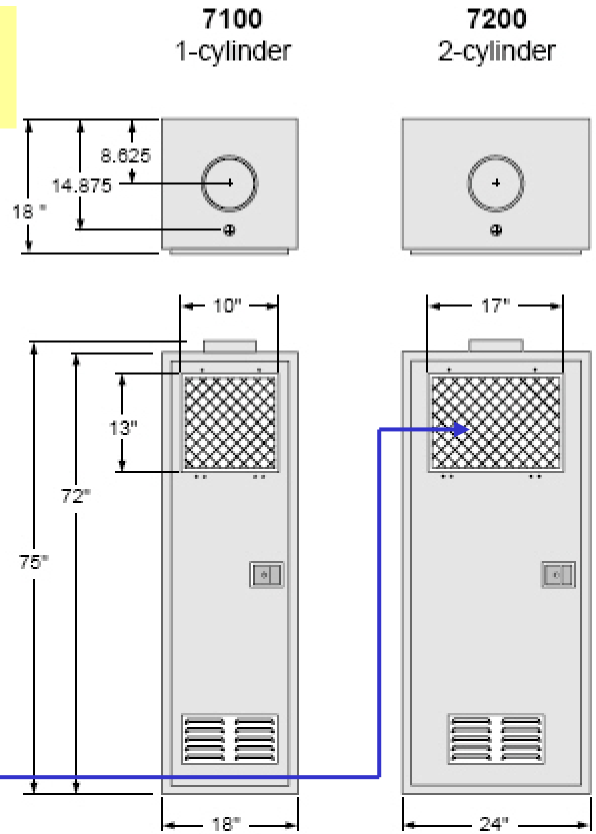
- Dome roof configurations
- Keyed door latch
- Air intake filter
- Custom colors
- Wall mounting brackets
- Full-length back panel

SAFETY EQUIPMENT

Safety Equipment Corporation
1141 Old County Road
Belmont, CA 94002
(650) 595-5422
Fax (650) 595-0143
E-Mail: Info@SafetyEquipmentCorp.com
Web: SafetyEquipmentCorp.com

ventilation duct

Fresh air in



The Uniform Fire Code requires 150-200 linear ft/min of air through the window opening, that should be provided by the experimental hall ventilation system.

$1300

This is the lowest quote we have obtained to date.

HAD Sensor

One candidate of such HAD sensor is RAEGuard LEL.

The **RAEGuard LEL** is a permanently mounted (fixed) catalytic bead combustible gas transmitter that operates from 9 to 36 VDC power source and provides a 4-20mA analog output in the range of 0-100%LEL combustible gas. The microprocessor based circuit is housed in an explosion-proof enclosure, the **RAEGuard LEL** is equipped with a local digital display of the gas concentration and function keys for performing calibration. The **RAEGuard LEL** is operated with a standard 4-20mA controller or as a stand-alone sensor module.

Key Features

- Highly poison-resistant catalytic bead combustible gas LEL sensor
- 4-20mA analog output of 0-100%LEL combustible gas including methane, acetylene, propane or other combustible gases
- Explosion-proof enclosure for hazardous environment application
- Magnetic key interface eliminates need to open explosion-proof housing when making calibration or other minor adjustments
- Operation at 9 to 36 VDC
- Dry contact output (<30V, 2A)

Applications:

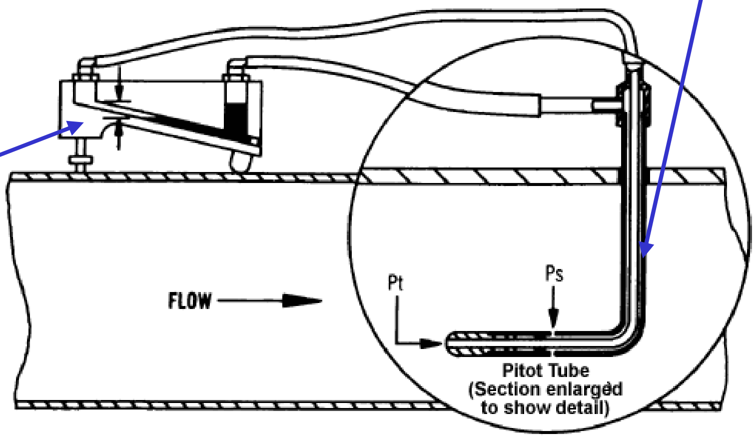
- Refineries
- Oil production
- Chemical plants
- Industrial safety
- Shipyard and maritime
- Power plants
- Steel mills

Hazardous Location Classification:

- UL: Class I, Division 1, Groups B, C and D
- Temperature Code T6

Air Ventilation Sensor and Controller

Working principle: Pitot tube to measure the air velocity.

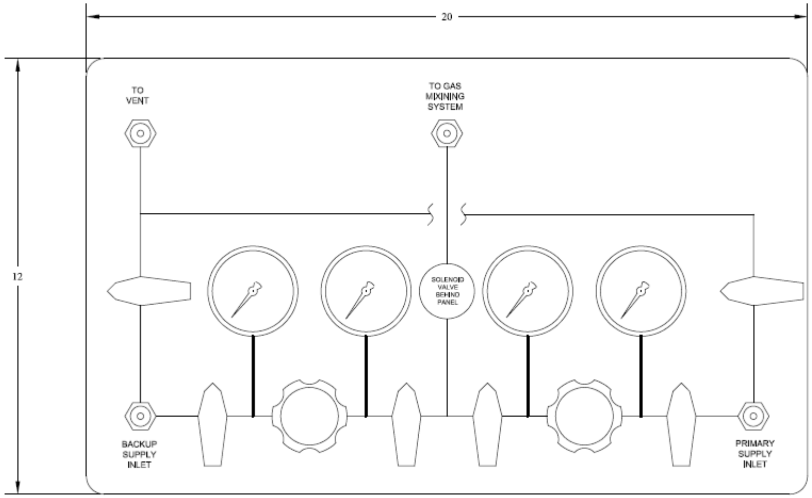


Pitot Tube senses total and static pressure.
Manometer measures velocity pressure –
(Difference between total and static pressures).

Pt is the total pressure, Ps is the static pressure.
Notice the sensing holes for these two pressures.
The manometer shown on the left can measure the pressure difference between Pt and Ps, this is Pv, the air velocity pressure.

Dwyer seriies DH Digihelic differential pressure controller

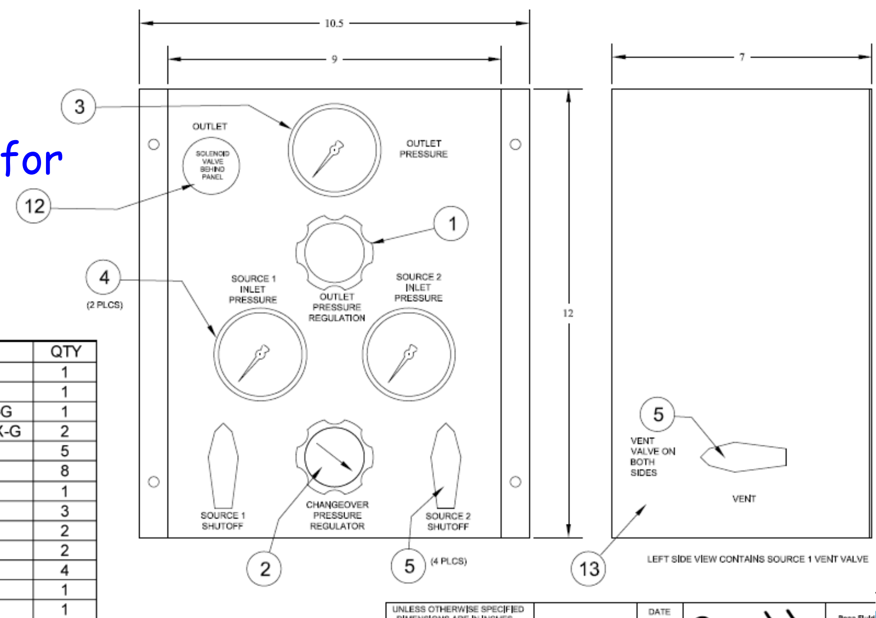
Gas switchover panels



Manual switchover panel for R134A, SF6 and Isobutane.

All tubing/fitting used on these panels are s.s.

Automatic switchover panel for Argon.



ITEM	P/N	QTY
1	KPR1ERL412A60000	1
2	KCS10FW412A2000	1
3	PGI-63C-PG300-CAQX-G	1
4	PGI-63C-PG5000-CAQX-G	2
5	SS-43GS4	5
6	SS-400-2-4	8
7	SS-4-P	1
8	SS-400-6	3
9	SS-400-3	2
10	SS-401-PC	2
11	SS-T4-S-035	4
12	E22N9DCCM	1
13	PANEL	1

Swagelok fitting/copper tubing rating

Swagelok tube fitting ends are rated to the working pressure of tubing. For ¼" pipe, 316 S.S. male fitting up to 8000 psig, female fitting up to 6600 psig; brass male fitting up to 4000 psig; female fitting up to 3300 psig. These ratings are much higher than highest pressure in our gas system (primary pressure of the argon cylinder is ~2100 psig). All tubing before the outlet of gas mixing panel is either stainless steel or copper. The plastic tubing is only used for connecting the gas distribution crate and RPC module where the gas pressure is just few cm water column above ambient pressure.

Schematic diagram of gas system plumbing