Daya Bay RPC Gas System: Safety Subsystem

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Outline

- Consideration to the Daya Bay RPC gas safety subsystem: ventilation, HAD, ODH;
- Experience from BaBar gas safety subsystem;
- Daya Bay RPC gas safety subsystem design;
- Cost estimation
- Summary

Safety issue of the Daya Bay gas system

Safety related issues for the Daya Bay RPC gas system:

(1) Flammable isobutane used in the gas mixture;

(2) Underground environment related oxygen deficit hazardous risk;

(3) Correctness of the gas mixing ratio to protect RPC chambers.

The gas safety subsystem should be able to monitor/control:

(1) Ventilation system status;

(2) Isobutane level in the environment (% of Lower Flammable Level, LFL);

(3) Gas flow rate for each gas;

(4) Gas tightness for each flow branch (not discuss in this report);

(5) Standalone hardware to handle the emergency situation and provide all signals for the slow control system.

Ventilation of the gas storage/mixing rooms

The ventilation system is the most essential core for the safety of the RPC gas system. As long as the ventilation system is working properly, the flammable and oxygen deficient issues won't threat the experiment.

We have to install air flow monitors at several critical points of the ventilation system in the gas storage/mixing rooms. If warning sign appears at any of these locations, the safety subsystem will shut off all gas bottles at the gas storage room and all gas inputs on gas mixing panel at once.

The air flow rate will be monitored by Photohelic pressure gauge and Pitot tube. The Pitot tube installed on the ventilation duct will deliver the total pressure and static pressure in the air flow to the Photohelic switch/gauge/transmitter, which measures the air flow velocity and controls the switch operation accordingly. According to BaBar's experience this setup is reliable, need very little maintenance except change the filters.

HAD sensors

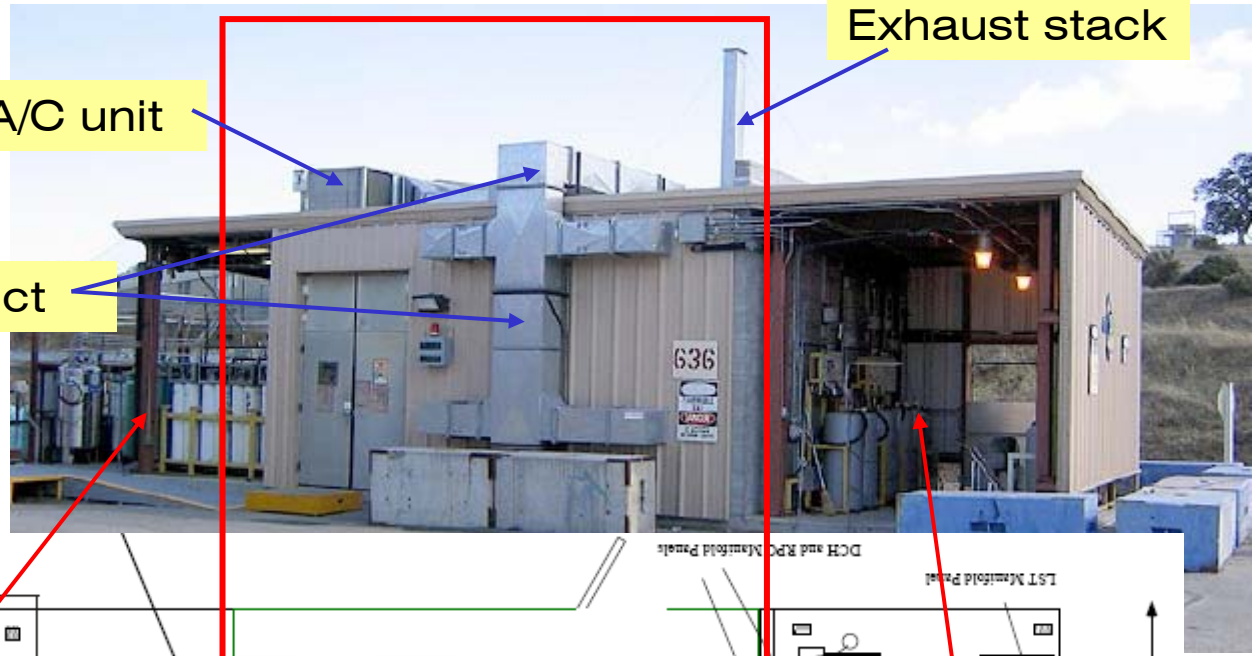
For the gas storage room and mixing room there is unavoidable gas leakage from isobutane tank and tube fittings, also the human's error, such as leaving loose gas fitting in the gas system during the bottle replacement, may cause unexpected gas leakage, therefore the HAD sensors installed in these places are the second defend line in our safety subsystem.

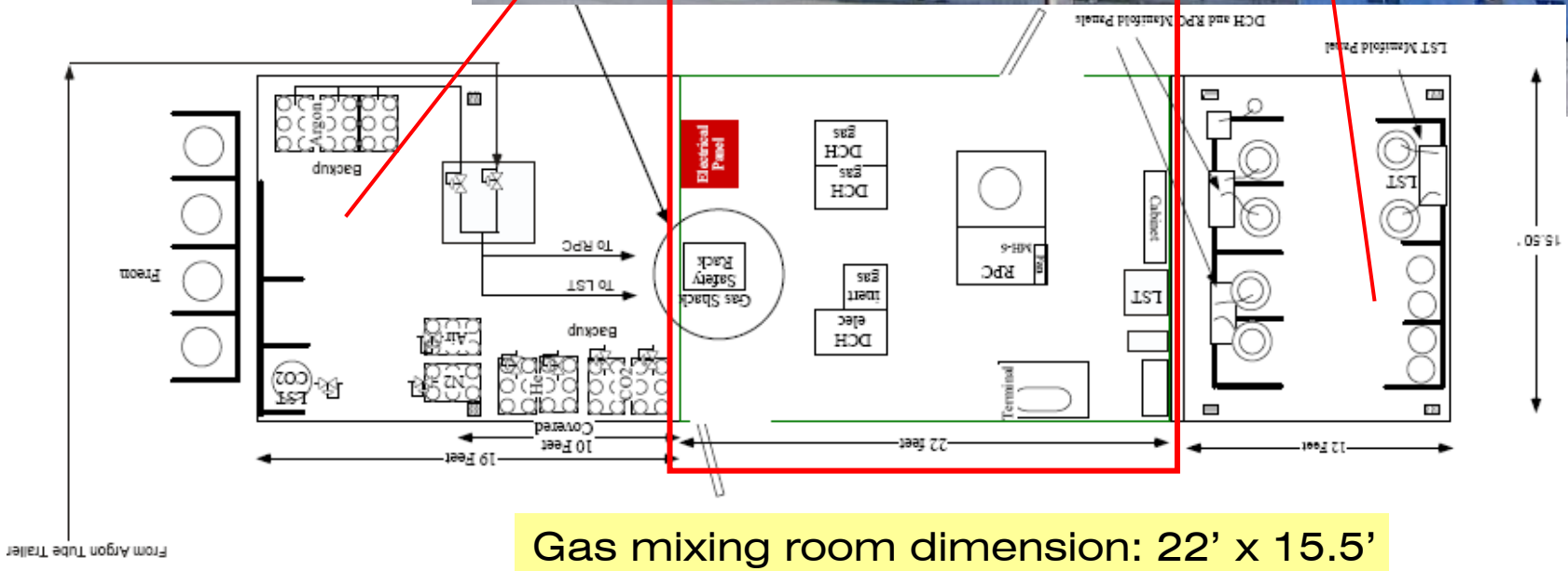
HAD sensor can detect the level of the specific flammable gas (in our case isobutane) in the atmosphere with the unit of % of LFL. Usually we set the alarming limit at 10% of LFL, in such case the system will automatically shut off all gas bottles and all inputs on the mixing panel.

Oxygen deficiency sensor

Since our lab is underground that is different from accelerator experiment situation, but as Dana has analyzed that " ... at present no failure rates high enough have been identified to consider the (gas) mixing room to require an ODH classification", for the simplicity and cost reduction, we'll not add ODH sensors into our system.

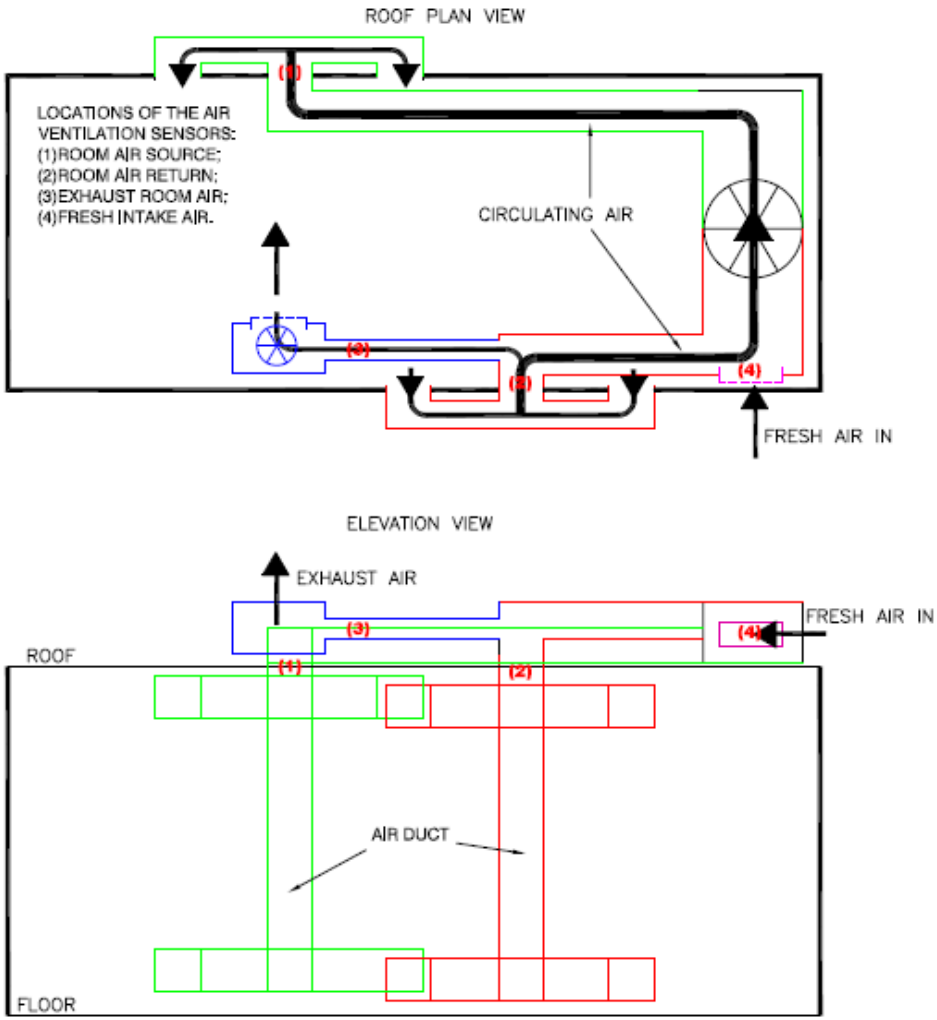
BaBar gas shack





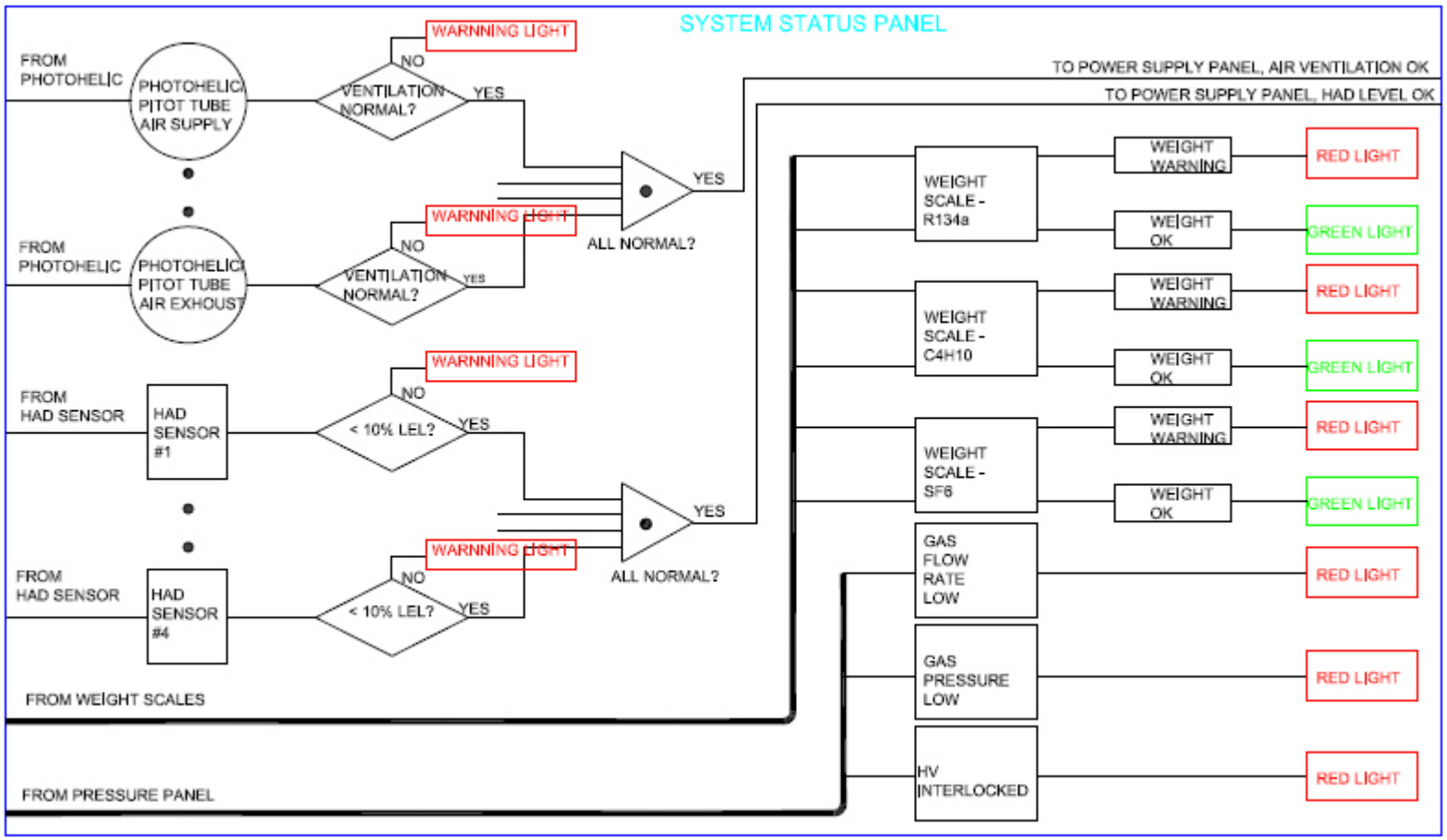
Gas mixing room dimension: 22’ x 15.5’

BaBar gas shack ventilation system



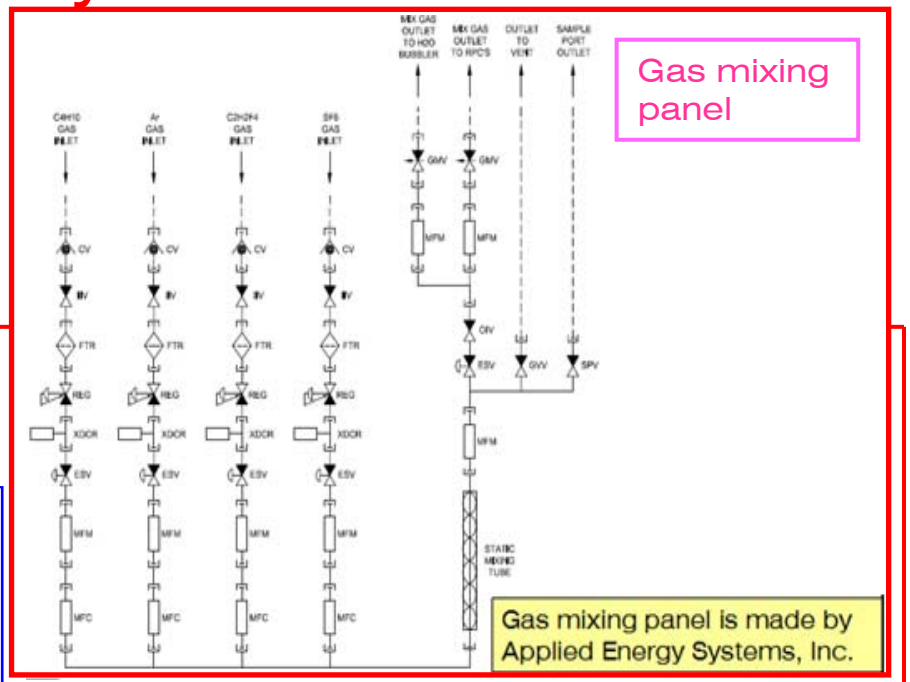
BaBar gas shack's air ventilation system circulates the room air with the air flow rate @2800CFM (the volume of gas shack is ~3400 CF), which is measured by sensor #1; part of it, 600 CFM, exhausted from above roof, and monitored by sensor #3; main part, 2200CFM, is returned to the system and monitored by sensor #2; fresh intake air, 600 CFM, is added to the circulating air flow, and monitored by sensor #4.

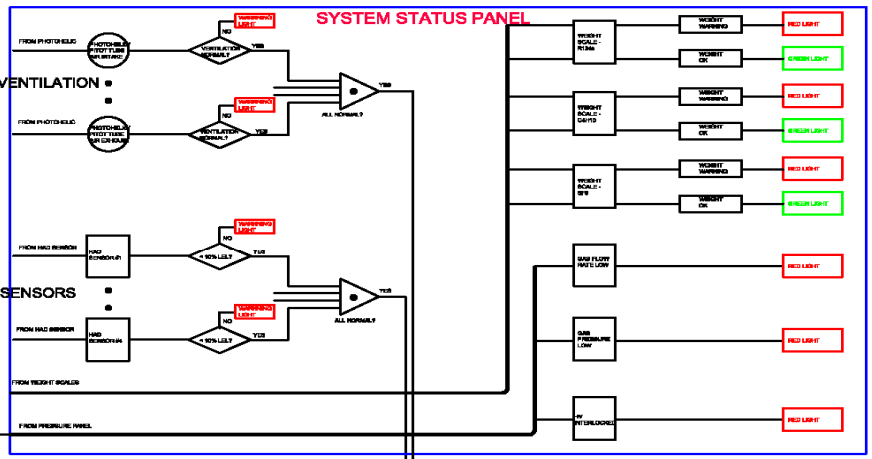
Block diagram of Daya Bay RPC gas safety subsystem

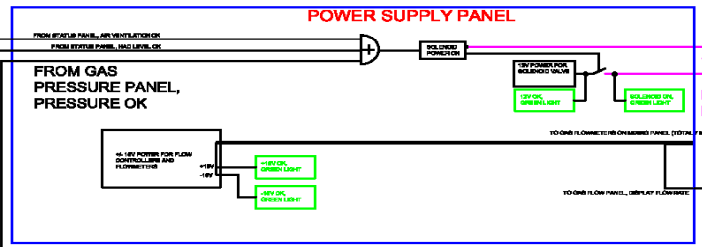


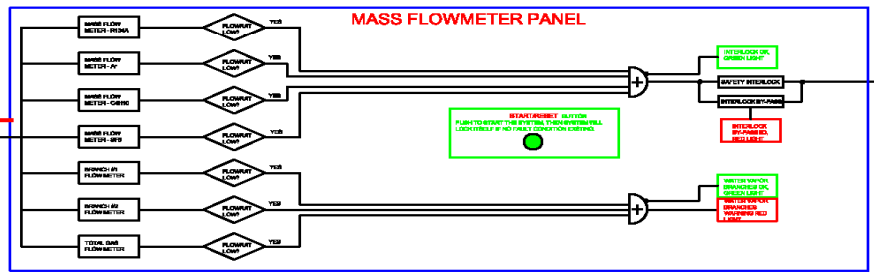
Block diagram of entire gas system

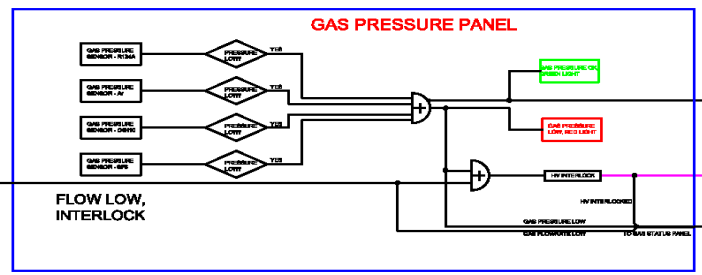
(1)Gas mixing panel; (2)Mass flowmeter panel; (3) Gas pressure panel; (4) Power supply panel; (5) System status panel.











Cost estimation of the safety subsystem

GAS SYSTEM STATUS PANEL										
Part Discription	**QTY**	**PRICE ea**	**DISTRIBUTOR**	**DISTRIB #**	**TOTAL PRICE**	**SOURCE OF QUOTE**	**Sub-total**	**# of sets**	**Total**	**Grand total**
24V converter	1	$95.00	Newark	83F2437	$95.00	Lambda kwd15-1212	$9,996.44	3	$29,989.32	$36,698.24
conn 12pin male-female	1	$10.00			$10.00					
conn 4pin male-female	5	$10.00			$50.00					
conn 8pin male-female	3	$10.00			$30.00					
Fuse	4	$5.00			$20.00					
krpa-11dn-24	1	$12.44	Newark	21F1087	$12.44	TYCO_Relay_KHAU_11DN				
LIGHT	14	$2.00			$28.00					
Power Socket	1	$5.00			$5.00					
HAD sensor (EX-5100)	4	$1,145.00	Enmet Corp.		$4,580.00	Email quote from Enmet. Http://www.enmet.com				
Simpson H335	4	$265.00			$1,060.00	Email_quote_Simpson_meter				
Photohelic 3000SGT	8	$418.00	Dwyer Instruments		$3,344.00	http://www.dwyer-inst.com/htdocs/pressure/Series3000Price.cfm				
Pitot tube (160-8)	8	$46.75	Dwyer Instruments		$374.00	http://www.dwyer-inst.com/htdocs/airvelocity/Series160Price.cfm				
Mounting accessories for Pitot tube	8	$48.50	Dwyer Instruments		$388.00	http://www.dwyer-inst.com/htdocs/airvelocity/Series160Price.cfm				
Front Panels 6u (19"x10.5")	1	$42.00	Newark	25B6425	$42.00	BUD PA-1106-BT	$538.00	3	$1,614.00	
Panel Silkscreening	1	$200.00			$200.00					
PCB board (size 150 sq"??)	1	$296			$296.00					
HAD sensor calibration equipment	1	$265.00				Email quote from Enmet.	$265.00	1	$265.00	
Labor	hours	charge/hour			Total cost					
PCB designs	16	85.82			1373.12		$4,829.92	1	$4,829.92	
panel deigns	8	85.82			686.56					
EP Lab	16	87.32			1397.12					
Assembly	16	85.82			1373.12					

Total for three halls: $37,000

Summary

- The core of the safety issue for Daya Bay RPC gas system is the air ventilation;
- BaBar ventilation system in gas mixing room is reviewed;
- HAD sensors to detect the % LFL for isobutane in environment;
- ODH monitor can be omitted according to Dana's analysis;
- Based on BaBar's experience Daya Bay RPC gas safety subsystem has been designned;
- The estimated cost for the safety subsystem is ~$37,000 for all three halls.