

## **The BaBar Drift Chamber Gas System**

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## 1. Introduction

The BaBar detector is composed of several subsystems. This document specifically describes the gas system for the BaBar Drift Chamber (DCH). It has been established in compliance with the SLAC-Preliminary Safety Assessment Document-BaBar SLAC-I-023-30000-000 (March 1996); the BaBar Hazard Classification is rated LOW.

The drift chamber represents a volume of 5m<sup>3</sup> filled with a gas mixture of 80% He and 20% C<sub>4</sub>H<sub>10</sub>. Gas will flow at approximately 15 l/min, giving one volume change every 5 to 8 hours. The system is able to run in semi-closed mode, with 10–15% of the gas vented, or in a completely open mode, where all gas goes to vent. The characteristics of the gas (pressure, composition, purity and temperature) are crucial to the DCH operation and will be controlled carefully.

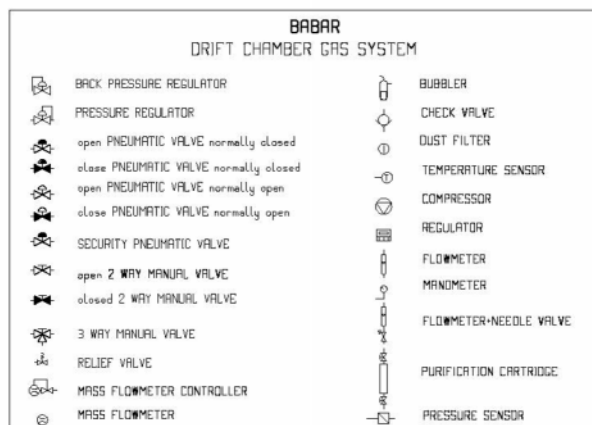
The BaBar Drift Chamber gas system is constructed with the following objectives in mind:

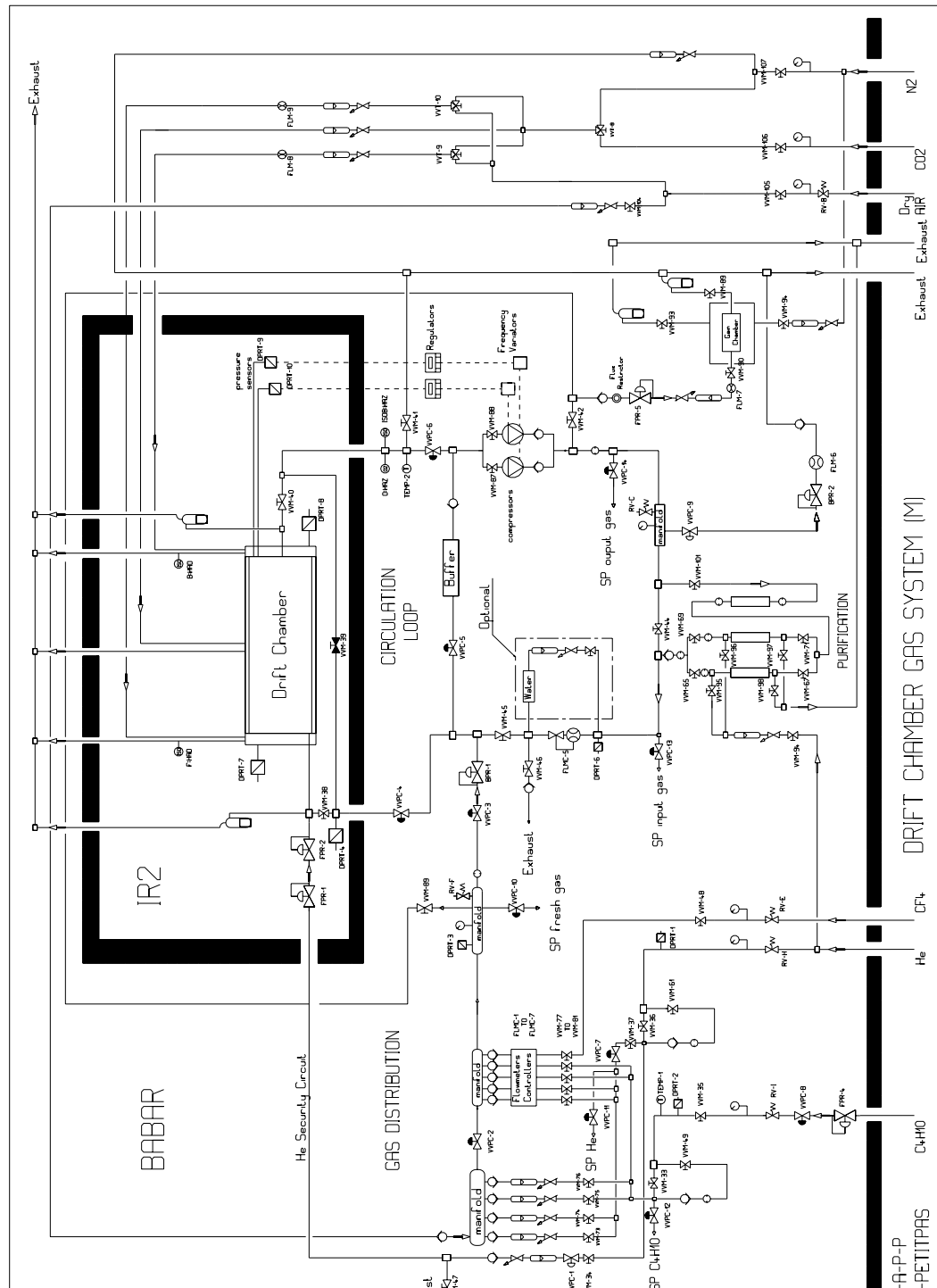
- Safety and long term reliability, including hardware safety control;
- Preparing the gas mixtures;
- Setting up the flows and pressures in the chamber;
- Gas recirculation and purification;
- Monitoring the different parameters delivered by the sensors.

The gas system is divided into few subsystems: distribution, circulation, analysis, monitoring, purification and safety control, over three locations: the gas pad, the gas hut (building 636) and racks B620D–9 and B620D–10 ("rack 10") on top the detector. Figure B1 is schematic of the complete system.

This document describes all the components and their functionality. More details are available on the web at <http://wwwlapp.in2p3.fr/babar/dch/gas/gas.html>.

*Figure 1. The drift chamber gas system (below and following page). Analysis sample points are labeled by "SP". Items in the box labeled "IR2" are located in racks 9 or 10 (B620D-10) except for the chamber itself; all other items are in the gas hut.*





## 2. General Description

### 2.1 The gas supply

SLAC is responsible for the gas supply contract with local vendors, and for the pipes from bottles to the gas shack and from the shack to IR2. Specifications for the shack and its safety system are described elsewhere.

### 2.2 The Gas Distribution

Design considerations for this function are:

- Precise gas mixture 80% He and 20% C<sub>4</sub>H<sub>10</sub> for data taking.
- Neutral gas input for shut downs, and chamber bulkheads.
- Water vapor input, for anti-aging properties (optional).
- Higher flow for purging.
- Possibility for a 3rd gas component.
- Manual or EPICS operation.

The fresh gas coming from the gas source is filtered and can be controlled for oxygen and humidity before mixture. All fresh gas pipes after the flowmeters converge on two static mixers from where the gas can flow to the chamber. A back pressure regulator ensures enough pressure (~300 mbar) in the gas input line for the analysis system. The gas input lines can be opened or closed by pneumatic valves. All pneumatic valves are equipped with a status sensor read out by the slow control computer.

### 2.3 Gas mixing station

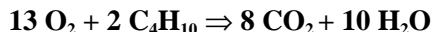
The system maintains the correct gas mixture, independently of temperature or atmospheric pressure, during data taking. It provides the possibility for a 3rd gas component, such as CF<sub>4</sub> or CO<sub>2</sub>.

The gas mixture and flow control is obtained using mass flowmeters and rotameters. Depending on the running conditions a different set is used. The list of available flows is at the end of this document.

### 2.4 Purification system

As the presence of oxygen in the gas affects the drift chamber performance, we have installed an oxygen purification system.

The purification is based on the following catalysis reaction on Palladium:



The reaction is activated by heating the Palladium at 180° C. The produced water is absorbed in an alumino-silicate molecular sieve. The system is installed in a separate rack (B636-07) and is composed of the following elements:

- The Palladium cartridge is wrapped inside a thermal insulation jacket and is heated with a resistor during normal system operation.

- Two molecular sieve insulated cartridges. One cartridge is used during normal operation and is not heated. The second cartridge can be regenerated in 24 Hours by increasing its temperature up to 250° C while flushing Helium at 2 lt/mn. This flushing is performed through a dedicated circuit going to the exhaust.
- Filters have been installed before and after the cartridges in order to avoid any aluminosilicate dust, migrating in the gas system.
- The insulation ensures that there is no high temperature hazard. The only part that is hot is located at the very bottom of the Palladium cartridge and cannot be touched by mistake.
- The regeneration of the molecular sieve is performed manually. An increase of the water content of the gas after the purification system is the indication that the sieve is saturated and should be regenerated.

## 2.5 Helium security line

The "Security line" is a separate He line that runs from the distribution rack to the chamber input manifold. When the chamber pressure drops below a threshold (~2.5 mbar) the line is opened and He flows until the pressure is above threshold. A rotometer sets the maximum flow rate to 4 lt/min, and a vent valve allows the line to be tested.

## 2.6 The chamber envelopes and the outer cylinder

The forward (~200 l) and backward (~1000 l) envelopes are flushed by CO<sub>2</sub> or Nitrogen. The gas in the rear bulkhead can be switched (via lockable valve) to dry air to allow work in this region. The gas in the forward bulkhead can independently be switched to air, but, as the suffocation risk does not exist in this region and to avoid any possible confusion, the valve is not lockable.

Operation during the 1999 cosmic run has shown that the relative pressure in the bulkheads stay well below the one in the chamber.

The outer cylinder is flushed with CO<sub>2</sub> or N<sub>2</sub> only.

**Table 1 : Neutral gas flow in the envelopes**

| Region         | Nitrogen flow   | CO <sub>2</sub> flow |
|----------------|-----------------|----------------------|
| Rear Bulkhead  | 0 – 40 NI / mn  | 0 – 33 NI / mn       |
| Front Bulkhead | 0 – 11 NI / mn  | 0 – 9.6 NI / mn      |
| Outer Cylinder | 0 – 6.4 NI / mn | 0 – 5 NI / mn        |

## 2.7 The exhaust lines

There is no gas released in the shack or IR2 area under any condition; all vented gas goes to a special exhaust line which is permanently ventilated with Nitrogen in order to avoid air and isobutane mixture in a closed volume. The flow is set by rotameter ( 0 to 950 lt/h).

## **2.8 Adding water**

We can add water vapor to the input gas if needed for chamber anti-aging properties. A quantity of gas controlled by a rotameter passes through a Plexiglas tank containing water at room temperature and is re-injected in the line, between two points with different pressures. This system is not installed at the moment.

## **2.9 Pipes and fittings**

All pipes are made from stainless steel. Within the racks in the gas hut, 3/8" lines are used. The long runs from the gas hut to rack 10 are 1.5", with the exception of the security line, which is 3/4". The runs from rack 10 to the detector range in diameter from 3/4" to 1.5".

## **2.10 Layout**

The distribution system occupies three racks. The first one (B636-06) is dedicated to the chamber gas, containing mass flowmeters, rotameters, pressure indicators and valves. The second rack (B636-04) contains all neutral gases and instrumentation. The third rack (B636-07) is dedicated to the purification system. Additional racks are used for the gas analysis system (B636-05) and the electrical system (B636-02).

# **3. The pressure loop and circulation**

Running in semi closed mode, the gas needs to circulate between the input and output manifold of the chamber. The circulation is performed using a compressor installed at the output at the forward end plate. We have chosen an explosion proof compressor with capacity of 1 m<sup>3</sup>/hr produced by KNF, Germany. A second, spare compressor is installed in the system.

The chamber is run at 4 mbar above atmospheric pressure. A differential pressure transmitter measuring the pressure on the forward end plate, is connected to a regulator, which compares the measured pressure with the desired set point, and sends a signal to a frequency variator which acts on the compressor speed. Such a system has been running at CERN for many experiments. It has been tested on our system and the relative chamber pressure can be stabilized within  $\pm 0.02$  mbar. This system is also duplicated. The pressure drop between the gas hut and detector is 1.6 mbar at a flow of 1 m<sup>3</sup>/hr [3].

The recirculated flow is controlled by a mass flowmeter. When the compressor runs, the pressure increases to 300 mbar in the loop between the compressor and the flowmeter. Using a back pressure regulator, we keep the pressure constant in the circulation loop, and at the same time we let some quantity of the gas, equal to the fresh gas supply (minus the leaks), to vent. This quantity is also measured.

Purification takes place on this high pressure line. Two sampling points, one checking the compressor output gas, and a second after purification are installed.

Two-way bubblers are installed on the input and output lines to allow gas to escape, via a dedicated 1.5" pipe, if the line pressure is greater than 15 mbar. The maximum safe chamber pressure is 30 mbar.

## 4. Gas monitoring and sampling

The performance of the drift chamber depends on the gas quality. We distinguish two types of measurements:

- Gas quality, temperature and pressure.
- Gain monitoring.

### 4.1 The gas quality measurements

The quality of the gas can be measured at five different locations ("sampling points") in the gas system: fresh input gas; circulating gas before and after purification; helium line; and isobutane line. Only the first three are used during normal running mode. To test the gas, the sample point is connected to a series of dedicated instruments measuring the isobutane concentration, humidity and oxygen presence. In addition, a small tank can be filled with a gas sample for an offline chromatograph or mass-spectrometer analysis. The analysis system is located in rack B636-05.

The analysis system is used to generate EPICS warnings and alarms and, during running mode, hardware alarms.

#### 4.1.1 Mixture analysis

An infrared analyzer is used to determine the percentage of isobutane; the rest is assumed to be helium. If we run with three gases a second analyzer will be necessary.

We use an NGA2000 from Rosemount Analytical to control an analysis module, which has a resolution of less than 1% of full scale ( full scale = 30%, but can be recalibrated). The system is calibrated with a reference gas ("SPAN gas") and N<sub>2</sub> for zeroing. The calibration operation should be repeated once per week.

#### 4.1.2 Oxygen analyzer

We use a Teledyne model 3000TA oxygen analyzer, which has 6 scales from 0-1 ppm to 0-100,000 ppm, with a precision of  $\pm 2\%$  for the 0-10 ppm scale. Our aim is to run the chamber with less than 50 ppm of O<sub>2</sub>.

#### 4.1.3 Humidity analyzer

We use a capacitive sensor from Xentaur, which is able to measure the dew point from -100° (fraction of ppm) to room temperature (percents).

### 4.2 Gain Measurements

A small test chamber is located on top of the rack B636-06 in order to monitor continuously the gain of the gas. It is possible to test either the fresh gas from the mixer or the gas from the circulation loop after the compressor.

The gain is characterized by the peak location in the <sup>55</sup>Fe spectrum observed in two cells. Changes in gain not explained by temperature and pressure variations are indication for bad quality data.

The gain chamber is inside a tight double Faraday cage flushed to the exhaust with neutral gas ( $N_2$  or  $CO_2$ ). This insures protection against electronic noise while avoiding any risk of isobutane accumulation in the cage.

The high voltage (1960 Volts and 900 Volts) is provided by a VME power supply located in the electric rack (B636-02).

The data acquisition is done with a dedicated PC reading a CAMAC crate. The analyzed spectra are sent to EPICS control system on a regular basis.

The monitoring chamber will be also part of the certification procedure for new isobutane bottles. In order to protect the monitoring chamber, the high voltage will not be turned on if the gas analyzers are not giving satisfactory indications of the gas quality.

## 5. Operation modes

There are three major running modes:

- REST
- RUNNING
- VME control

The selected mode is indicated by an LED on the front panel of the electronics rack or by an EPICS panel.

### 5.1 *The REST mode*

This mode is designed to keep the chamber in a safe situation regardless of atmospheric pressure variations. No fresh gas is supplied from the main circuit, the gas is not recirculated, and the chamber is connected to the He safety line to prevent under pressure. All the pneumatic valves are in their default position: VVPC\_1 and VVPC\_9 open; VVPC\_2 to VVPC\_8 closed, and the compressors off. This mode can be chosen at any time either from EPICS control panel or from a manual switch on the front of the electrical rack.

#### 5.1.1 ALARM mode

The system switches to SAFE mode in case of an alarm or power failure, and a latched alarm signal is generated. The system requires the alarm to be acknowledged by pressing the REST mode button in EPICS or on the electronics front panel. "Safe" mode differs from "Rest" mode in the settings of manual valves.

### 5.2 *Running mode*

During data taking we use the RUNNING mode. Fresh gas is supplied (~2 lt/min) and recirculated (15 lt/min). The same quantity of gas as the fresh one is vented in order to renew the gas mixture. The system is designed to renew completely a chamber volume every 40 to 60 hours. This mode can be chosen after following specific procedures either from EPICS control panel or from a manual switch on the front of the electrical rack.



### 5.3 VME mode

This mode is reserved only for experts. Using the EPICS control panels the expert user can open or close any pneumatic valve (if allowed by the interlock system), start the compressor or choose specific sampling points. However, in order to facilitate the system operation, a few standard situations are programmed.

- Purging with He: High He flow ( $> 30$  l/min) in order to establish a He atmosphere in the chamber after having expose it to air or isobutane. This operation lasts until the oxygen concentration is below 0.25 % and the isobutane content is below 1%.
- Mixture stabilization: The chamber is purged with a He isobutane mixture ( $\sim 10$  lt/min) in order to get the desired isobutane concentration. At the same time the purifiers are saturated. The gas is vented, not recirculated, and 1 to 2 days are necessary to achieve the right gas mixture.
- Purging racks and lines: Used to purge all pumping in the gas hut and rack 10.
- Open running: The gas circulation is stopped and the fresh gas escapes through the output bubbler. This operation is foreseen only as a test mode.

Checklists and procedure for each mode and the transitions between modes are given on the DCh safety web page.

## 6. Gas System Safety

The isobutane flammability range in air is 1.8-8.4%, so although the nominal 80% Helium and 20% Isobutane mixture is above the flammable limit under normal operations, it will form a flammable mixture if diluted in air [1].

The level of risk inside the gas racks in the gas shack, is classified between 0 and 2. Given the total gas volume present in the system we find a risk of 1 on a scale from 0 to 3 with increasing hazard classification. Risk 1 is defined as “risk of SMALL local flash fire or explosion” [2]. All instrumentation inside the gas racks is compatible with this risk.

The first and most important component of the safety system is the prevention of leaks:

- Pipes are from stainless steel welded and pressure tested by a certified technician. Swagelock or Conflat/Varian connectors are used when welding is not practical.
- bubblers and relief valves ensure that the chamber is not subjected to pressures greater than 15 mbar and that pressures elsewhere are below the tested limit. Relief valves vent to an exhaust line. The properties of the relief valves are summarized in Table 7.1.
- The leakrate through the endplates is 0.08 l/min; the leaks are contained by a secondary bulkhead. There are no measurable leaks through outer cylinder. A mylar wrap (open at the front end, where gas cannot accumulate) forms a secondary seal.
- We use explosion proof pneumatic valves. Status sensors are also explosion proof.
- Intrinsic security sensors are installed. They are allowed to run in an explosive atmosphere.
- The compressors are also explosion proof.

The second aspect of the safety system is to prevent explosive mixtures if there is a leak:

- The gas hut has ventilation and restrictors on the isobutane flow so that a flammable mixture cannot be formed in the hut.
- N<sub>2</sub> is flushed through the bulkheads and outer cylinder volume to displace O<sub>2</sub> and to dilute any gas leaks below the flammable limit.
- Nitrogen flows through the exhaust line.
- An oxygen sensor inhibits the isobutane flow.

Ignition sources are also restricted:

- Small amount of electrical material, compatible with zone 1 risk, are used . The electrical rack is separated by more than 1.5m from the gas equipment.
- High voltage and electronics power supplies are disabled by gas alarms.

Finally, sensors monitor the include pressures, temperatures and flows of the gas system. These are interlocked via hardware to the safety system and via EPICS to the slow control system. There are also two HAD sensors in rack B620D-10; two to monitor the isobutane content of the bulkhead CO<sub>2</sub>, and one to monitor the chamber return gas. The return gas is also analyzed for oxygen content using a dedicated O<sub>2</sub> sensor. The alarms and responses generated by the safety system are discussed in greater detail in on the DCh safety web page.

**Table 2 : Summary of relief valve properties. In addition, bubblers on the inlet and output lines ensure that the chamber pressure remains below 30 mbar for flow rates up to 8 times the maximum purge rate.**

| <i>Name</i> | <i>Location</i>  | <i>Nominal Line Pressure (bar)</i> | <i>Release Pressure (bar)</i> |
|-------------|------------------|------------------------------------|-------------------------------|
| RV-I        | Isobutane Line   | 1.5                                | 2.4                           |
| RV-H        | Helium Line      | 1.7                                | 2.4                           |
| RV-E        | 3rd Gas Line     | 1.5                                | 2.4                           |
| RV-F        | Fresh Gas        | 0.2                                | 1.7                           |
| RV-C        | Circulation Loop | 0.4                                | 1.6                           |
| RV-A        | Air Input        | 1.5                                | 2.5                           |

## 7. Programmable Automate (Nano-automate TSX07)

Three Schneider TSX07 process controllers ("nanoautomates") are used to control the gas system and handle alarms. This is a commercial device that is commonly used for automatic systems and is widely used at CERN as safety controllers for gas systems.

The nanoautomates are programmed in a graphical version of PL7. Two programs are used (there are two "masters" and one "slave") but all three communicate, giving a system with a total of 42 inputs and 30 outputs. The programming will be modified only by a qualified expert after the new version of the code has been certified in a test stand. The nanoautomate includes password protection to stop unauthorized modifications.

The controller repeatedly loops over the same algorithm, with a maximum cycle time of 150 ms. The program in RAM is protected against power failure by a 30-day battery and is compared against an EEPROM version to check for corruption. After a power failure, the TSX07 restart automatically and put the system in "safe" mode. (If the entire gas system power has gone off, the system will already have defaulted to safe mode).

The nanoautomate is discussed in greater detail on the safety web page, including a complete list of inputs, outputs and alarm modes.

## **8. Slow control**

The slow control system is completely integrated in the global BaBar one. All instruments and valves are monitored via a VME crate and a CPU running VXWORKS and a SUN station running EPICS. An ACROMAG 9210 ADC (12 bit, 8 channels) is used to read in analog signals, which are all 0-10 V. The electro-valves are controlled by a 24V signal driven by a digital-output optically-isolated output register XYCOM 220 ). The valve position sensors are monitored by a Xycom 212 digital input module.

Data from the gain chamber will be digitized using a DAQ card in a PC. The method of transferring this information to EPICs is being studied.

## **9. Installation**

The gas system occupies three areas:

- The gas supply area, outside the gas shack (building 636), where the gas supply and spare bottles are stored.
- The main gas racks located in building 636, which include distribution, monitoring, and electronics. Two of the main gas racks contain the distribution and return lines, and the gas analysis system. One rack contains the neutral gases, and the last one contains the VME crate and electrical equipment.
- Two racks on top of the detector (B620D-9 and B620D-10), for equipment installed on the input and output manifolds, which includes bulers, valves, pressure sensors, and HAD sensors.

## 10. Material list

### 10.1 Mass flowmeters

| <i>Type</i>   | <i>Gas</i> | <i>Flow (Nlt/min)</i> | <i>To Do Purpose</i> | <i>Input</i> | <i>Output</i> |
|---------------|------------|-----------------------|----------------------|--------------|---------------|
| HI-TEC F201AC | He         | 10                    | Open Syst            | 0-10V        | 0-10V         |
| HI-TEC F201C  | C4H10      | 2                     | Open Syst            | 0-10V        | 0-10V         |
| HI-TEC F-200C | He         | 2                     | Semi closed          | 0-10V        | 0-10V         |
| HI-TEC F-200C | C4H10      | 0.5                   | Semi closed          | 0-10V        | 0-10V         |
| HI-TEC F-200C | CF4        |                       | Anti-aging           | 0-10V        | 0-10V         |
| HI-TEC F-200C | Mixture    | 20                    | Control Circ         | 0-10V        | 0-10V         |
| HI-TEC F-200C | Mixture    | 3                     | Control Output       | 0-10V        | 0-10V         |

### 10.2 Rotameters

| <i>Type</i>          | <i>Gas</i>                        | <i>Purpose</i>                | <i>Flow (Nlt/min)</i> |
|----------------------|-----------------------------------|-------------------------------|-----------------------|
| Brooks SHORATE 1355E | He                                | Purging                       | 80                    |
| Brooks SHORATE 1355E | N <sub>2</sub> (CO <sub>2</sub> ) | Purge Rear Bulkhead           | 40 (33)               |
| Brooks SHORATE 1355E | N <sub>2</sub> (CO <sub>2</sub> ) | Purge Front Bulkhead          | 11 (9.6)              |
| Brooks SHORATE 1355E | N <sub>2</sub> (CO <sub>2</sub> ) | Purge Outer Cylinder          | 6.4 (5)               |
| Brooks SHORATE 1355E | He                                | Running                       | 10                    |
| Brooks SHORATE 1355E | C4H10                             | Running                       | 3                     |
| Brooks SHORATE 1355E | C4H10                             | Mixture stabilization         | 10                    |
| Brooks SHORATE 1355E | He                                | Security                      | 10                    |
| Brooks SHORATE 1355E | N2                                | Exhaust flushing              | 16                    |
| Brooks SHORATE 1355E | Air                               | Flushing                      | 21                    |
| Brooks SHORATE 1355E | He                                | Molecular Sieve Regen-eration | 2                     |

5% precision is required for these rotameters.

### 10.3 Compressor

| <i>Type</i>  | <i>Maximum flow</i> |
|--------------|---------------------|
| Power Supply | Nb                  |

KNF 143 ANE 30nl/min

110V/60Hz 2

Only one compressor is used under normal circumstances—the second is a spare. The compressors are explosion proof and can be coupled.

#### 10.4 Pressure Transducers

| <i>Type</i>          | <i>Purpose</i>              | <i>Range(mbar)</i><br><i>Resolution</i> | <i>Signal</i> | <i>Alarms</i> |
|----------------------|-----------------------------|---|---------------|---------------|
| ROSEMOUNT<br>11516P3 | DCH pressure and regulation | -5 to 10/0.5%                           | 4-20mA        | Min / Max     |
| KELLER PR23          | Fresh gas P                 | 0-1200mb / 0.5%                         | —             | Min           |
| KELLER PR41          | Inlet gas P                 | 0-20mb / 0.5%                           | —             | Min / Max     |
| KELLER PR41          | Front Bulkhead              | 0-20mb / 0.5%                           | —             | Min / Max     |
| KELLER PR41          | Rear bulkhead               | 0-20mb / 0.5%                           | —             | Min / Max     |
| KELLER PR23          | Circulation Loop            | 0-1200mb / 0.5%                         | —             | Min           |
| KELLER PR23          | He pressure                 | 0-2500mb / 0.5%                         | —             | Min           |
| KELLER PR23          | isobutane pressure          | 0-2500mb / 0.5%                         | —             | Min           |
| KELLER PR23          | Analysis Loop               | 0-1200mb / 0.5%                         | —             | Min           |
| KELLER PB            | Atmospheric                 | 900-1100                                |               |               |

All pressure transducer values are displayed on West 8010 channel display modules, which also produces a 0-10V output that is read into EPICS by a VME ADC.

#### 10.5 Relief Valves

| <i>Type</i>   | <i>Location</i>                                      | <i>Nb</i> |
|---------------|--|-----------|
| Nupro ss4pa4  | He line, Fresh gas, Air input                        | 3         |
| Nupro ss4ca13 | Isobutane line, 3rd component line, circulation loop | 3         |

#### 10.6 Gas Analysis

| <i>Instrument</i>  | <i>Function</i>   | <i>Output</i> | <i>Sensitivity</i> |
|--------------------|-------------------|---------------|--------------------|
| Teledyne 3000T     | Oxygen Analyzer   | 4-20mA        | 0.5%FS             |
| Xentaur            | Humidity Analyzer | 4-20 mA       |                    |
| NGA 2000 Rosemount | Gas composition   | 0-10V         | 1% FS              |

## 10.7 Pipes

Stainless steel.

## 10.8 Valves

| <i>Valve</i> | <i>Type</i>                   | <i>Nb</i> |
|--------------|-------------------------------|-----------|
| Pneumatic    | WHITEY SS43S4-PPW/S-EEXDIICT6 | 14        |
| Manual       | WHITEY SS43S4                 | 86        |

All valves are intrinsically safe and are connected with SWAGELOCK fittings. All pneumatic valves are equipped with status sensors.

## 10.9 Pressure regulator

| <i>Type</i>    | <i>Front pressure</i> | <i>Back pressure</i> | <i>Nb</i> |
|----------------|-----------------------|----------------------|-----------|
| TESCOM 44-2300 | 2-10mbar              | 200-1000 mbar        | 2         |
| DUNGS FRS 505  | 500mbar               | 2-10mbars            | 1         |

## 10.10 Racks

| <i>Type</i>                  | <i>Dimensions(mm) HxLxW</i> | <i>Nb</i> |
|------------------------------|-----------------------------|-----------|
| EURORACK UNIVERSAL 21117-089 | 2020x600x900                | 4         |

There are 3 racks dedicated to the gas instrumentation, and a fourth one is dedicated to the electricity and readout electronics. The electronics rack contains the following items:

- VME crate
- Low voltage supplies
- Pneumatic valve control module
- Interface cards between gas instruments and readout electronics
- Electrical security equipment
- Mass flowmeter electronics
- Pressure displays
- Regulator and frequency variator
- The nano automates.

## **11. Contact Person**

Additional information is available from  
<http://wwwlapp.in2p3.fr/babar/dch/gas/gas.html> or from Yannis Karyotakis, PI of the LAPP BaBar group, [karyotakis@lapp.in2p3.fr](mailto:karyotakis@lapp.in2p3.fr).

## **12. Acknowledgments**

We would like to thank M. Bosteels, D. Peach, C. Nuttall, G. Fetchenauer, and Ch. Schäfer from L3 and CERN who taught us a lot on gas systems, spent many hours with us showing different systems, and discussed with us the best solution for BaBar. We would also like to thank the people involved in the CLEO III detector gas system, especially B. Heltsley and Prof. M. Perl.

## **13. References**

- [1] Executive Summary Fire Hazards Analysis for the BaBar Detector Project, November 1996.
- [2] CERN Flammable Gas Safety code, November 1996, G Rev.
- [3] Adam Boyarski, BaBar Note no TNDC 98-78