Summary of session 3: Materials and gases

H. Kolanoski [a]

[a]Institut für Physik, Humboldt-Universität zu Berlin, Germany

This summary gives an overview of the different contributions to the Session 3 on "Materials and Gases". A comprehensive survey of the subject (aging studies, materials, gases, gas systems, test and validation procedures) and the lessons to be learned for construction and operation of detectors was given in the invited review talk by Mar Capeans.

1. Introduction and Overview

In the long time between this and the previous Aging Workshop, which took place at Berkeley in 1986, our requirements on the radiation hardness of the detectors have changed by several orders of magnitude. Fifteen years ago, the charges collected on the anodes of wire chambers per year of operation were on the order of mC/cm and are now often rather C/cm. Most demanding in this respect is the physics program of the LHC experiments, with HERA-B serving as a test bed: searching for one event in 10^{12} or more interactions the experiments have to run at very high interaction rates and corresponding high particle flux densities in the detectors. Thus, the detectors have to cope with high rates and high occupancies, which has stimulated developments to improve the granularity, the electronics speed and the aging properties of the detectors. Typically also the size of the detectors and the channel count increased in the last years by orders of magnitude which forced to look for cheap, modular and efficient production methods. In summary, we are asking for larger, cheaper, faster, fine-grained detectors with very high radiation resistance.

These tougher requirements and the notion that for the big experiments a failure would be unbearable, has initiated a lot of research and development to come to radiation-hard detectors. An overview of these developments was given in the first talk of this session by Mar Capeans. Her main message was that we are today, despite the vastly increased requirements, able to plan for safe detectors by evaluating proper materials and gases together with the operation conditions using improved test procedures and analysis methods, and by efficiently employing the existing knowledge stored in data bases and publications. Although aging phenomena can always give surprises and one has to gain experience with each project, a lot of problems are avoidable by preselecting materials and gases, and by employing systematic acceptance tests.

This session provided a general overview on this topic in the invited review talk at the beginning, as well as specific examples for tests of materials and gases, test procedures and analysis methods. Clearly, the proper choice of "materials and gases" is of so basic importance for all gaseous detectors that the topic is naturally addressed in all sessions. An overview of the subjects addressed in the presentations of this session is given in Table 1.

2. Materials, Gases and Gas Systems

The chamber construction, the used materials, and the choice of drift gases depend very much on the specific application of the detector. The formerly common mixtures of argon with hydrocarbons [K. Kurvinen], such as Ar-ethane, with a convenient drift velocity plateau and good resolution are not suited for very high radiation loads. For this case, mixtures of a noble gas (Ar, Xe) with CF_4 and CO_2 [V. Lebedev, K. Dehmelt, A. Schreiner] were found to be radiation resistant,

Table 1
List of contributions to this session and related keywords (NRA = nuclear reaction analysis, GC = gas chromatography, DC= drift chamber, HC = honeycomb, SEM = scanning electron microscopy, EDS = energy dispersive X-ray spectroscopy).

presentation by	detector	studied effect	gases	analysis methods
M. Capeans	comprehensive review			
R. Henderson	DC	anode aging	DME	gain monitoring (^{55}Fe)
V. Blinov	DC	anode aging	DME	gain monitoring (^{55}Fe)
V. Lebedev	ATLAS straws	anode corrosion	$Xe/CF_4/CO_2$	NRA, SEM/EDS
K. Kurvinen	test chamber	avalanche products	Ar/C_2H_4	GC, cryo-trapping
H.-B. Dreis	MSGC	open gas system	Ar/CO_2	GC
K. Dehmelt	drift tubes (HC)	closed gas system	$Ar/CF_4/CO_2$	GC, gain monitoring (^{55}Fe)
M. Hohlmann	drift tubes (HC)	closed gas system	$Ar/CF_4/CO_2$	GC, gain monitoring (^{55}Fe)
A. Schreiner	drift tubes (HC)	anode corrosion	$Ar/CF_4/CO_2$	gain monitoring (^{55}Fe), SEM/EDS

with the CF_4 content providing a fast drift velocity that is usually required in high-rate experiments. If the drift velocity is of less importance, as in MSGCs, Ar/CO_2 [H.-B. Dreis] offers similar radiation hardness and avoids potential problems with aggressive avalanche products from CF_4 [A. Schreiner].

A quite different field of applications is offered by DME or DME mixtures: the high ionisation density and low diffusion allows to reach the best spatial resolution at the expense of a rather low drift velocity and high sensitivity to the ambient parameters temperature and pressure. The experiments show that DME-based drift gases do not cause aging effects if the materials are properly chosen and if the gas has a very high purity [R. Henderson, V. Blinov].

For the choice of proper materials the general rule applies [M. Capeans]: an efficient preselection can be done using data bases and publications, but everything has to be validated by systematic acceptance tests and in the real environment. Such an evaluation for prototype and full-scale gas systems with open or closed-loop in HERA-B is presented in three contributions [H.-B. Dreis, K. Dehmelt, M. Hohlmann].

3. Test Setups and Analysis Methods

In all talks of this session, tests and test setups have been described and general rules have been derived [M. Capeans], such as: the test setup and the test condition should be as close as possible to reality. The restrictions come, for example, from the available time, usually the reduced size of a test chamber, or the available radiation. This requires a specific understanding of the parameter dependence and the extrapolation to realistic conditions. Experimentally derived models for avalanche and polymerisation processes serve as input here [K. Kurvinen, V. Blinov, A. Schreiner].

Together with the increased requirements on the aging performance also the analysis methods have been developed to quite high standards: monitoring of the gas purity by gas chromatography both in the running experiments [H.-B. Dreis, K. Dehmelt, M. Hohlmann] and for specific aging studies [M. Capeans, K. Kurvinen] has become nearly a standard. A particularly sensitive method for detection of organic compounds created in the avalanche was shown by K. Kurvinen. A standard is also the use of electron microscopy for the investigation of electrode surfaces and the related analysis methods with sensitivity to the element composition as SEM or EDS [A. Schreiner, M. Capeans, V. Lebedev]. A quite specific method is the Nuclear Reaction Analysis (NRA) employing nuclear reactions to analyse penetration of species into the electrodes [V. Lebedev] which, for example, could be the reason for the etching phenomena as observed in CF_4 based gases.