Materials & Aging Reference

F.J. Barbosa, JLab, 2 April 2009

The following two tables were obtained from a recent publication and thesis and is an excellent resource on tests and QA/QC of straws:

STRAW PERFORMANCE STUDIES AND QUALITY ASSURANCE FOR THE ATLAS TRANSITION RADIATION TRACKER
Peter Cwetanski
http://ethesis.helsinki.fi/julkaisut/mat/fysik/vk/cwetanski/strawper.pdf

TABLE 5-I An excerpt of the list of numerous gas system components which have been successfully validated in ageing tests in Ar-CO_2 70/30 and Xe-CO_2-O_2 70/27/3 [72].

Element	Details	Preparation	Ageing in Ar-mix	Ageing in Xe-mix
Pipe	Stainless steel 316L	ultrasonic bath in iso-propyl alcohol	NO	NO
Fitting	Gyrolok	ultrasonic bath in iso-propyl alcohol	NO	NO
Fitting	Swagelok	-	NO	NO
Flow-meter	Gilmont ACCUCAL	-	NO	NO
Electronic mass flow controllers	Bronkhorst	-	-	NO
Pressure regulator	Scott C21-8	-	-	NO
Pressure regulator	Scott 218	-	NO	-
Valve	Swagelok SS-43S6MM-SC11	-	NO	NO
Valve	SS Needle valve Gyr-olok	-	NO	NO

[1] The level of purity of the gases (Ar, CO_2) is an issue not treated here. Long-term tests have led to believe that no significant ageing-relevant trace constituents are introduced with the single gas mixture components.

[2] No signs of ageing practically means an amplitude degradation of less than 2 %, which is in the range of the measurement accuracy.

TABLE 5-II Cleanliness specifications for the TRT gas system [73].

Materials		
Elastomers (gas seals)	preferred	EPDM, Viton, Teflon
	forbidden	Rubber (NBR, Buna N)
Metals	preferred	Stainless steel, copper, brass
	forbidden	Aluminium
Plastics	preferred	ULTEM, PEEK+
Thread tightening	preferred	Teflon band
	forbidden	Si-joint, Loctite
Glues	preferred	Araldite® AY103/HY991 TRA-BOND 2115
Bubbler oils	preferred	None (water, if needed)
	forbidden	All Si-containing and low pressure organic oils
Lubricants	preferred	To be avoided; if needed use Kryotox or Apiezon
	forbidden	Any other

The next reference, from J. A. Kadyk, is older but has very important information regarding materials and aging:

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Nuclear Instruments and Methods in Physics Research A300 (1991) 436–479
North-Holland

Wire chamber aging *

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An overview of wire chamber aging is presented. A history of wire aging studies and the manifestations of wire aging are reviewed. Fundamental chemical principles relating to wire chamber operation are presented, and the dependences of wire aging on certain wire chamber operating parameters are discussed Aging results from experimental detectors and laboratory experiments are summarized. Techniques for analysis of wire deposits and compositions of such deposits are discussed. Some effects of wire material and gas additives on wire aging are interpreted in chemical terms. A chemical model of wire aging is developed, and similarities of wire chamber plasmas to low-pressure rf-discharge plasmas are suggested. Procedures recommended for reducing wire aging effects are summarized.

Table 1
Some commonly used materials in wire chamber systems (see glossary for some abbreviations used)

Material	Common or trade name	"Rating"	Comments
Gas tubing, plumbing, bubblers			
Stainless steel		very good	electropolished SS is best
Copper, hydrogen fired		very good	
Copper, refrigeration		perhaps OK	some Cu tubing is drawn using lubricating oil: bad
Aluminum		depends on gas	Al is very active chemically, but forms a protective oxide. Not a very good cathode material
Polyethylene	Poly-flo	good	
Polyamide 11	Nylon, Rilsan 11	very good	works with DME
Polyvinyl chloride (with plasticizer added)	PVC, Tygon	very bad	outgases phthalates, halogenated hydrocarbons – causes aging
Polytetrafluoroethylene	PTFE Teflon	good if "baked out"	electron capture in DME ("unbaked" FEP)
Perfluoroethylene propylene	FEP Teflon		
Perfluoroalkoxy	PFA Teflon		
Trichloroethylene, and Trichlorotrifluoroethane	chlorinated cleaning solvents	bad if any residue remains	can outgas: chlorine probably causes fast aging
Silicone grease		bad	silicone often found on anode
Silicone oil (in bubbler)		bad [a]	moderate to severe aging
High-boiling polycyclic petroleum fraction (in bubbler)	mineral oil	OK [a]	
Water (in bubbler)		OK	beneficial in small concentrations "additive" (deionized water best)
Refined petroleum oil (in bubbler)	mechanical pump oil	OK [a]	
Chamber materials (see also materials above used for plumbing):			
Fiberglass/epoxy	G10	probably OK	must have *clean surface*: mold-release agent (silicones) may be on surface (very bad)
Methyl methacrylate	Lucite, Plexiglas	OK	
Glass	–	OK	
Polymethacrylimide	Polyfoam	OK	
Polyethylene terephthalate	Mylar	OK	
(?)	Rohacell	probably OK	
Alumina (Al_2O_3)	ceramic	OK	Al_2O_3 can accumulate charge
Glass ceramic (SiO_2, Al_2O_3, MgO, K_2O, B_2O_3, F)	Macor	probably OK	bad results reported with DME
Epoxies	Torr-Seal	OK	good results with all of these, but the "5-minute" can be hygroscopic (surface moisture)
	"5-minute"	OK	
	Epon/Versamid	OK	
Polyurethane		probably bad	report of bad effects from soft urethane adhesive
Silicone polymers	RTV: 1 part	bad	acetic acid smell: causes aging
	RTV: 2 part	?	probably OK – little data
Polyoxymethylene	Delrin, Hostaform	OK (?)	
Polyphenylene oxide	Noryl	OK (?)	
Fluorinated copolymer	Viton	good, usually	bad results reported using DME
Polychlorotrifluoroethylene	Kel-F	good	

Table 1 (continued)

Material	Common or trade name	"Rating"	Comments
Chamber materials (see also materials above used for plumbing).			
Perfluoroelastomer	Kalrez, Chemraz	good	works well with DME, but structurally weak
Ethylene-tetrafluoro-ethylene copolymer	Tefzel	good	
Polyvinylidene fluoride	Kynar	good	
Polyimide	Kapton	good	
Higher molecular weight alkanes	paraffin	OK (?)	
(Waxes and resins)	resin	OK (?)	
	beeswax	OK (?)	

[a] Little or no aging observed when argon/ethane (50/50) supply was deliberately bubbled through, mineral oil, or Duo-Seal mechanical pump oil, just upstream of test chamber, but significant aging was observed with silicone oil (Dow 704) even though the concentration in the gas was very low: vapor pressure is quoted by manufacturer as 1.4×10^{-8} Torr. About 0.2 C/cm of charge transfer was achieved during these tests (see table 3).

Table 2
Results from experiments

Gas	Aging observed [a]	Gain	Charge [C/cm]	Cathode field or wire diameter	Plumbing [b]	Other materials [b]	Running time or other information	Ref.
Ar/C_2H_6 (40/60)	None	10^5	0.01	35 kV/cm	SS(100 m) + Nylon (10 m)		35 μm Ni–Cr anode	II-1
Ar/C_2H_6 (50/50)	GL, DC	3×10^4	0.01	(planar low field)	no PVC	paraffin, resin beeswax; soft urethane adhesive; G10 coated with epoxy	1 year	II-2
Ar/C_2H_6 (50/50)	None	4×10^4	0.02	10 kV/cm	metal		deposits only on anode (silicon)	II-3
Ar/C_2H_6 (50/50)	GL, DC, SC	10^4–2×10^5	0.02	50 μm	50 m PVC + Cu	SS, Mylar polyethylene and silicone oil and vacuum grease	silicon on anode; 2 years	II-4
Ar/C_2H_6 (60/40) + 0.1% iC_3H_7OH	None	10^4–2×10^5	0.01–0.02	50 μm	50 m PVC + Cu		2 years	II-4
Ar/C_2H_6 (50/50)	SC	2×10^5	0.05	75 μm	> 100 m Cu	Al–Mylar, G10, RTV, epoxy		II-5
Ar/C_2H_6 (50/50) + 1.5% C_2H_5OH	GL	2×10^5	0.3	75 μm	> 100 m Cu	Al, Mylar, G10, RTV, epoxy	Rate-related efficiency due to anode deposits	II-5
Ar/C_2H_6 (50/50) + 2% C_2H_5OH	GL	5×10^4	0.2–0.4	18–20 kV/cm	70 m Cu, 10 m non-PVC	vacuum oil, Al, epoxy	5 years; oil found in gas; no aging after gas filter added	II-6
Ar/C_2H_6 (50/50) + 0.3% C_2H_5OH	None	4–8×10^4	0.035–0.04	10–15 kV/cm	30 m Cu	G10 delrin, epoxies, Al–Mylar, teflon, vacuum grease	Also Viton O-rings. Vertex detector. 1.5 yr using Stablohm 800 anode wire (40 μm diameter)	II-7
Ar/CH_4 (80/20)	SC	2×10^5	0.03	100 μm		Plastic insulation including phthalates	8.5 atm pressure. Failure after 3.5 months. Deposits on both	II-8

$Ar/CH_4/H_2$ (79.5/19.5/1)	GL	?	0.25	100 μm		Mylar, Aclar	Silicon on anode. Failure after 100 days	II-3
$Ar/CH_4/iC_4H_{10}$ (88.5/8.9/2.6)	GL	$3-4 \times 10^4$	0.02	0.94 kV/cm	50 m steel, Cu	G10, cables; Rohacell	4 bar pressure, *sealed*; 300–1000 ppm H_2O 6 years	II-9
Ar/CO_2 (95/5)	None	?	0.22	35 kV/cm	70 m Cu, non-PVC plastic	O-rings	3 bar pressure vertex detector	II-10
$Ar/CO_2/CH_4$ (89/10/1)	None	7×10^4	0.01	20–26 kV/cm	90 m Cu	SS, glass, brass, teflon, kapton	1.15 bar pressure; no oils or greases; vertex detector	II-11
$Ar/CO_2/CH_4$ (49.5/49.5/1)	None	3×10^6	0.025	1.6 kV/cm	polyethylene	Al–Mylar, Delrin, epoxy, Teflon, Lucite, vacuum grease	Straw chamber, vertex detector, 4 atm., 2 years	II-12
$Ar/CO_2/CF_3Br$ (65/35/0.5)	GL	10^4	0.1–0.2	6.7 kV/cm	PVC, polyethylene	Al–Mylar, RTV	Silicon deposits on both electrodes; research grade gas; fluorine on cathode foil; MWPC, $(\Delta G/G) \approx -10\%$ at 0.4–4.0 mC/cm	II-13
$Ar/iC_4H_{10}/iC_3H_7OH$ (65/35/1.5)	None	6×10^4	> 0.03	(planar; low field)	50 m Cu 10 m Rilsan	Mylar, epoxy	3-year, no deposits on anode wires, MWPC	II-14
Ar/iC_4H_{10}/methylal (53/40/7)	GL	10^5	0.3	4.4 kV/cm	60 m SS 25 m Rilsan	epoxy, Polyfoam	4 years; MWPC ~ 1 μm anode deposit	II-14
Ar/iC_4H_{10}/methylal (75/20/5)	None	3×10^4	0.2	5 kV/cm		epoxy, G10, paraffin, resin, beeswax	2 years; soft urethane adhesive covered up with 5-min. epoxy; now OK	II-2
Ar/iC_4H_{10}/methylal/ CF_3Br (66/30/4/0.25)	GL	10^8	0.2	1.5 kV/cm		Al	Straw tubes, SS anode, vertex detector	II-15
C_3H_8/methylal (97/3)	GL, DC		0.008				Dark current cured by adding H_2O (2000 ppm) or oxygen filter	II-16

[a] GL = gain loss; DC = dark current (excessive); SC = self-sustained current (Malter discharge), NC = no change in gain.

[b] PVC = polyvinyl chloride (Tygon or equivalent); SS = stainless steel; Cu = copper, Polyfoam = polymethacrylimide; Rilsan = Nylon = polyamide 11, RTV = silicone-based Room Temperature Vulcanizate. Also see table 1 for list of names and compositions of commonly used plastics.