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REPORT OF THE SYNCHROTRON RADIATION VACUUM WORKSHOP

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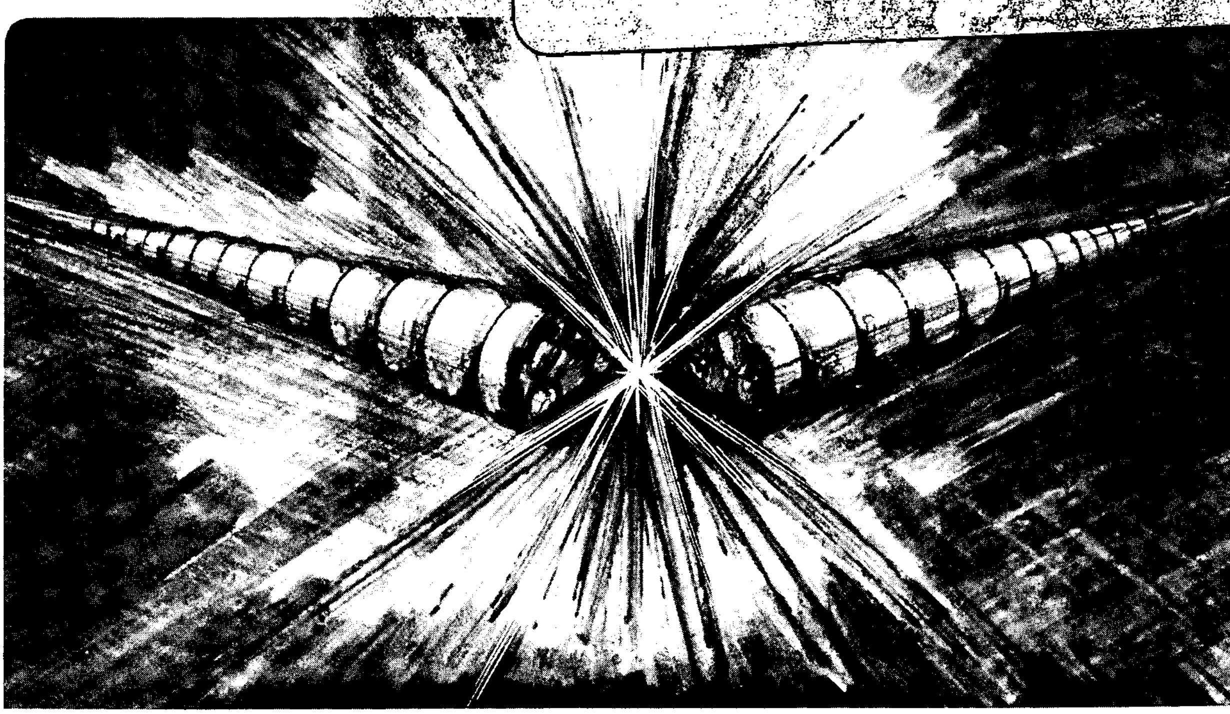
R.T. Avery

June 1984



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REPORT OF THE SYNCHROTRON RADIATION VACUUM WORKSHOP*

JULY 25-26, 1983

ROBERT T. AVERY
Chairman

June 1984

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Contents

PREFACE

The Synchrotron Radiation Vacuum Workshop was held at Lawrence Berkeley Laboratory on July 25-26, 1983. The 41 participants addressed two problems of particular concern to the designers of synchrotron radiation facilities: (a) photon-initiated gas desorption from vacuum chamber walls and (b) carbon deposition on optical components. The purposes of the workshop were twofold: (1) to assess the current state of knowledge on the workshop topics and (2) to suggest near-term R&D on these effects to obtain information upon which to base the final design of the Advanced Light Source storage ring and beam lines.

1. SUMMARY OF RESULTS

The Synchrotron Radiation Vacuum Workshop was held to consider two vacuum-related problems that bear on the design of storage rings and beam lines for synchrotron radiation facilities. These problems are gas desorption from the vacuum chamber walls and carbon deposition on optical components. Participants surveyed existing knowledge on these topics and recommended studies that should be performed as soon as possible to provide more definitive experimental data on these topics. This data will permit optimization of the final design of the Advanced Light Source (ALS) and its associated beam lines. It also should prove useful for other synchrotron radiation facilities as well.

Gas desorption from practical engineering surfaces bombarded by photons is a complex of multiple processes occuring within the conglomerate surface layers (oxides, carbon, adsorbed gases, etc.). Photoelectrons and secondary electrons play a significant role as they leave the bombarded wall and again as they arrive at a second surface. Photon-initiated desorption dominates over ordinary thermal desorption. (Here, the term "photon-initiated desorption" includes all desorption processes initiated by photons including photon-stimulated desorption, photo desorption and photon-induced dissociation.) Upon startup, the vacuum pressure typically rises from $\sim 10^{-9}$ torr by a few orders of magnitude, but continuing photon bombardment gradually reduces the desorption rate as desorbable materials are removed from the wall. Typical experience with electron storage rings is that a vacuum of 10^{-8} torr, which allows a beam lifetime of the order of 10 hours, can be achieved after 1 year of operation. On subsequent pump-downs it takes about one to three months to reach this desirable pressure.

Many photon-initiated desorption experiments have been conducted on carefully prepared scientific samples. Only a few experiments have been done on practical surfaces for vacuum components. To identify the best materials, pretreatments, and configurations for the vacuum chamber, Workshop participants suggested R&D studies that should be performed immediately.

1) Test candidate materials for the vacuum chamber interior (e.g., Au, Cu, Ag, Al, Ti, etc.) for their susceptibility to desorption.

2) Test possible surface treatments (e.g., chem-clean, bake, glow discharge, etc.) to judge their effectiveness at removing the desorable materials.

3) Test candidate surface geometries (sawteeth, slopes) and system designs (pumping chambers and strategies, multiple walls) to identify the best combination.

4) Perform tests using electron bombardment, but confirm the results using photon bombardment.

For the ALS, a vacuum of 10^{-9} torr will be required to achieve a lifetime of 10 to 12 hours. To minimize the commissioning phase, the system should be able to reach this pressure goal within 1 month of turn-on, and within 1 week on subsequent pump downs. These goals each represent a factor of 10 improvement over typical experience. A proposed design for the ALS Storage Ring vacuum chamber has a large, continuous distributed pump chamber providing evacuation rates of ~1000 liters/second-meter (~10 times greater than that of existing rings). Moreover, most photons strike a water-cooled target in the pump chamber (instead of in the beam chamber as is typical), so less than 10% of the desorbed gas molecules will get into the beam chamber. Favorable comments were voiced for this novel approach, which holds promise for achieving the desired factor of 100 improvement over and above improvements obtained by the suggested R&D program.

Carbon deposition occurs rapidly if the pressure exceeds 10^{-9} torr. It markedly reduces the reflectance of beam line optical components between the carbon K edge (284 eV) and 1 keV. Evidence indicates that the carbon is graphitic and comes from residual gases. The darkening occurs where photons strike the optical surfaces. At temperatures of ~125°C, the deposition rate decreases. At pressures below 10^{-10} torr, the effect is negligible.

Although an analytical model has been developed for the process, the participants recommended further research to identify the gas species involved (CO, CO_2, hydrocarbons) and to evaluate promising palliative measures, such as heating, having cryosurfaces near the optical components, and removing the coating using O_2 partial pressure. For the short term, the most effective solution is a very high vacuum ($< 10^{-9}$ torr) in the beam lines.

2. GAS DESORPTION OVERVIEW

Presentations were made by K. Kennedy (LBL), B. Scott (SLAC), J. Schuchman (BNL), A. Mathewson (CERN), D. Lichtman (U. Wisc.), and R. Stulen (Sandia). These were followed by very lively and open discussion. Following are some of the key facts and findings of the Workshop on this topic.

2.1 Typical Electron Ring Experience

The vacuum operating experiences at existing electron storage rings are not identical but there are many similarities. Aluminum chambers seem to behave quite comparably to stainless steel chambers. The following performance is representative of both.

	Beam Current	Approximate Vacuum Pressure (torr)	Approximate Beam Lifetime (hours)
After initial startup:			
1 month	None	10^{-9}	–
1 month	Full	10^{-7}	1
1 year	Full	10^{-8}	10
Subsequent pumpdowns:			
1 week	None	10^{-9}	–
1 week	Full	10^{-7}	1
3 months	Full	10^{-8}	10

2.2 Gas Desorption Processes

Numerous experiments have been conducted on carefully prepared scientific samples such as crystals cleaved in vacuo and freshly deposited metal surfaces. These are not representative of engineering materials that can be used for construction of a storage ring vacuum system. Such "engineeering" surfaces are usually a complex rough conglomerate of oxides, carbon, adsorbed gases and other materials overlaying the metal substrate. These surface constituents have widely-varying binding energies.

When an engineering surface is bombarded by photons, many desorption processes can occur essentially simultaneously including:

- photon-stimulated desorption
- photo-desorption
- photon-induced dissocation
- thermal desorption
- electron-stimulated desorption

Each is a distinctly different process and can result in desorption of differing gas species. Which process predominates can depend, among other things, on substrate material, surface constituents, bombardment duration and photon energy threshold.

It appears likely that such desorption from engineering surfaces can be attributed primarily to photoelectrons and secondary electrons that were initiated by the photon bombardment. These can cause desorption as they exit through the surface layers of the bombarded wall and again as they re-enter the surface layers at a second surface, which need not be directly illuminated by the primary photon beam. Photons can be scattered to second surfaces but probably are of less significance.

Gas desorption experiments using direct electron bombardment are much easier to perform than ones using photon bombardment. There was concurrence that such direct electron bombardment experiments can produce similar, but not identical, effects and could prove very useful for screening candidates.

2.3 Gas Desorption R&D Studies

Although there is much data in the literature on photon-initiated gas desorption, there is only sparse data relating to engineering surfaces. Here, the term "photon-induced desorption" is used to include all gas-producing processes due to photon bombardment. There was a concensus that further R&D study of gas desorption resulting from photon bombardment of engineering surfaces was of high priority and could lead to significantly reduced desorption rates for future storage rings such as the ALS Storage Ring. These R&D studies should include:

1) Tests for desorption rates of candidate materials for the vacuum chamber interior including gold, silver, copper, titanium and non-evaporable getter (NEG) materials.

2) Tests for change in desorption rates due to candidate pre-treatments and in-situ treatments of vacuum surfaces including chemical-cleaning, vapor cleaning, plating, electropolishing, etching, baking and glow discharge (at elevated temperature).

3) Tests of candiate surface geometries (e.g., sawteeth, slopes, roughness) and candidate system arrangements (e.g., pumping, baffles, geometry) to identify the most promising candidates.

The foregoing tests can be conducted using direct electron bombardment to screen candidates, but the results should be confirmed using photon bombardment at a suitable synchrotron radiation beamline. Excessive thermal desorption caused by high bombarding flux densities must be avoided. Surface analysis techniques (e.g., Auger, LEED, SIMS) should be considered to shed further light on the processes. Residual gas analysis (RGA) should be included but special precautions are needed because, for example, the RGA equipment itself can be a source of gases and because many heavier gases may cling to intervening walls before reaching the RGA. Controlled-atmosphere aluminum extrusions (Ref. 83-18, Appendix E) appear very promising.

2.4 ALS Storage Ring Vacuum

A pressure below 10^{-9} torr is required to achieve a vacuum-related lifetime (1/e) of 12 hours for the electrons in the storage ring. This is approximately a factor 10 more stringent than for typical existing storage rings.

As pointed out earlier, existing storage rings take many months to a year or more to reach their vacuum objective. The ALS staff stated that they hoped to achieve the ALS vacuum in perhaps one-tenth the time. This goal requires a further factor of 10 improvement relative to existing storage ring vacuum systems. The participants concurred with the desirability of this goal.

A proposed design for the ALS Storage Ring vacuum system was presented which has a large continuous distributed pumping chamber connected by a continuous slot to the beam chamber. This arrangement would provide ~1000 liter/second-meter of pumping speed from the beam chamber (~10 times that of existing rings). Furthermore, most of the photons would pass through the slot into the pumping chamber where they would strike a water-cooled absorber (except those destined for beam lines). Most of the resulting gas molecules would be directly pumped in the pumping chamber with less than 10% reaching the beam chamber. This would result in a further factor of 10 improvement. Thus, this arrangement holds the promise of achieving the desired factor of 100 improvement relative to existing rings. It also would accommodate use of a range of materials, treatments and pumping techniques in accordance with the outcome of the R&D studies, which could provide even further improvement in the vacuum relative to existing rings. Favorable comments on this concept were voiced by participants. Fabrication considerations for such a large chamber need to be validated. No "fatal flaw" with the concept was suggested.

2.5 Gas Desorption Conclusions

The principal conclusions were:

1) Gas desorption due to photon bombardment of engineering surfaces is a complex process for which there is sparse experimental information.

2) The concepts for the ALS Storage Ring vacuum system appear promising for achieving the improved vacuum and faster pumpdown desired for the ALS Storage Ring.

3) Further R&D studies as presented above should be undertaken with high priority and offer the promise of a significant reduction in desorption rates.

4) A further workshop on this topic may be warranted in approximately 1-2 years if there is sufficient new data to report.

~125°C than at room temperature. The authors did not determine which residual gas species (e.g., CO, CO_2, hydrocarbons) were contributing to the process.

The authors formulated an analytical model to represent the observed phenomena. The model looks at the fraction of the surface at steady state that is covered by carbonaceous gas molecules and at their cracking rate which is taken proportional to the fractional coverage. With low fractional coverage, the carbon deposition rate is proportional to pressure which agrees with the observed low deposition rates at low pressures. For a given intensity of photoelectrons, the fractional coverage of adsorbed carbonaceous gas molecules increases as the pressure is increased and when the fractional coverage approaches unity the carbon deposition rate approaches a fixed saturation value in agreement with experimental observations.

A post-workshop communication from V. Rehn (see Appendix F) sheds additional light on the foregoing DESY research. Replotting the equation for the analytical model onto a log-log plot (Appendix F) more clearly shows the saturation values. It shows at pressures below 10^{-9} to 10^{-10} torr that acceptably low carbon deposition rates can be achieved even at very high photon intensities (such as for the Advanced Light Source). Rehn cautions against exposing optical elements to undulator radiation when the ambient pressure is high. He also cautions against relying on the DESY model far outside its region of verification, such as for free-electron-laser beams.

3.3 Carbon Deposition R&D Studies

Although the German experiments shed considerable light on this topic, the participants recommended that further R&D would be of significant benefit, but not with as high a priority as for the gas desorption R&D studies discussed earlier. These carbon deposition R&D studies should include:

1) Tests to evaluate which gas species are significant. (It was noted that CO molecules attach to a surface with the O exposed which suggests that CO may be the principal contributor.
2) Tests to assess the benefits of nearby cryogenically-cooled surfaces.

3. CARBON DEPOSITION OVERVIEW

Presentations were made by V. Rehn (China Lake), F. Brown (U. Illinois) and C. Pruett (U. Wisconsin) after which there was open and interactive discussion. Following are some of the key facts and findings of the Workshop on this topic.

3.1 Observed Phenomena

Darkening has occurred on mirrors and other optical surfaces in synchrotron radiation beam lines. Evidence indicates that the darkened surface consists of graphitic carbon overlayers. Reflectance from such optical surfaces is markedly reduced between the carbon K edge (284 eV) and ~1 keV. The darkening occurs primarily where the photon beam strikes and generally increases with photon flux, although on uncoated fused silica mirrors evidence was presented showing reduced darkening at the center of the smile-shaped bombarded area. It was reported that major darkening had occurred within a few months for beam line mirrors operating above 10^{-7} to 10^{-8} torr. In contrast, other reports indicated no significant darkening after several years at approximately 10^{-10} torr. The foregoing should not be confused with darkening of insulating materials due to reduction of metal oxides into metal plus oxygen molecules.

3.2 Recent Experiment at DESY

Results of a set of experiments conducted at HASYLAB at DESY, Hamburg, on the deposition of carbon on mirror surfaces were published recently.[1] This set of experiments has significantly increased the state of knowledge on this topic. It confirms the graphitic carbon nature of the coating. It suggests that photoelectrons cause cracking of carbonaceous gas molecules adsorbed on the mirror surface. They observed for their photon intensities that the darkening rate saturates (no further increase) above pressures in the 10^{-7} torr range. The experiments were mostly conducted in the 10^{-7} to 10^{-8} torr ranges. Lower deposition rates were observed at

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[1] Boller, K., Haelbich, R-P, Hogrefe, H., Jark, W., and Kunz, C. "Investigation of Carbon Contamination of Mirror Surfaces Exposed to Synchrotron Radiation," Nucl. Instr. & Meth., 208, p. 273 (1983). Also printed as Report DESY SR-82-18.

3) Tests of the effectiveness of a partial pressure of O_2 (or other oxidant) in removing accumulated carbon, perhaps in conjunction with heating, photon bombardment, or glow discharge.

4) Tests of the effect of temperatures above 125°C.

It again was the concensus that electrons could be used to simulate the process, but the results should be confirmed using photons. Saturation effects need to be considered when designing the tests.

3.4 Carbon Deposition Conclusions

The principal conclusions were:

1) Use of vacuum below 10^{-9} to 10^{-10} torr, perhaps in conjunction with moderate heating, is a short-term solution.

2) The R&D studies suggested above should be performed.

3) A further workshop on this topic is warranted only if there is new evidence to present.

APPENDIX A

Agenda
SYNCHROTRON RADIATION VACUUM WORKSHOP

Lawrence Berkeley Laboratory
Building 71 Conference Room
July 25-26, 1983

MONDAY, July 25, 1983

8:30 am	Registration, Bldg. 71 Conference Room	
9:00 am	Welcome	K.H. Berkner
9:10 am	Introduction to Workshop	R. Avery
9:20 am	The Advanced Light Source Project	R. Sah
9:40 am	The ALS Vacuum System and Related R&D Program	K. Kennedy
10:00 am	Gas Desorption Experience at Electron Storage Rings	B. Scott, J. Schuchman
10:20 am	Gas Desorption Experiment at Orsay	A. Mathewson
11:20 am	Physics of Gas Desorption	D. Lichtman, R. Stulen
12:45 pm	**Lunch**	
1:30 pm	Guided Discussion on Gas Desorption Including Possible Future Progress	E. Garwin
3:30 pm	Intermission	
3:45 pm	Guided Discussion (continued)	E. Garwin
4:45 pm	Final Conclusions and Recommendations on Gas Desorption	E. Garwin
5:30 pm	**Social Hour**	
6:30 pm	**Dinner**	

Agenda (continued)
SYNCHROTRON RADIATION VACUUM WORKSHOP

July 25-26, 1983

TUESDAY, July 26, 1983

8:30 am	Announcements and Introduction	R. Avery
8:45 am	Experiences with Darkening of Optical Components by Photons	V. Rehn, F. Brown and C. Pruett
10:00 am	**Intermission**	
10:20 am	Physics of Darkening of Optical Components by Photons and Photoelectrons	D. Lichtman
11:45 am	Discussion on Darkening of Optical Components Including Possible Alleviation and Future Programs	V. Rehn
12:45 pm	**Lunch**	
1:45 pm	Final Conclusions and Recommendations	V. Rehn
2:30 pm	Conclusion of Workshop	

APPENDIX B

DISUCSSION GUIDELINES

SYNCHROTRON RADIATION VACUUM WORKSHOP

GAS DESORPTION TOPICS

- Storage Ring Experience
  - Without electron beam
  - With electron beam versus time
  - Ditto after venting for new component
  - Gases desorbed: H_2, CO, CO_2, CH_4, etc.

- Experimental Evidence
  - Neutrals versus ions
  - Threshold energy
  - Incident angl.

- Physics Processes Involved
  - Photon-stimulated desorption (PSD)
  - Photo-desorption
  - Role of photo-electrons and secondary electrons
  - Effect of electrical or magnetic fields

- Gas Species
  - Where does H_2, CO, CO_2 and CH_4 come from?

- Materials
  - Al, SS, Cu, Au, Ti, AlZr.
  - Electro-plated thickness?
  - Role of surface oxides, carbon, etc.

GAS DESORPTION TOPICS (continued)

- Surface Treatment
  - Acid or alkali clean
  - Electropolish
  - Nitride
  - Electron bombard
  - Glow discharge
  - Bake

- Future Experiments?
  - Simulate by electron-stimulated desorption (ESD)
  - Simulate by ion-stimulated desorption (ISD)
  - Verify using photons? Measure neutrals or ions? At what facility? Collaborative effort?
  - Surface analysis (Auger, ESCA/XPS)?

- Comments on ALS Vacuum Concepts

- Promising Approaches to Pursue
  - Materials?
  - Treatments?
  - Other?

- Need for Future Workshop?

CARBON DEPOSITION TOPICS

- Observed Darkening versus:
  - Pressure
  - Residual gas constitutents
  - Time
  - Photon energy (wavelength)
  - Angle of incidence
  - Photon intensity

- Source of Contamination:
  - On surface when installed?
  - Residual gas? Which species?

- Experimental evidence
  - Nature of coating? Graphitic?

- Processes Involved
  - Reduction of CO, CO_2, CH_4, etc.?
  - Role of photons, photoelectrons and secondary electrons?

- Possible Prevention or Cleaning
  - More pumping (e.g., cryo-pumping)?
  - Heating or cooling?
  - Partial pressure of O_2, NO or H_2 possibly at elevated temperature?
  - Glow discharge?

- Future Experiments?
  - On any of above "cures"?
  - Can photon process be simulated by electron or ion bombardment?
  - Surface analysis?
  - Any others?

- Need for Future Workshop?

APPENDIX C

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APPENDIX D

ELECTRON STORAGE RING/VACUUM DATA SHEETS FROM RESPONDING FACILITIES

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring: Beijing Electron Positron Collider (BEPC) Date: 18/7/83

Institution: Institute of High Energy Physics Data supplied by: Zhang Nai-Sen

Date of first circulating beam (or goal): 1988

Beam energy, Typical (E_0, GeV): 2.2

Max. (E_m, Gev): 2.8

Avg. Beam current, Typical(I_0, mA): 200

Max. (I_m, mA): 200

Radius of curvature in bend magnets (m): 10.3445

Ring circumference (m): 238.4

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) ______
or acceleration voltage/turn due to bend magnets at E_0(kV) ______

VACUUM CHAMBER:

Aperture: horizontal (cm): 12 vertical(cm): 5.8

Chamber material: Al Alloy

Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material ______

Chamber preparation before installation: Perchlorethylene vapor degreasing-alkaline detergent - demineralized water

In-situ chamber treatment (e.g. bake, glow): glow-discharge

VACUUM PUMPING:

Distributed pumping: type: Ti Distributed Sputter-Ion Pump

total speed: 4600 l/s

Lumped pumping: type: IP 40 x 500 l/s 32 x 50 l/s

total speed: 21600 l/s

Distance between lumped pumps (m): Avg. ~ 7

How is vacuum pressure monitored? operating pressure ≤ 1.5×10^{-8} Torr (Design value) Ion gages

Procedures to avoid ion-trapping? ______

Published articles describing the machine and/or vacuum system:
Summary of the Preliminary Design of Beijing 2.2/2.8 Gev Electron Positron Collider
Institute of High Energy Physics Academia Sinica Dec. 1982

Additional features or comments ______

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) ≥ 6 h
at Beam Energy (GeV) 2.8 GeV
and Beam Current (mA) 130 ma
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) ≤ 1.5 x10-8

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened

Comments

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring HESYRL Date July 18

Institution HESYRL Data supplied by Bao Zhong-mou

Date of first circulating beam (or goal) 1987

Beam energy, Typical (E_0, GeV) 0.800

Max. (E_m, Gev)

Avg. Beam current, Typical(I_0, mA) 300

Max. (I_m, mA)

Radius of curvature in bend magnets (m) 2.22

Ring circumference (m) 66.13

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 4.89

or acceleration voltage/turn due to bend magnets at E_0(kV) 16.31

VACUUM CHAMBER:

Aperture: horizontal (cm) ±4.0 vertical(cm) ±2.1

Chamber material Stainless steel

Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Cu

Chamber preparation before installation perchlorethylene vapor, degreasing-alkaline, detergent-demineralized water

In-situ chamber treatment (e.g. bake, glow): glow-discharge and bake

VACUUM PUMPING:

Distributed pumping: type sputter ion

total speed 24001/s

Lumped pumping: type sputter Ion

total speed 9200 1/s

Distance between lumped pumps (m) 3.0

How is vacuum pressure monitored? Ion gauge or Ion current of SIP

Procedures to avoid ion-trapping? none

Published articles describing the machine and/or vacuum system "Hefei Synchrotron Radiation Laboratory(HESYRL) An 800 Mev Electron Storage Ring and Its Synchrotron Radiation Experiment Area". Synchrotron Radiation Instrumentation Conference, 9-13 August 1982, Hanburg-DESY

Additional features or comments None

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 10.0
at Beam Energy (GeV) 0.800
and Beam Current (mA) 300
Fraction of beam remaining ______
Pressure required to achieve desired lifetime (Torr) 10^{-9}

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments ______

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened ______

Comments ______

*Fraction of beam remaining is ______

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring BESSY — Date 09.08.1983

Institution BESSY GmbH — Data supplied by G. Mülhaupt

Date of first circulating beam (or goal) Dezember 1981

Beam energy, Typical (E_0, GeV) 0.775

Max. (E_m, Gev) 0.800

Avg. Beam current, Typical(I_0, mA) 200

Max. (I_m, mA) 340

Radius of curvature in bend magnets (m) 1.78

Ring circumference (m) 62.4

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 3.5

or acceleration voltage/turn due to bend magnets at E_0(kV) 18

VACUUM CHAMBER:

Aperture: horizontal (cm) ± 3.0 vertical(cm) ± 2.0

Chamber material Stainless Steel

Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Cu

Chamber preparation before installation Per chlorettylene vapor degreasing-
ultrasound cleaning - heating to τ ≥ 200 C°

In-situ chamber treatment (e.g. bake, glow): bake τ ≥ 150° C°

VACUUM PUMPING:

Distributed pumping: type Sputter Ion

total speed ~ ~~1200 l/s~~

Lumped pumping: type Sputter Ion

total speed 9200 l/s

Distance between lumped pumps (m) 3 arg avg.?

How is vacuum pressure monitored? Ion gages (1 at each quadrant)
discharge-current of lumped Ion Sputter pumps

Procedures to avoid ion-trapping? No

Published articles describing the machine and/or vacuum system

1) Proc. 1979 Part. Mce Conf., IEEE Trans act. Nucl.Sc.,Vol-NS26,No.3,June 79

2) Nucl. Instr. Meth.,Vol. 172, Xlos 1,2 May 1980, p.55

3) Proc. 1983 Part. Mce. Conf., Santa Fé

Additional features or comments

Bessy page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) > 3 h
at Beam Energy (GeV) .8
and Beam Current (mA) 500
Fraction of beam remaining 1/2
Pressure required to achieve desired lifetime (Torr) $1 \cdot 10^{-9}$

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr) *1	Pressure With Beam (Torr) *1	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now	.2	~150	$2 \cdots 6 \cdot 10^{-10}$	$1 \cdots 2 \cdot 10^{-9}$	3

Comments *1 Pressure measured in straight sections; pressure in dipole-chambers roughly 2····5 times worse

After opening chamber to install a new ring vacuum component:

1. After one week	.2	4	$1 \cdots 2 \cdot 10^{-9}$	$3 \cdots 6 \cdot 10^{-9}$	1.5
2. After one month	.2	16	$2 \cdots 6 \cdot 10^{-10}$	$1 \cdots 2 \cdot 10^{-9}$	3
3. After 6 months	"	"	"	"	"

What procedure is followed when chamber is opened
bake out at $T > 150°$ for 75 h

Comments

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring ADONE Date July 1983
Institution INFN Data supplied by S.Tazzari-V.Chimenti
Date of first circulating beam (or goal) December 1967

Beam energy, Typical (E_0, GeV) 1.5
Max. (E_m, Gev) 1.5
Avg. Beam current, Typical(I_0, mA) 50÷ 80
Max. (I_m, mA) 2 x 100
Radius of curvature in bend magnets (m) 5
Ring circumference (m) 105

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 9x2 at E_m, I_m
or acceleration voltage/turn due to bend magnets at E_0(kV)

VACUUM CHAMBER:

Aperture: horizontal (~~cm~~ mm?) 240 vertical(~~cm~~ mm) 80
Chamber material Stainless Steel AISI 304L
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material not different

Chamber preparation before installation Electrolytic treatment in warm alkaline solutions

In-situ chamber treatment (e.g. bake, glow): bake at 300°C

VACUUM PUMPING:

Distributed pumping: type
total speed

Lumped pumping: type Sputter ion
total speed 14.000 l/s

Distance between lumped pumps (m) 4.5

How is vacuum pressure monitored? B.A. gages

Procedures to avoid ion-trapping?

Published articles describing the machine and/or vacuum system

- IEEE-NS-16, 3 p. 1073 (1969)
- Proceedings of the Vth International Conference on High Energy Accelerators, Frascati, 378 (1965)

Additional features or comments

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 10
at Beam Energy (GeV) 1.5
and Beam Current (mA) 2x100
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) $1\cdot10^{-9}$

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. ~~After first week of beam~~			$\Delta p/i$ =	$3\cdot10^{-10}$ Torr/mA	
2. ~~After 2 months of beam~~		.055		$1.7\ 10^{-10}$	
3. ~~After 1 year of beam~~		.125		$1.2\ 10^{-10}$	
4. ~~Now~~		.176			

Comments Above values referred to first operation. Our best values of $\Delta p/i$: $1 \div 5\cdot10^{-11}$ $\frac{\text{Torr}}{\text{mA}}$
after about 100 A–h $\left(\Delta P = 4\times10^{-11}(200) = 8\times10^{-9}\ \text{Torr}\right)$

$\left(\frac{100\ \text{Ah}}{.2\ \text{A}} = 500\ \text{hours}\right)$

After opening chamber to install a new ring vacuum component: * see comments

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened opening to dry air

Comments * not significantly different from above if whole chamber is let up to air

*Fraction of beam remaining is 1/e

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring: Photon Factory Date: July 20. 1983
Institution: National Lab. for High Energy Phys. Data supplied by: Masanori Kobayashi
Date of first circulating beam (or goal): Feb. 27, '82 (4-turn), March 11, '82 (accumulated)

Beam energy, Typical (E_0, GeV): 2.5
Max. (E_m, Gev): 3.0
Avg. Beam current, Typical(I_0, mA): 150
Max. (I_m, mA): 253
Radius of curvature in bend magnets (m): 8.66
Ring circumference (m): 187

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW): 63.6 watt/mrad
or acceleration voltage/turn due to bend magnets at E_0(kV): 400 KW at 500 mA & 2.5 GeV

VACUUM CHAMBER:

Aperture: horizontal (cm): 140 (B), 153 (Q) vertical(cm): 53 (B) 70 (Q)
Chamber material: A-6063 T6, (~80%) & SUS304, 304L & 316L for bellows (~20%)
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material: Cu (OFHC)

Chamber preparation before installation: No. i.e. as recieved from factory

In-situ chamber treatment (e.g. bake, glow): baking at 150~170°C for Al 250~300°C for SUS in 48 hrs. ArGDC. (10% O2) final period in baking

VACUUM PUMPING:

Distributed pumping: type: diode (Ti) for Bending, Ti Sub. P for Q-duct
total speed: 150~170 l/s x 28 set, ≲ 500 l/s x 50 set

Lumped pumping: type: diode (Ti & Ta) type SIP
total speed: nominaly 120 l/s x 50 set

Distance between lumped pumps (m): 187 m / 50 set

How is vacuum pressure monitored? At first, Inverted Magnetron Gauge, & Now nude-BA-gauge 50 set

Procedures to avoid ion-trapping? Electrodes for ArGDC in B-ducts are used at -400V. It looks fairly useful but not enough.

Published articles describing the machine and/or vacuum system:
Nucl. Instr. Methods 177 (1980) 111
Results & experience will be submitted in "Shinku" (in Japanese) and JUST.

Additional features or comments:

Photon Factory - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) ≳ 10
at Beam Energy (GeV) 2.5
and Beam Current (mA) 400 ~ 500
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) < 1×10⁻⁹ Torr

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr) Average along the ring	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam		~80	1×10^{-10} >	$1\sim2\times10^{-9}$	
4. Now		~85	1×10^{-10} >	$\lesssim 1\times10^{-9}$	450 at 100 mA

Comments ArGDC is useful for reduction of pressure in low current. It look not so useful in higher current.
After supply of gas molecules from non-irradiated parts of the duct is reduced by ArGDC, self cleaning is useful.

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened Baking.
When new component is installed, local ArGDC will be necessary.

Comments

*Fraction of beam remaining is 1/e

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring SOR Date 1983-7-19
Institution ISSP, University of Tokyo Data supplied by A. Mikuni and T. Miyahara
Date of first circulating beam (or goal) 1974 December

Beam energy, Typical (E_0, GeV) 0.38
Max. (E_m, Gev) 0.40
Avg. Beam current, Typical(I_0, mA) 300
Max. (I_m, mA) 510
Radius of curvature in bend magnets (m) 1.1
Ring circumference (m) 17.4

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 0.50
or acceleration voltage/turn due to bend magnets at E_0(kV) 1.68

VACUUM CHAMBER:

Aperture: horizontal (cm) 9 vertical(cm) 3.5
Chamber material SUS 304
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material —

Chamber preparation before installation
1 Super-sonic washing in soap and then athelon solution
2 Washing in nitric acid and alcohl

In-situ chamber treatment (e.g. bake, glow): Ar glow discharge in Ar and O_2 gas
baking at 250°C for 48 hours

VACUUM PUMPING:

Distributed pumping: type noble ion pump.
total speed 1200 l/sec

Lumped pumping: type spatter ion pump and Ti getter pump
total speed 8200 l/sec

Distance between lumped pumps (m) 4.3

How is vacuum pressure monitored? nude ion gauge

Procedures to avoid ion-trapping? —

Published articles describing the machine and/or vacuum system
T. Miyahara et al, Particle Accel. 7 163 (1976)
H. Kitamura, NIM 177 (1980) 107

Additional features or comments

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 4
at Beam Energy (GeV) 0.38
and Beam Current (mA) 300
Fraction of beam remaining
Pressure required to achieve desired lifetime (Torr) 10^{-9}

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now	0.300		10^{-10}	10^{-9}	3~4

Comments

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened
opened with dry N_2 gas filled and closed

Comments

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring TRISTAN ACCUMULATION RING Date July 23, 1983
Institution KEK Data supplied by G. Horikoshi
Date of first circulating beam (or goal) ______

Beam energy, Typical (E_0, GeV) 6
Max. (E_m, Gev) ______
Avg. Beam current, Typical(I_0, mA) 30
Max. (I_m, mA) ______
Radius of curvature in bend magnets (m) 23.2
Ring circumference (m) 377

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 147
or acceleration voltage/turn due to bend magnets at E_0(kV) ______

VACUUM CHAMBER:

Aperture: horizontal (cm) 9.0 vertical(cm) 4.8
Chamber material Aluminum Alloy 6063-T6
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material ______

Chamber preparation before installation Special extrusion with oxygen and argon gas inside the tube.

In-situ chamber treatment (e.g. bake, glow): ______

VACUUM PUMPING:

Distributed pumping: type Sputter Ion Pump
total speed 50 ℓ/s × 5 × 56 = 14000 ℓ/s

Lumped pumping: type Sputter Ion Pump
total speed 30 ℓ/s × 80 = 2400 ℓ/s

Distance between lumped pumps (m) 4.4

How is vacuum pressure monitored? Measurement of discharge current of SIP

Procedures to avoid ion-trapping? ______

Published articles describing the machine and/or vacuum system
H. Ishimaru et al., IEEE Trans. NS-30, No.3, 1983

Additional features or comments ______

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring: TRISTAN MAIN RING

Date: July 23, 1983

Institution:

Data supplied by: G. Horikoshi

Date of first circulating beam (or goal):

Beam energy, Typical (E_0, GeV): 30

Max. (E_m, GeV):

Avg. Beam current, Typical (I_0, mA): 15

Max. (I_m, mA):

Radius of curvature in bend magnets (m): 246.5

Ring circumference (m): 3018

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW): 4350

or acceleration voltage/turn due to bend magnets at E_0 (kV):

VACUUM CHAMBER:

Aperture: horizontal (cm): 11.0 vertical (cm): 5.4

Chamber material:

Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material:

Chamber preparation before installation:

Special extrusion(cf. TRISTAN ACCUMULATION RING).

In-situ chamber treatment (e.g. bake, glow):

VACUUM PUMPING:

Distributed pumping: type: Sputter Ion Pump

total speed: 100 ℓ/s/m × 6m × 292 = 175,200 ℓ/s

Lumped pumping: type: Sputter Ion Pump

total speed: 30 ℓ/s × 350 = 10,500 ℓ/s

Distance between lumped pumps (m): 8

How is vacuum pressure monitored? Measurement of discharge current of SIP

Procedures to avoid ion-trapping?

Published articles describing the machine and/or vacuum system:

Additional features or comments:

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring: UVSOR Date: 15, July, 1983
Institution: Inst. for Molecular Science Data supplied by: Makoto WATANABE
Date of first circulating beam (or goal): 1, November, 1983

Beam energy, Typical (E_0, GeV): 0.6
Max. (E_m, Gev): 0.8
Avg. Beam current, Typical(I_0, mA): 200
Max. (I_m, mA): 500
Radius of curvature in bend magnets (m): 2.2
Ring circumference (m): 53.6

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW): 1.04
or acceleration voltage/turn due to bend magnets at E_0(kV): 5.21

VACUUM CHAMBER:

Aperture: horizontal (cm): 11 vertical(cm): 3.8
Chamber material: Stainless steel
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material: ______

Chamber preparation before installation: ______

In-situ chamber treatment (e.g. bake, glow): baking 200°C, argon discharge (bending section only).

VACUUM PUMPING:

Distributed pumping: type: ion sputter pump
total speed: 1000 l/s

Lumped pumping: type: ion sputter pump
total speed: 6000 l/s and titanium sublimation pumps ⇓ total 20000 l/s
Distance between lumped pumps (m): 4.5 m (average)
How is vacuum pressure monitored? ion gauge

Procedures to avoid ion-trapping? At present No. However, clearing electrodes can be installed if necessary.

Published articles describing the machine and/or vacuum system:
M. Watanabe et al. IEEE Trans. NS-28 (1981), 3175.
"DESIGN OF UVSOR LIGHT SOURCE AT IMS"

Additional features or comments: ______

UVSOR - φ290 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 24 — lifetime due to vacuum (Touschek lifetime is 1 hour.)
at Beam Energy (GeV) 0.6
and Beam Current (mA) 500
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) 1 x 10⁻⁹

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments ______________________________

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened ______________________________

Comments ______________________________

*Fraction of beam remaining is ______________________________

TERAS

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring: TERAS*
Date: Aug. 6, '83
Institution: Electrotechnical Lab.
Data supplied by: Takio Tomimasu
Date of first circulating beam (or goal): Oct. 7, '81

Beam energy, Typical (E_0, GeV): 0.6
Max. (E_m, Gev): 0.8 (goal)
Avg. Beam current, Typical (I_0, mA): 90
Max. (I_m, mA): 300 (goal)
Radius of curvature in bend magnets (m): 2.0
Ring circumference (m): 31.44

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW): 1.3 kW
or acceleration voltage/turn due to bend magnets at E_0(kV): 5.7

VACUUM CHAMBER:

Aperture: horizontal (cm): ± 5.6 vertical(cm): + 1.8
Chamber material: SUS 316L
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material:

Chamber preparation before installation:

In-situ chamber treatment (e.g. bake, glow): bake and glow-discharge

VACUUM PUMPING:

Distributed pumping: type: Sputter Ion
total speed: 1500 l/s

Lumped pumping: type: Sputter Ion and Ti-sub
total speed: 11500 l/s

Distance between lumped pumps (m): 4.0

How is vacuum pressure monitored? Ion gauges

Procedures to avoid ion-trapping?

Published articles describing the machine and/or vacuum system
"A 600-MeV ETL Electron Storage Ring"
Particle Accelerator Conference
Santa Fe, New Mexico March 21-23, 1983

Additional features or comments
* TERAS, Tsukuba Electron Ring for Accelerating and Storage

TERAS

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) ____
at Beam Energy (GeV) ____
and Beam Current (mA) ____
Fraction of beam remaining ____
Pressure required to achieve desired lifetime (Torr) ____

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam	0.003		3×10^{-10}	7×10^{-9}	1.0
2. After 2 months of beam					
3. After 1 year of beam	0.1		3×10^{-10}	8×10^{-9}	4.0
4. Now					

Comments ____

After opening chamber to install a new ring vacuum component:

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After one week	0.01		5×10^{-10}	6.5×10^{-9}	0.5
2. After one month	0.03				0.5
3. After 6 months					

What procedure is followed when chamber is opened Dry N_2 is filled.

Comments ADDRESS: Electrotechnical Laboratory
1-1-4, Umezono, Sakura-Mura, Nihari-Gun
Ibaraki, JAPAN

*Fraction of beam remaining is 1/e

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring LEP
Date 21ST JULY 1983
Institution CERN
Data supplied by A.G. MATHEWSON
Date of first circulating beam (or goal) 1988/1989

Beam energy, Typical (E_0, GeV) INJECTION 20 GeV, PHASE 1 - 51 GeV
Max. (E_m, GeV) PHASE 2 - 86 GeV, PHASE 3 - 125 GeV
Avg. Beam current, Typical (I_0, mA)
Max. (I_m, mA) 2 × 3 mA (e^+e^-)
Radius of curvature in bend magnets (m) 3.1×10^3
Ring circumference (m) 26.659×10^3

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 51 GeV 1.2 MW
or acceleration voltage/turn due to bend magnets at E_0 (kV) 86 GeV 15 MW
125 GeV 89 MW

VACUUM CHAMBER:

Aperture: horizontal (cm) 13.1 vertical (cm) 7.0
Chamber material Al EXTRUDAL ISO AlMgSi 6060
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material

Chamber preparation before installation AFTER ALL MACHINING AND JUST BEFORE WELDING FLANGES TUBE IS ETCHED IN NaOH. THE FLANGES ARE NOT ETCHED BUT CLEANED SEPARATELY IN A NON-ETCH SOLUTION. BAKED AT 150°C 24 HOURS FOR LEAK TEST + VACUUM LIMIT. MAYBE GLOW IN Ar

In-situ chamber treatment (e.g. bake, glow): BAKE 24 hours 150°C

VACUUM PUMPING:

Distributed pumping: type ~~ION PUMP (TRIODE)~~ N.E.G.
total speed 10^3 to 20 ls^{-1} per metre depending on gas load

Lumped pumping: type ION PUMP (TRIODE)
total speed

Air (ls^{-1})	CH_4	P torr
26	32	10^{-9}
36	57	10^{-8}
38	70	10^{-7}

Distance between lumped pumps (m) 20

How is vacuum pressure monitored? BA IONIZATION GAUGES + ION PUMPS

Procedures to avoid ion-trapping? NONE

Published articles describing the machine and/or vacuum system
LEP MACHINE - LEP STUDY GROUP, CERN/ISR-LEP/79-33 1979
VACUUM SYSTEM - THE LEP VACUUM SYSTEM LEP NOTE 449 7th JUNE 1983 PRESENTED AT 9th INT VAC CONG. MADRID SEPT - 1983

Additional features or comments DUE TO THE SIZE OF THE MACHINE ONLY 3 SO CALLED PILOT SECTORS WILL BE FULLY INSTRUMENTED (≈ 1422 m = 3 × 471 m) WITH VACUUM GAUGES AND RESIDUAL GAS ANALYZER PERMANENTLY CONNECTED TO THE CENTRAL COMPUTER SYSTEM. ALSO ALL CHAMBERS WILL BE COATED WITH 3 to 8 mm OF Pb SHIELDING

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 20h due to beam/gas
at Beam Energy (GeV) 51, 86, 125
and Beam Current (mA) 2×3mA at 51 GeV less at higher energies
Fraction of beam remaining
Pressure required to achieve desired lifetime (Torr) Low 10^{-9}

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened

Comments

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring SRS Date 15-7-83
Institution DARESBURY LABORATORY Data supplied by G. SAXON
Date of first circulating beam (or goal)

Beam energy, Typical (E_0, GeV) 2·0
Max. (E_m, Gev) 2·0
Avg. Beam current, Typical(I_0, mA) 250
Max. (I_m, mA) 370
Radius of curvature in bend magnets (m) 5.56
Ring circumference (m) 90

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 70
or acceleration voltage/turn due to bend magnets at E_0(kV) 255

VACUUM CHAMBER:

Aperture: horizontal (cm) 16 to 11·5 vertical(cm) 2·7 to 4·5
Chamber material Stainless Steel
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Copper

Chamber preparation before installation i) Degrease
ii) Glow Discharge
iii) Bake-out to 300°C (where practicable, not r.f. cavities)

In-situ chamber treatment (e.g. bake, glow): Bake-out 200°C
(except r.f. cavities)

VACUUM PUMPING:

Distributed pumping: type Diode ion pump
total speed ~ 3200 l/s at 10^{-9} torr

Lumped pumping: type Triode ion pump + Sublimation Pump
total speed ~3200 l/s ~ 7000 l/s (at 10^{-4} torr)

Distance between lumped pumps (m) 6

How is vacuum pressure monitored? B.A Ion Gauges in Straights

Procedures to avoid ion-trapping? Clearing electrodes installed but not used because ion effects are not, in general, destructive

Published articles describing the machine and/or vacuum system
SRS Vacuum System Vacuum 28 471 (1978)
See also Design Study for a Dedicated Source of Synchrotron Radiation, D.L Report DL/SRF/R2 (1975)

Additional features or comments

SRS · page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 10
at Beam Energy (GeV) 2
and Beam Current (mA) 370
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) 10^{-9} torr

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments June 80 – Nov. 80 Unbaked Integr. Dose < 1Ah, life ~ 30 min, 100mA
Sept 81 Baked 1.8 GeV I.D 30Ah $\frac{dP}{dI}$ 10^{-10}–10^{-11} Torr/mA, life 8–10h at 100mA
(see attached curve for further details on intensity dependence)
Sept 82 Baked 2.0 GeV I.D: 200Ah $\frac{dP}{dI}$ 10^{-11}–10^{-12} Torr/mA life ~20h at 100mA
(Several sectors had been up to atmosphere in this time)

After opening chamber to install a new ring vacuum component:

1. After one week				
2. After one month				
3. After 6 months				

What procedure is followed when chamber is opened Bake-out to 200°C
(except cavities which are r.f conditioned)

Comments There have been a series of vacuum accidents (of windows etc) in 1983, and a few small leaks which mask statistics. Lifetime is ~10h at 100mA now with Average Pressure (in Straight Sections 1–2 $\times 10^{-9}$ torr).

*Fraction of beam remaining is 1/e

SRS
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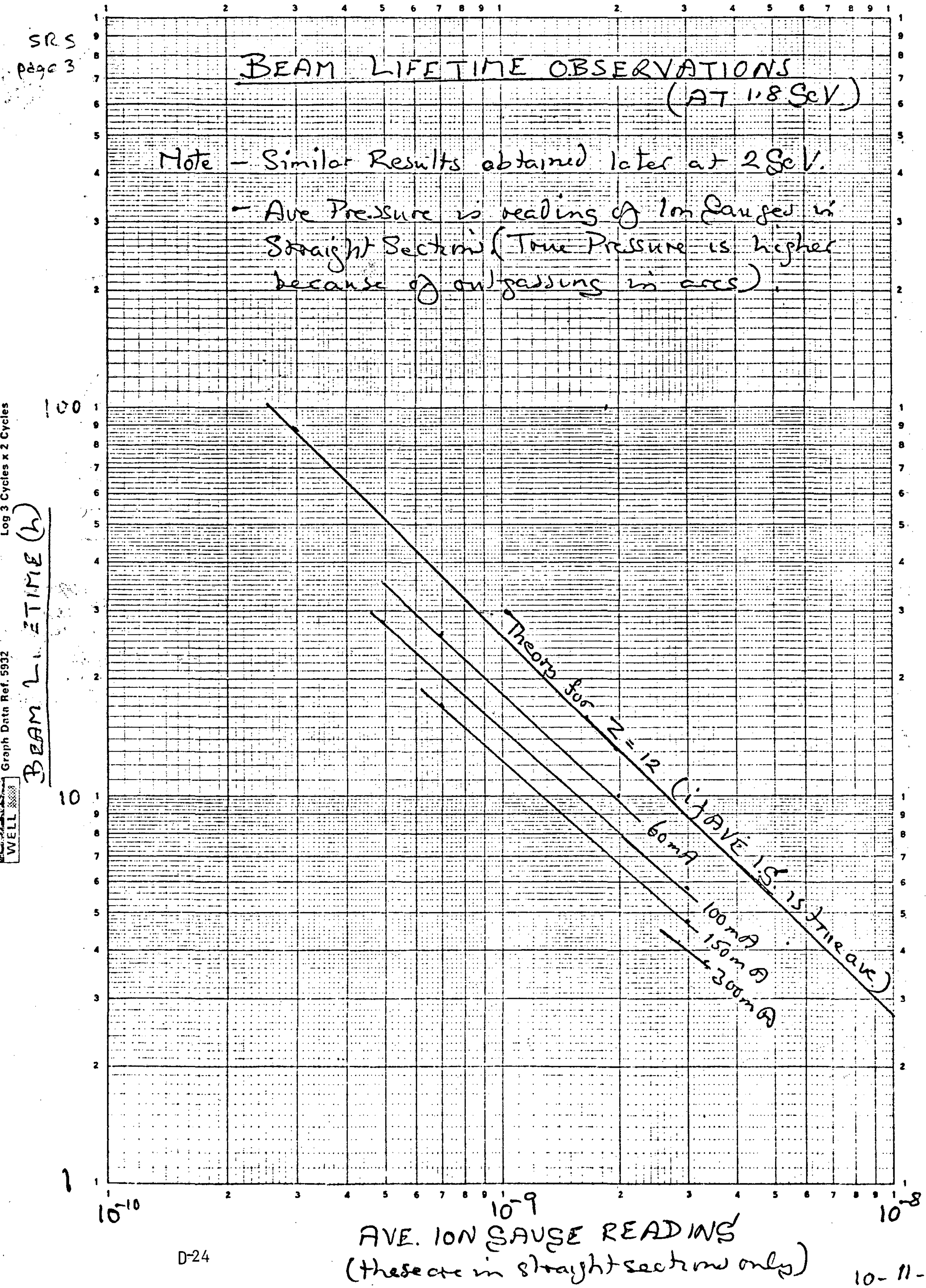

D-24

10-11-9

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring SURF   Date 23 July, 1983
Institution NBS   Data supplied by LR Hughey
Date of first circulating beam (or goal) 1973 or 1974

Beam energy, Typical (E_0, GeV) 0.282
Max. (E_m, GeV) 0.300 (or a little more)
Avg. Beam current, Typical(I_0, mA) 15
Max. (I_m, mA) same
Radius of curvature in bend magnets (m) 0.84
Ring circumference (m) 2.216

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) ____
or acceleration voltage/turn due to bend magnets at E_0 (kV) ____

VACUUM CHAMBER:

Aperture: horizontal (cm) 25 vertical(cm) 10
Chamber material 304 stainless steel
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material same
Chamber preparation before installation baked at ~250°C

In-situ chamber treatment (e.g. bake, glow): bake at ~ 130-150 °C.

VACUUM PUMPING:

Distributed pumping: type internal ion pump elements and one 200 l/s
total speed holding pump total speed ~ 1000 l/s
Lumped pumping: type ____
total speed ____
Distance between lumped pumps (m) ____
How is vacuum pressure monitored? a single ion gauge

Procedures to avoid ion-trapping? none

Published articles describing the machine and/or vacuum system ____
For any additional information contact:
Lanny Hughey
NBS, Physics A 251, Washington, DC 20234
Additional features or comments ____

SURF - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) At ~ 10 x 10^{-9} the vacuum seems
at Beam Energy (GeV) to impose a ½ life of about 6 hrs.
and Beam Current (mA) At our usual beam currents of 10-30 mA
Fraction of beam remaining our life time is Touschek limited.
Pressure required to achieve desired lifetime (Torr) ______

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments We have never observed any presure rise due to stored beam, even with our occational 35- 45 mA beams.

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened The chamber is usually vented on Friday and new features installed. The chamber is
Comments then pumped out and baked for three days. On Tuesday morning the pressure nearly back to normal (~ 2x10^{-8}) and beams are injected and accelerated. When the magnet is up to usual operating field (1.2 T) the vacuum is normal ~ 6 - 10 x 10^{-9}.

*Fraction of beam remaining is ______

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring SPEAR **Date** 7/19/83
Institution SLAC **Data supplied by** B. Scott
Date of first circulating beam (or goal) April 1972

Beam energy, Typical (E_0, GeV) 1.5 - 3.5
Max. (E_m, GeV) 3.7
Avg. Beam current, Typical (I_0, mA) 100 mA at 3 Gev
Max. (I_m, mA) 50 (colliding beams)
Radius of curvature in bend magnets (m) 12.716
Ring circumference (m) ARC + IR 234.1 ARCS 189.2

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 56.4 KW/Beam at 3 GeV 100 mA
or acceleration voltage/turn due to bend magnets at E_1(kV)

VACUUM CHAMBER:

Aperture: horizontal (cm) 15.54 **vertical** (cm) 4.62
Chamber material Aluminum 6061-T 6
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Aluminum

Chamber preparation before installation

Chemical etch, bakeout to 170°C

In-situ chamber treatment (e.g. bake, glow): None accept after accidental venting when bakeout may be necessary

VACUUM PUMPING:

Distributed pumping: type Sputter Ion (Diode)
total speed 36 (600)= 21,600 L/s
Lumped pumping: type Sputter Ion (triode)
total speed Arcs 16 (400) 6,400 liters/sec
Distance between lumped pumps (m) 11.69 m
How is vacuum pressure monitored? BA Ion Gauge

Procedures to avoid ion-trapping? N/A

Published articles describing the machine and/or vacuum system

Vacuum system for Stanford Storage Ring, SPEAR, Journal Vac. Sci & Tech vol.8 No.1
Vacuum sysem for Stanford - LBL Storage Ring, PEP, SLAC Pub. 1547, 1975

Additional features or comments

SPEAR - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 8 hrs
at Beam Energy (GeV) 3.0 GeV
and Beam Current (mA) 100 mA
Fraction of beam remaining 50% 12 hrs run time between fills
Pressure required to achieve desired lifetime (Torr) 10-9 range

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments Clean-up time after opening of system depends on beam energy, current and bunch structure of beam during the start-up period.

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened Clean-up of work area and flanges; smoke free atmosphere; if tunnel roof blocks are removed the

Comments work area is isolated with plastic sheeting to reduce air and dust circulation; dry nitrogen purge at all times when system is open.

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring PEP Date 7/14/83
Institution Data supplied by J. Jurow
Date of first circulating beam (or goal) 4/21/80

Beam energy, Typical (E_0, GeV) 14.5
Max. (E_m, Gev)
Avg. Beam current, Typical(I_0, mA) 35
Max. (I_m, mA) 42
Radius of curvature in bend magnets (m) 165.5
Ring circumference (m) 238.3

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 827 KW/e$^-$ beam
or acceleration voltage/turn due to bend magnets at E_0(kV)

VACUUM CHAMBER:

Aperture: horizontal (cm) 9 vertical(cm) 5
Chamber material Aluminum
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Aluminum

Chamber preparation before installation Clean and Bake

In-situ chamber treatment (e.g. bake, glow): Bake due to accidental let-up

VACUUM PUMPING:

Distributed pumping: type Sputter Ion
total speed 9600 ℓ/sec

Lumped pumping: type Sputter Ion
total speed 51000 ℓ/sec

Distance between lumped pumps (m) 14

How is vacuum pressure monitored? Bayard-Alpert Gauges
Computer recorded

Procedures to avoid ion-trapping? None

Published articles describing the machine and/or vacuum system
Vacuum System for the Stanford-LBC Storage
Ring (PEP), IEEE Transactions Vol. NS-22, No. 3, 1975

Additional features or comments

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 4
at Beam Energy (GeV) 14.5
and Beam Current (mA) 35
Fraction of beam remaining 80% after 2 hours
Pressure required to achieve desired lifetime (Torr) ______

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments ______

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened ______

Comments ______

*Fraction of beam remaining is ______

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring SLC-e^- Damping Ring Date 7/13/83
Institution Stanford Linear Acc. Center Data supplied by D. Wright
Date of first circulating beam (or goal) Feb. 1983

Beam energy, Typical (E_0, GeV) 1.21 GeV (950 MeV)
Max. (E_m, Gev) 1.21 GeV
Avg. Beam current, Typical(I_0, mA) 141 mA (1-3 mA)
Max. (I_m, mA) 141 mA
Radius of curvature in bend magnets (m) 2.049 m
Ring circumference (m) 35.27

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 13.1 kW
or acceleration voltage/turn due to bend magnets at E_0(kV)

VACUUM CHAMBER:

Aperture: horizontal (cm) 2.0 cm vertical(cm) 1.5 cm
Chamber material 6061 - T6 Aluminum & Stainless Steel
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material

Chamber preparation before installation N_2 purge bakeout @ 180°c followed by vacuum bakeout @ 180°c

In-situ chamber treatment (e.g. bake, glow): none

VACUUM PUMPING:

Distributed pumping: type Diode sputter - ion pumps
total speed 7.3 x 10 ℓ/s
Lumped pumping: type Diode Sputter - ion pumps
total speed 960 ℓ/s
Distance between lumped pumps (m) 1.3 m
How is vacuum pressure monitored? nude B-A ion gauges

Procedures to avoid ion-trapping? Clearing field electrodes

Published articles describing the machine and/or vacuum system
SLAC Linear Collider Conceptual Design Report (SLAC Report -229)

Additional features or comments

SLC Damp - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 50 min (see comments)
at Beam Energy (GeV) 1.21 GeV
and Beam Current (mA) 141 mA
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) ~~5×10^{-9} Torr~~

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam	958 MeV 0.2 mA	22.5 mA-hr	8.5×10^{-9}	1.1×10^{-8}	50 min
2. After 2 months of beam	0.5 mA	180mA-hr	5.8×10^{-9}	1.0×10^{-8}	50 min
3. After 1 year of beam	--	----	----	----	-----
4. Now	0.9mA	360mA-hr	5.8×10^{-9}	8.8×10^{-9}	50 min

Comments In normal operation beams are ejected after 5.5 m sec

After opening chamber to install a new ring vacuum component:

1. After one week	1.4mA	22.5 mA-hr	2.0×10^{-8}	2.8×10^{-8}	50 min
2. After one month	0.5mA	90mA-hr	5.8×10^{-9}	1.0×10^{-8}	50 min
3. After 6 months					

What procedure is followed when chamber is opened Vent to dry N_2 (boil-off from liquid); maintain N_2 purge while open; purge overnight after closing if possib

Comments

*Fraction of beam remaining is 1/e

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring NSLS VUV   Date 7-13-83
Institution Brookhaven Nat Lab   Data supplied by J. Schuchman
Date of first circulating beam (or goal) Aug 1981

Beam energy, Typical (E_0, GeV) .75
Max. (E_m, Gev) .8
Avg. Beam current, Typical(I_0, mA) 200
Max. (I_m, mA) 1000
Radius of curvature in bend magnets (m) 1.91
Ring circumference (m) 51

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW) 14
or acceleration voltage/turn due to bend magnets at E_0(kV)

VACUUM CHAMBER:

Aperture: horizontal (cm) 8   vertical(cm) 4.2
Chamber material Alum. VAW Alloy 19/06 LVW
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material —

Chamber preparation before installation
Caustic Etch, see NSLS SPEC SLS-07.12-1-18

In-situ chamber treatment (e.g. bake, glow):
Vacuum Bakeout 150°C for 72 hrs.

VACUUM PUMPING:

Distributed pumping: type Sputter Ion - Diode
total speed 1800 ℓ/sec at 10^{-9} Torr

Lumped pumping: type Sputter Ion (P&E DI)
total speed 1320 ℓ/sec at 10^{-9} Torr

Distance between lumped pumps (m) 4.3 Avg.

How is vacuum pressure monitored? Sputter Ion Pump Current

Procedures to avoid ion-trapping? Chamber has provisions for clearing electrodes; Option of 1 bunch, 3 bunch or 9 bunch with gap operation.

Published articles describing the machine and/or vacuum system
Vacuum System for NSLS, J. Vac. Sci. Technol., 16(2), Mar/Apr. 1979 720.
Final Design & Status of the NSLS Vacuum System, J. Vac. Sci. Technol. A-1(2), Apr-June 1983, 196.

Additional features or comments
Ti Sublimination Pumping Speed 7000 ℓ/sec

NSLS
VUV - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 5 hrs
at Beam Energy (GeV) .75
and Beam Current (mA) 1000
Fraction of beam remaining
Pressure required to achieve desired lifetime (Torr) 10^{-9}

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened
Vent with LN_2 trapped dry nitrogen.

Comments Future plans to vent with LN_2 boil-off.

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring NSLS X-RAY Date 7-13-83
Institution ______ Data supplied by J. Schuchman
Date of first circulating beam (or goal) Sept 1982

Beam energy, Typical (E_o, GeV) 2
Max. (E_m, Gev) 2.5
Avg. Beam current, Typical(I_o, mA) 10
Max. (I_m, mA) 500
Radius of curvature in bend magnets (m) 6.875
Ring circumference (m) 170

Synchrotron radiation power due to bend magnets at E_o, I_o (kW) 251
or acceleration voltage/turn due to bend magnets at E_o(kV) 505

VACUUM CHAMBER:

Aperture: horizontal (cm) 8 vertical(cm) 4.2
Chamber material Alum. VAW Alloy 19/06 LVW
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material —

Chamber preparation before installation
Caustic Etch, see NSLS SPEC SLS-07.12-1-1B
Vacuum Bakeout 150°C 48 hrs.

In-situ chamber treatment (e.g. bake, glow):
Vacuum Bakeout 150°C for 72 hrs

VACUUM PUMPING:

Distributed pumping: type Sputter Ion - Diode
total speed 6 0 ℓ/sec at 10^{-9} Torr
Lumped pumping: type Sputter Ion (P+E DI)
total speed 2640 ℓ/sec at 10^{-9} Torr
Distance between lumped pumps (m) 5.3
How is vacuum pressure monitored? Sputter Ion Pump Current

Procedures to avoid ion-trapping? chamber has provision for clearing electrodes; Option of 1 bunch, 3 bunch, or 30 bunch with gap operation.
Published articles describing the machine and/or vacuum system
Vacuum System for NSLS, J. Vac. Sci. Technol. 16 (2), Mar/Apr. 1979, 720.
Final Design & Status of the NSLS Vacuum System, J. Vac. Sci. Technol. A-1 (2), Apr - June 1983, 196.
Additional features or comments
Ti Sublimination Pumping Speed 16800 ℓ/sec

NSLS

X-RAY - page 2

ELECTRON STORAGE RING/VACUUM DATA SHEET

DESIRED VACUUM:

Desired beam lifetime (hours) 10 hrs
at Beam Energy (GeV) 2.5
and Beam Current (mA) 500
Fraction of beam remaining
Pressure required to achieve desired lifetime (Torr) 10^{-9} Torr

OPERATING EXPERIENCE

	Beam Current (A)	Integrated Beam Current (A-hours)	Pressure Without Beam (Torr)	Pressure With Beam (Torr)	Beam Lifetime* (Hours)
1. After first week of beam					
2. After 2 months of beam					
3. After 1 year of beam					
4. Now					

Comments

After opening chamber to install a new ring vacuum component:

1. After one week					
2. After one month					
3. After 6 months					

What procedure is followed when chamber is opened
Vent with LN_2 trapped dry nitrogen.
Comments Future plans to vent with LN_2 boil-off

*Fraction of beam remaining is

ELECTRON STORAGE RING/VACUUM DATA SHEET

Name of the Ring Advanced Light Source (ALS) Date 7/7/83
Institution Lawrence Berkeley Laboratory Data supplied by Kurt Kennedy
Date of first circulating beam (or goal) 1988

Beam energy, Typical (E_0, GeV) 1.3
Max. (E_m, Gev) 1.9
Avg. Beam current, Typical(I_0, mA) 400
Max. (I_m, mA) 400
Radius of curvature in bend magnets (m) 3.97
Ring circumference (m) 182.

Synchrotron radiation power due to bend magnets at E_0, I_0 (kW)
or acceleration voltage/turn due to bend magnets at E_0(kV) 64

VACUUM CHAMBER:

Aperture: horizontal (cm) ±3.2 vertical(cm) ±2.5
Chamber material Al Alloy
Material impinged by synchrotron radiation from the bend magnets (photon absorber) if different from chamber material Cu

Chamber preparation before installation Perchlorethylene vapor degreasing - alkaline detergent - demineralized water

In-situ chamber treatment (e.g. bake, glow): glow-discharge

VACUUM PUMPING:

Distributed pumping: type NEG (or cryo, or Ti-sub. -- being studied)
total speed 40,000 l/s

Lumped pumping: type Sputter Ion
total speed 18,000

Distance between lumped pumps (m) Avg. 4.0 meter

How is vacuum pressure monitored Ion gages

Procedures to avoid ion-trapping Critical ion mass > 10 amu except 250 bunch mode. Then 250 full and 54 empty buckets should avoid trapping.

Published articles describing the machine and/or vacuum system
"The Advanced Light Source"
Particle Accelerator Conference
Santa Fe, New Mexico March 21-23, 1983
Additional features or comments See enclosed. Pumping speed shown above is the speed through the slot connecting storage ring and antechamber.

DESIRED VACUUM:

Desired beam lifetime (hours) > 6 hrs. (Touschek + gas scattering)
at Beam Energy (GeV) 1.3
and Beam Current (mA) 400
Fraction of beam remaining 1/e
Pressure required to achieve desired lifetime (Torr) 10^{-9} Torr

OPERATING EXPERIENCE (None)

PAPERS RELATIVE TO VACUUM SYSTEMS OF ELECTRON STORAGE RINGS AND ASSOCIATED PHOTON BEAMLINES

63-1 E.L. Garwin, "3 BeV Colliding Beam Vacuum System", SLAC Memorandum, August, 1963

68-1 J.R. Young, "Outgassing Characteristics of Stainless Steel and Aluminum with Different Surface Treatments", J. Vac. Sci. Technol. 6 (3), 398 (October 1968).

68-2 E.L. Garwin, E.W. Hoyt, M. Rabinowitz and J. Jurow, "Electron-induced Desorption of Gases from Aluminum", Proc. of the Fourth International Vacuum Congress, 1968.

75-1 D. Bostic, U. Cummings, N. Dean, B. Jeong, and J. Jurow, "Vacuum System for the Stanford-LBL Storage Ring (PEP)", IEEE Trans. Nucl. Sci. NS-22, No. 3 (1975).

76-1 S. Brumbach and M. Kaminsky, "X-Ray Impact Induced Desorption of Gases from Surfaces", J. Nucl. Materials 63 (1), 188-192 (1976).

76-2 A.G. Mathewson, "Ion Induced Desorption Coefficients for Titanium Alloy, Pure Aluminum and Stainless Steel", CERN-ISR-VA/76-5, (March 1976).

76-3 A.G. Mathewson, P. Verbeek, A. Grillot, and R. Calder, "Thermal Desorption of CO From Stainless Steel", CERN-ISR-VA/76-27 (July 1976).

76-4 A.G. Mathewson, "The Surface Properties of Inconel 600 and Inconel 625 Studied by Scanning Electron Microscopy, Auger Electron Spectroscopy and Ion Induced Desorption", CERN-ISR-VA/76-29 (July 1976).

76-5 M-H. Achard, "Electron and Ion Induced Gas Desorption from Stainless Steel, OFHC Copper, Titanium and Pure Aluminum", CERN-ISR-VA/76-34 (August 1976).

76-6 J. Kouptsidis and A.G. Mathewson, "Reduction of the Photoelectron Induced Gas Desorption in the PETRA Vacuum System by In Situ Argon Glow Discharge Cleaning", DESY 76/49 (September 1976).

76-7 A.G. Mathewson, "The Effect of Cleaning and Other Surface Treatments on the Surface Composition of Technological Materials", CERN-ISR-VA/76-41 (October 1976).

77-1 D. Lichtman, "A Study of Electron and UV Photon Surface Interactions", 1976-77 Progress Report, University of Wisconsin (1977).

77-2 V.G. Rogozinskii and V.L. Ushkov, "Beam Effect on Pressure in the Vacuum Chamber of the IHEP Proton Synchrotron", Report IFVE-OUNK 77-71 (Russ., 1977), Abstract from INIS Atomindex 10 (6), No. 437862 (1979).

77-3 E. Fischer, "Ultrahigh Vacuum Technology for Storage Rings", IEEE Trans. Nucl. Sci. NS-24, (3) (June 1977).

77-4 D.A. Shirley, J. Stohr, P.S. Wehner, R.S. Williams, and L.G. Apai, "Photoemission from Noble Metal and Adsorbates Using Synchrotron Radiation", Physica Scripta 16, 398-413 (1977).

77-5 M. Drinkwine and D. Lichtman, "Electron Stimulated Desorption: A Critical Review", Progress in Surface Science 8, 123 (1977).

77-6 C. Benvenuti and J.C. Decroux, "A Linear Pump for Conductance Limited Vacuum Systems", in Proceedings of the 7th International Vacuum Congress and 3rd International Conference on Solid Surfaces (Vienna, September 12-16, 1977), p. 85 (1977).

77-7 R. Calder, A. Grillot, F. Le Normand, and A.G. Mathewson, "Cleaning and Surface Analysis of Stainless Steel Ultrahigh Vacuum Chambers by Argon Gas Discharge", in Proc. 7th Intern. Vac. Congr. and 3rd Intern. Conf. Solid Surfaces (1977).

77-8 R. Franchy and D. Menzel, "Photodesorption at High Energies", Proc. 7th Intern. Vac. Congr. and 3rd Intern. Conf. Solid Surfaces, pp. 1209-1212, Vienna (1977).

77-9 J.S. Kouptsidis, "Vacuum Problems of Electron Storage Rings", Proc. 7th Intern. Vac. Congr. and 3rd Intern. Conf. Solid Surfaces, p. 341 (1977).

77-10 B.A. Tricket, "Vacuum Systems for the Daresbury Synchrotron Radiation Source", Proc. 7th Intern. Vac. Congr. and 3rd Intern. Conf. Solid Surfaces, p. 347 (1977).

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78-2 D.J. Harra, "Review of Sticking Coefficients and Sorption Capacities of Gases on Titanium Films", J. Vac. Sci. Technol. 13 (1), 471 (January-February 1978).

78-3 D.E. Aspens and V. Rehn, "In-Situ Monitoring of Mirror Surfaces in Synchrotron Radiation Applications, in Workshop on X-Ray Instrumentation for Synchrotron Radiation Research, edited by H. Winick and G. Brown, p. VII-67 (April 3-5, 1978).

78-4 D.A. Shirley, "Beam Line Chemistry", in Workshop on X-Ray Instrumentation for Synchrotron Radiation Research, edited by H. Winick and G. Brown, pp. 80-100 (April 3-5, 1978).

78-5 A.G. Mathewson, G. Horikoshi, and J. Mizuno, "Some Notes on the Photoelectron Induced Gas Desorption Problems in the Photon Factory and Tristan", KEK-78-9 (June 1978).

78-6 R.S. Vaughan Watkins and E.M. Williams, "An Appraisal of Glow Discharge Treatment of Copper Surfaces by the Technique of Electron Stimulated Desorption", Vacuum 28 (10/11), 459-465 (1978).

78-7 B.A. Trickett, "The Vacuum System for the Daresbury Synchrotron Radiation Source", Vacuum 28 (10/11), 471-482 (1978).

78-8 J.C. Schuchman, J.B. Godel, W. Jordan, and T. Oversluizen, "Vacuum System for National Synchrotron Light Source", BNL-25010, submitted to J. Vac. Sci. Technol., 25th National Vacuum Symposium, November 27-30, 1978.

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12 October 1983

R. T. Avery
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Berkeley, California 94720

Dear Bob:

For your report of the Synchrotron-Radiation Vacuum Workshop, I would like to suggest both optimistic and cautionary comments. The question relates to the extrapolation of both experience and the DESY model to much higher photon-flux densities relevant to the ALS undulator beam lines. The optimistic comment comes from the prediction by the DESY model of "intensity saturation" of the contamination rate. I have replotted their Eq. 2 on a log-log plot showing four decades of intensity to illustrate the effect. For pressures of 10^{-9} T and below, a hundred-fold increase in intensity produces less than a two-fold increase in contamination rate.

The first cautionary comment relates to the combination of high intensity and high pressure. In this regime, the contamination rate increases linearly with intensity, and a hundred-fold increase in intensity would decrease the mirror lifetime from ~ 3 mo to ~ 0.03 mo, or about one day. Thus, undulator radiation must never strike a mirror surface when the ambient pressure is high.

The second caution is the obvious one of relying on the model far outside its region of verification. Although undulator radiation should not be intense enough to stimulate non-linear multiphoton excitations, there could be increases in the cracking cross section especially in FEL beams. If so, the contamination rate would increase sharply above the threshold intensity. The true saturation would occur when every molecule striking the surface is cracked, and even at 10^{-10} T this would produce of order 10 atomic layers of carbon per day, or a mirror lifetime of 1 - 10 days.

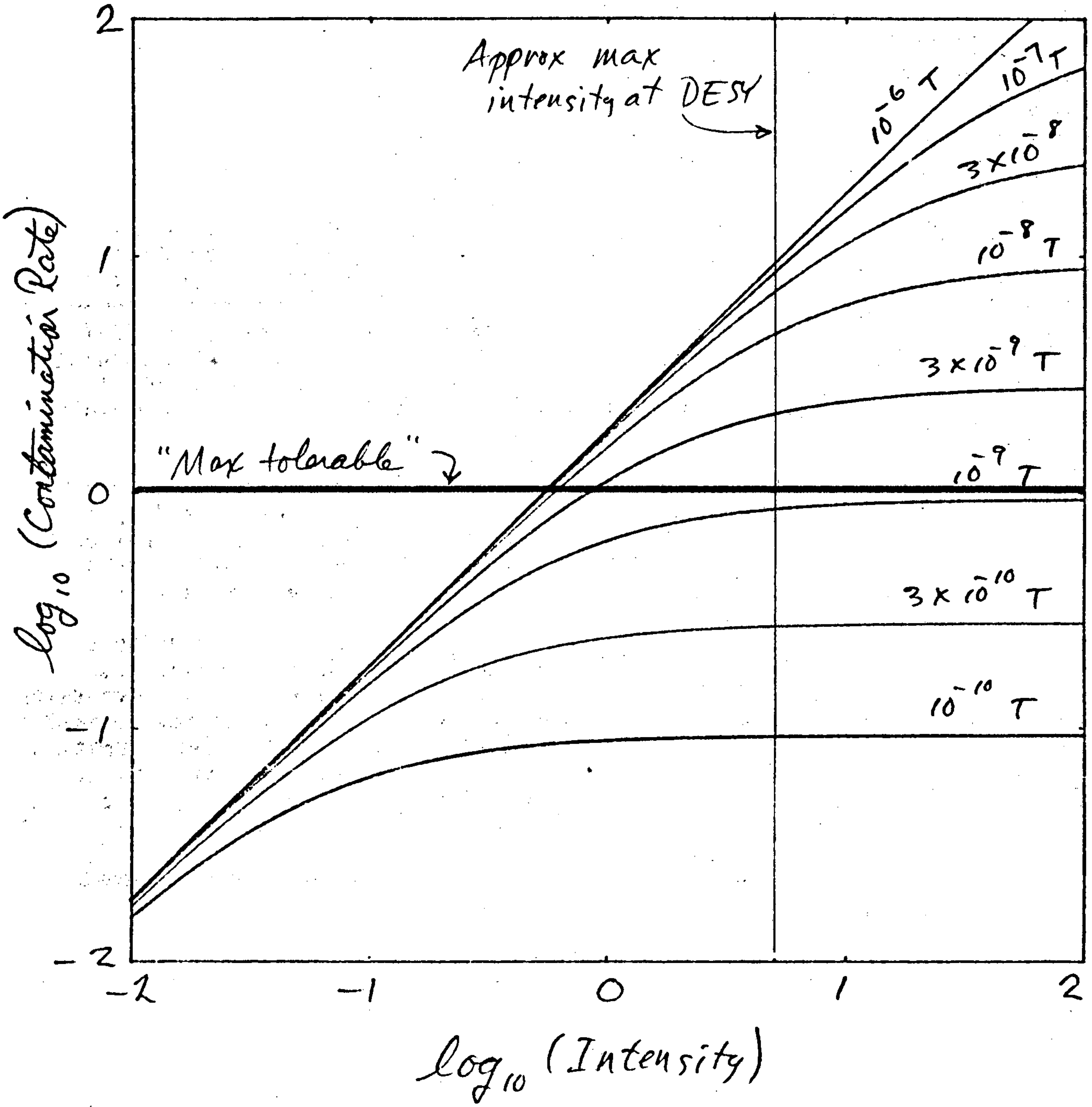
These few additional comments should provide a more reasoned report on these problems, as well as a better basis for the recommendations.

Sincerely,

Vic

V. Rehn

Enclosure:
(1) Log_{10} Graph


Approx max intensity at DESY
"Max tolerable"
10^{-6} T
10^{-7} T
3×10^{-8}
10^{-8} T
3×10^{-9} T
10^{-9} T
3×10^{-10} T
10^{-10} T
$\log_{10}$ (Contamination Rate)
$\log_{10}$ (Intensity)
2
1
0
−1
−2
−2
−1
0
1
2

Encl (1)

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