SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE	**Guidelines for UHV-Components at SOLARIS** Solaris Standards & Recommended Practices

Version:	2.2
Owner:	Andrzej Marendziak; andrzej.marendziak@uj.edu.pl
Reviewed by:	
Approved by:	
Location:	
Filename:	**Guidelines for UHV-components at Solaris**
Last update:	2022-02-15

Revision history

Version	Date	Description	Sign
1.2	2017-01-13		Marcin Zając
1.3	2017-01-22		Jacek Szade
1.4	2017-03-30	Chapter 3.5	Andrzej Marendziak
1.5	2018-10-31	Chapter 3.5, 3.6, 3.7, 4	Andrzej Marendziak
1.6	2019-01-31	Chapter 3.4, 4.6	Andrzej Marendziak
1.7	2019-04-12	Chapter 3.8	Andrzej Marendziak
1.8	2019-05-14	Chapter 3.5	Andrzej Marendziak
1.9	2019-07-03	Chapter 3.2	Andrzej Marendziak
2.0	2020-01-31	Chapter 3.1, 3.2, 3.4	Andrzej Marendziak
2.1	2021-02-02	Chapter 3.1, 3.9	Andrzej Marendziak
2.2	2022-02-15	Chapter 3.4	Mateusz Wiśniowski

Authors:

Andrzej Marendziak
Marcin Zając
Jacek Szade
Mateusz Wiśniowski

Content

1. General Information

Performance of the vacuum system, effective and reliable operation of particle accelerators is strongly related to obtain and keeping Ultra High Vacuum (UHV) conditions. The guidelines of UHV-components at Solaris contains important information regarding: vacuum technology, current standard of vacuum equipment, installation procedures, cleaning, acceptance test and protocols for UHV components. It is required to consider these guidelines during installation of vacuum system at Solaris. The guidelines apply to individual parts of the machine: Linear Accelerator, Transfer Line, Storage Ring, Front-End and also for Beamlines, End Stations and all the vacuum equipment used during installation process.

Deviations during the design and installation from these guidelines need to be clarified and accepted in advance by the Solaris Vacuum Group.

2. Technologies and materials

Specific information regarding technologies and materials for UHV components and devices have been described in separate document. This document "**Technologies and materials for SOLARIS UHV devices**" define specifications of Solaris vacuum chambers, including tender documents for manufacturing and quality assurance. Manufacturing and cleaning guidelines for UHV devices have been also in details presented.

3. Standard of typical vacuum components

In this chapters current standards of vacuum component and device will be presented. All described components/devices are defined by the brand of contractor, and all the components/devices have been so far implemented and tested in the vacuum system of synchrotron Solaris.

3.1. Vacuum Pumps and Pumping Stations

Only dry pumps shall be used during installation, maintenance process and operation on the synchrotron vacuum system.

Only dry pumps shall be used in mobile pumps carts (mobile pumping stations) dedicated for installation and maintenance of synchrotron vacuum system. These pumps shall be dry and free of oils, lubricants, hydrocarbons or other fluids in the pumping chamber and shall not generate particulate or particles during operation. Each pumping carts shall fulfill vacuum criteria regarding leak tightness and residual gas composition. If mobile pumps carts is intended to perform leak check of vacuum components based on Residual Gas Analyzer (RGA), calibration of the mobile pumps carts is required by external calibrated leak. Additional requirements may include but not limited to: specific vacuum connections, specific electrical supplies, radiation levels, etc.

- Requirements regarding primary/fore pumps:
  - low level of vibration and noise
  - oil free
  - halogens free
  - interlock system and safety valves when used in vacuum system
  - scroll pumps shall be equipped with inlet dust filter

- Requirements regarding turbomolecular pumps:
  - pump build based on parts which are free of grease/lubricants
  - interlock system and safety valves when used in vacuum system

Specification of pump station available at Solaris has been presented below.

Multistage Roots Dry Pump: APC15 Adixen
Fore Vacuum Gauge: Thermovac Transmitter TTR91
Turbomolecular Pump: Turbovac SL300 or SL80
High Vacuum Gauge: Full Range Gauge/Bayard Alpert ITR 90
Mass spectrometer: SRA RGA100 or 200 Optional
Pumping ports: CF40, CF63
Leak check ports: KF25
Venting ports: KF25
Remote Control, Data Acquisition Software

Mobile Pump Station from Prevac

Typical fore pumps used at Solaris:

- scroll pump Edwards Vacuum XDS 6i (product number: A73501983)
- scroll pump Edwards Vacuum XDS 15i (product number: A73501983)
- diaphragm pump Pfeiffer Vacuum MVP070 (product number: PK T01 310)
- roots pump Pfeiffer Vacuum ACP 15 (product number: V5SATSMFEF)
- roots pump Kashiyama NeoDry15E (product number: NeoDry15E-2DBK)

Typical turbomolecular pumps used at Solaris:

- Pfeiffer Vacuum HiPace 80 (product number: PM P03 944)
- Pfeiffer Vacuum HiPace 300 (product number: PM P03 901)
- Pfeiffer Vacuum HiPace 400 (product number: PM P04 024)
- Pfeiffer Vacuum HiPace 700 (product number: PM P03 934)

3.2. Vacuum Gauges

Different kind of vacuum gauges may be used for total pressure measurements in Low, High and UHV pressure regimes. Application may vary depending on the type of vacuum systems.

- Thermal Conductivity (Pirani) Gauges used for measurement in the range atmosphere to 10^{-4} mbar. Mostly used in Pump Stations, Beamlines and End Stations.
  Typical vacuum gauges used at Solaris:
  - Leybold: TTR 91
  - Pfeiffer: TPR 280

- Cold Cathode Gauges (Penning and Inverted Magnetron) used for measurement in the range from 10^{-3} to 10^{-10} mbar. Mostly used in Machine, Beamlines and End Stations.
  Typical vacuum gauges used at Solaris:
  - Pfeiffer: IKR 270, IKR 060, IKR 070

- Hot Ion Combi Gauges (Pirani and Bayard Alpert) full range gauge used for measurement in the range from 1000 to $5 \cdot 10^{-10}$ mbar. Mostly used in Pump Stations dedicated for bake-out process. **Typical vacuum gauges used at Solaris:**
  - Leybold: ITR 90
  - Pfeiffer: PBR 260

- Cold Cathode Combi Gauges (Pirani and Penning) used for measurement in the range from 1000 to 10^{-10} mbar. Mostly used in Machine, Beamlines and End Stations.
  Typical vacuum gauges used at Solaris:
  - Pfeiffer: PKR 261

Other measurement devices may also be considered. Gauges will be used to measure the vacuum levels within the vacuum system and provide outputs signals (interlocks) necessary to control valves, pumps and other vacuum devices.

Due to the presence of a radiation environment in accelerator the drive electronics shall be separated from the gauge head. **Typical vacuum gauge controllers used at Solaris:**

- Pfeiffer: TPG 361, TPG 362, TPG366

In case of communication only Ethernet computer networking technologies shall be used at Solaris.

3.3. Leak detectors

Two PHOENIX L300i **dry** helium Leak Detectors (LD) are available at Solaris. Parameters of the LD has been presented below:

Helium Leak Detector		L300i Dry
Lowest detectable helium leak rate		
Vacuum operation	≤ $3 \cdot 10^{-11}$	mbar l/s
Sniffer operation	≤ $1 \cdot 10^{-7}$	mbar l/s
Maximum measurable helium leak rate		
Vacuum operation	> 0.1	mbar l/s
Measurement ranges	12 decades	
Maximum permissible inlet pressure	15	mbar
Pumping speed during pump-down, 50 Hz/ 60 Hz	1.6/1.8	m3 /h
Helium pumping speed in the vacuum mode	> 2.5	l/s
Time constant for the leak rate signal	<1	s
Time until ready for operation	≤ 2	min
Power consumption	350	VA
Inlet flange	DN 25 KF	
Dimensions (W x H x D)	495 x 456 x 314	mm
Weight	35.5	kg

Parameters of helium leak detectorL300i Dray

Leak detectors can be used to confirm the integrity of vacuum system, but during the measurement in closed spaces, some precaution has to be made. For venting or gas ballast a helium free gas at atmospheric pressure should be used. Ambient air can be contaminated with helium due to spraying or charging, so it is recommended to connect a hose to the vent- and fore vacuum port. The pressure in this hose must not exceed **1050 mbar**. Additional hose should be connected to the exhaust port which leads to fresh air.

3.4. Residual Gas Analysers

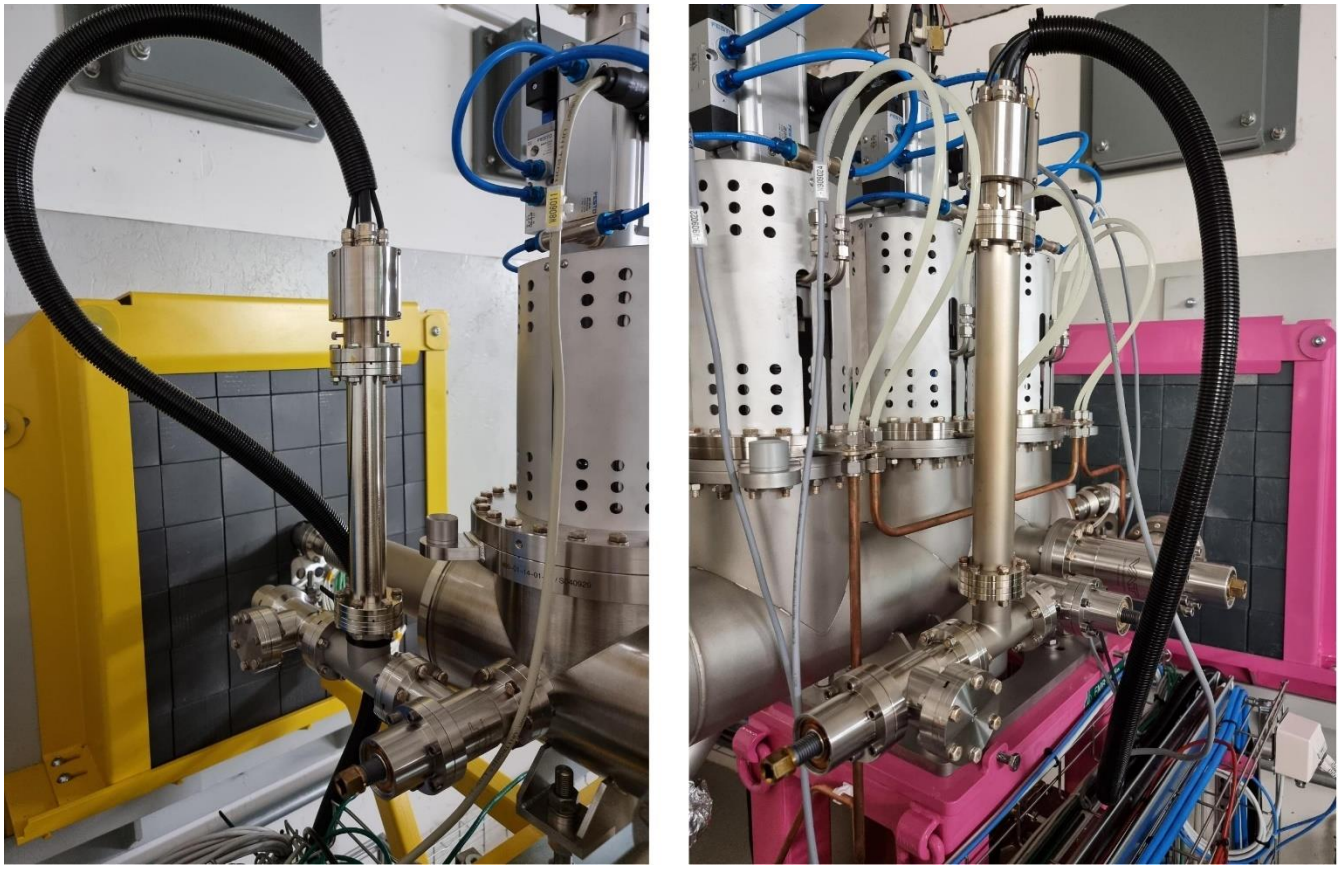
Residual Gas Analysers (RGA) will be used within a vacuum system for the measurement of partial pressures. Main application is to define gas composition during pump down new assembled vacuum system, maintenance or during operation. After calibration of RGA by calibrated leak, RGA can also support leak testing of vacuum vessels. Not resistant to radiation device **SRS RGA 100** has been chosen for residual gas analysis at experimental hall, outside of the storage ring. Parameters of the RGA available at Solaris has been presented below:

Mass Range RGA100	100	Amu
Mass filter type	Quadrupole	
Detector type	Faraday cup (FC) and Electron multiplier (EM)	
Filament materials	Tungsten	
Measurement ranges	6 decades of dynamic range	
Resolution	Better than 0.5 amu @ 10 % peak	
Sensitivity	$2e^{-4}$ (FC)	A/Torr
Minimum detectable partial pressure (FC)	$6.6e^{-11}$	mbar
Minimum detectable partial pressure (EM)	$6.6e^{-14}$	mbar

Operating pressure range (FC)	UHV < 1.3e-4	mbar
Operating pressure range (EM)	UHV < 1.3e-6	mbar
Operating temperature	70	°C
Bake-out temperature	300 without ECU	°C
Communication	RS232	
Flange fitting	CF40	

Parameters of SRS Residual Gas Analyzers

Storage ring applications require the RGA to operate in an environment that could damage the electronics when they are directly coupled to the analyzer. Operation in harsh environments (e.g. high temperature and/or ionizing radiation) required RGA with the control electronics located in a safe or shielded position. **Hiden HAL 101 RC** device with 3 meters extenders, radiation resistant cable has been chosen for residual gas analysis at Solaris. The residual gas analyzer is located in the front-end vacuum chamber. It is connected to the vacuum system consisting of: a DN 40CF tee, two all metal easy-close angle valves VAT DN 40CF (54132-GE02-0001) and a flange dedicated for one of the valves. This system is used to mount or dismount the RGA without the need to vent the front-end vacuum chamber.



RGA HIDEN HAL 101 RC installed in the front-end vacuum chambers

Mass Range HAL 101 RC	100	amu
Mass filter type	Quadrupole	
Detector type	Faraday cup (FC) and Channeltron Electron Multiplier (CEM)	
Filament materials	Twin filament Oxide coated iridium	
Measurement ranges	8 decades of dynamic range	
Resolution	Better than 0.5 amu @ 10 % peak	
Sensitivity	$2e^{-4}$ (FC)	A/mbar
Minimum detectable partial pressure (FC)	$1.0e^{-11}$	mbar
Minimum detectable partial pressure (MP)	$5.0e^{-14}$	mbar
Operating pressure range (FC)	UHV < 1.0e-4	mbar
Operating pressure range (CEM)	UHV < 1.0e-6	mbar
Bake-out temperature	250 with extender or without ECU	°C
Communication	Ethernet	
Flange fitting	CF40	
Cable lengths RC interface to RF head	3	m
Cable lengths RC interface to PC	Up to 750 metres with unbridged Ethernet link	
PC Software	MASsoft Professional	

Parameters of HIDEN HAL 101 RC Residual Gas Analyzers

In case of communication only Ethernet computer networking technologies shall be used at Solaris.

3.5. Sputter Ion Pumps

Definition of the standard of Sputter Ion Pumps (SIP) will be preliminary limited to the machine only. All SIPs already used at Solaris have been produced by **Gamma Vacuum**. Type of the pumping ports size/location is strictly defined by the project. All ion pumps which have been already installed at Solaris are differential (DI) or conventional (CV) type. Noble gas stable pump element with one titanium and one tantalum cathode.

Typical models used at Solaris:

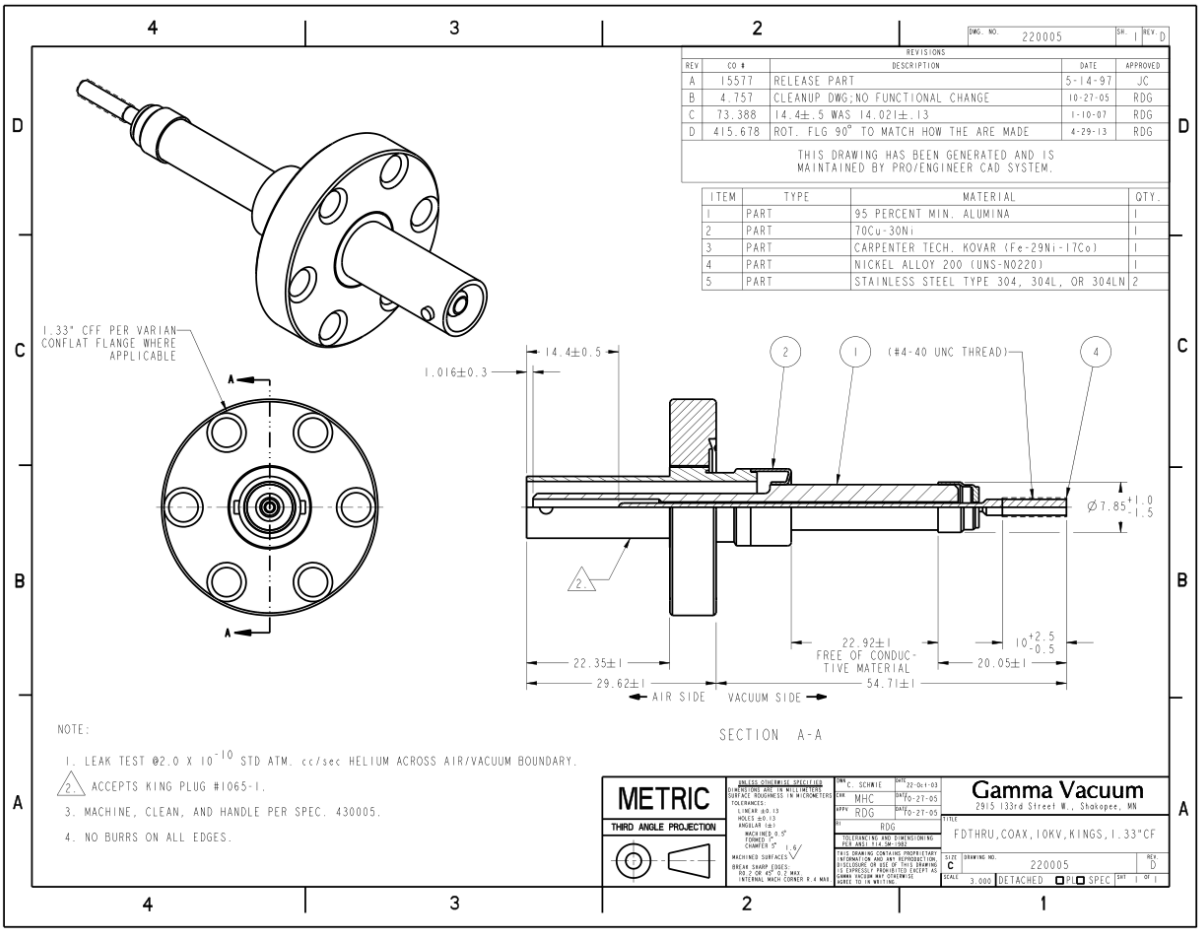
- 25S, 45S, 75S, 100L, 150T, 200L, 600LX

Where:

- S – Small ion pumps (Mini - 75S)
- L – Low profile ion pumps (100L - 1200LX)
- T – Tall profile (150TV – 600TV)

Type of the ceramic feedthroughs installed with SIP:

- SAFECONN 10kv SHV



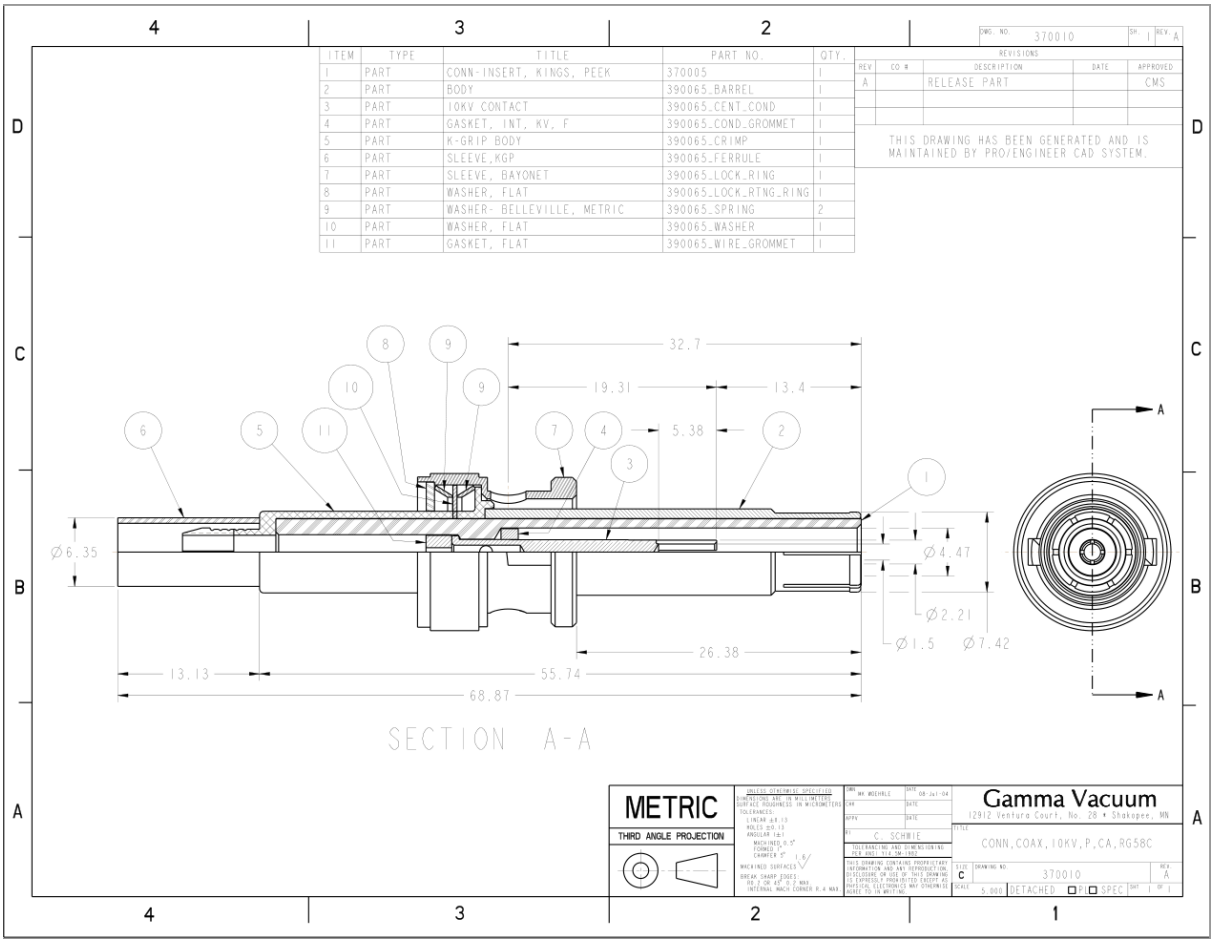
Gamma Vacuum ceramic feedthrough

Type of cable connector pump side (bakeable):

- SAFECONN (catalog number: G310043)
- SHV-10 (10kV) (catalog number: G370010)

Type of cable connector controller side (non-bakeable):

- SAFECONN (catalog number: G310025)
- SHV-10 (10kV) (catalog number: G390065)



Gamma Vacuum cable connector SHV-10

Dimension of bakeable and non-bakeable connectors stays the same but material is different.

Type of cable connectors for controller and pump side:

SAFECONN – pump side	SAFECONN – controller side	SHV-10 – pump & controller side

Gamma Vacuum cable connectors

Non-safeconn cables required to bypass controller interlock by dedicated terminator to be able to apply high voltage to the sputter ion pump.

Typical controllers used at Solaris:

- Small Pump Controller (SPC)
- Large Pump Controller (LPC, QPC)
- Multiple Pump Controller (MPC, MPCQ)

SPC-1-P-S-1-EC230-S-S-N / SPC-1-P-S-1-B24-E-S-N

LPC-1-P-S-1-EC230-E-H-N

MPC-2-P-S-2-EC230-E-N-N

QPC-1-P-S-1-EC230-S-S-N

MPCQ-2-P-S-2-EC230-S-S-N

Gamma Vacuum SIP controller with typical description

In case of communication only Ethernet computer networking technologies shall be used at Solaris.

Compatibility between SIP and controller or TSP has been presented below.

SPC	MINI/ 3S/10S/25S/45S/75S
LPC/QPC	45S/75S/100L/200L/300L/150TV/300TV/
MPC/MPCQ	100L/200L/300L/400L/400LX/600L/600LX/800LX/1200LX/150TV/300TV/600TV
TSP cartridge	200L/300L/400L/400LX/600L/600LX/800LX/1200LX/150TV/300TV/600TV

Specification of Gamma Vacuum compatibility

Depends of application proper type of SIP should be used:

- CV Conventional (100% Titanium)
- CVX Conventional (SEM Shielding)
- DI Differential (50% Titanium 50% Tantalum)
- DIX Differential (SEM Shielding)
- TR Triode (Slotted Titanium)

Depends of application additional upgrade of SIP is possible:

- Heaters
- TSP pump
- NEG cartridge

Pumping speed [l/s, Nitrogen] depends from type of SIP:

Type	CV	DI	TR
45	40	35	35
75	75	60	60
100	100	80	80
150	150	120	120
200	200	160	160
250	250	200	200
300	300	240	240
400	400	320	320
500	500	400	400
600	600	480	480
800	800	640	640
1200	1200	960	960

Based on Solaris experience only small pump controllers (SPC) shall be used to control sputter ion pumps. In case of the cable:

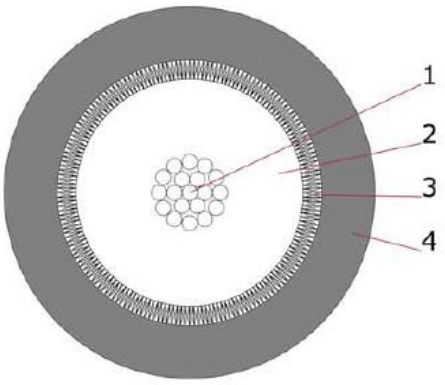
- Non-bakeable connector SHV-10 shall be used from controller side.
- Non-bakeable connector SHV-10 shall be used from sputter ion pumps side.
- Bakeable connectors shall be used from sputter ion pumps side only during installation process (cables are provided by Solaris vacuum group).

Non-bakeables connectors require dedicated cable which in Solaris case is: HSL-8S-0.75-B-2

HSL-8S-0.75-B-2

8kV$_{DC}$ / 3kV$_{AC}$ - AWG18 - SILICONE DIELECTRIC

▪ CONSTRUCTION



1. Conductor	AWG18 Cu/Sn (23xAWG32 t.p.c.)	0.75mm² Ø 1.16mm
2. Dielectric	Silicone	Ø 3mm
3. Braid	Cu/Sn (AWG36 t.p.c.) 85% Coverage	Ø 3.5mm
4. Jacket	Silicone	Ø 4.9mm ± 0.2mm

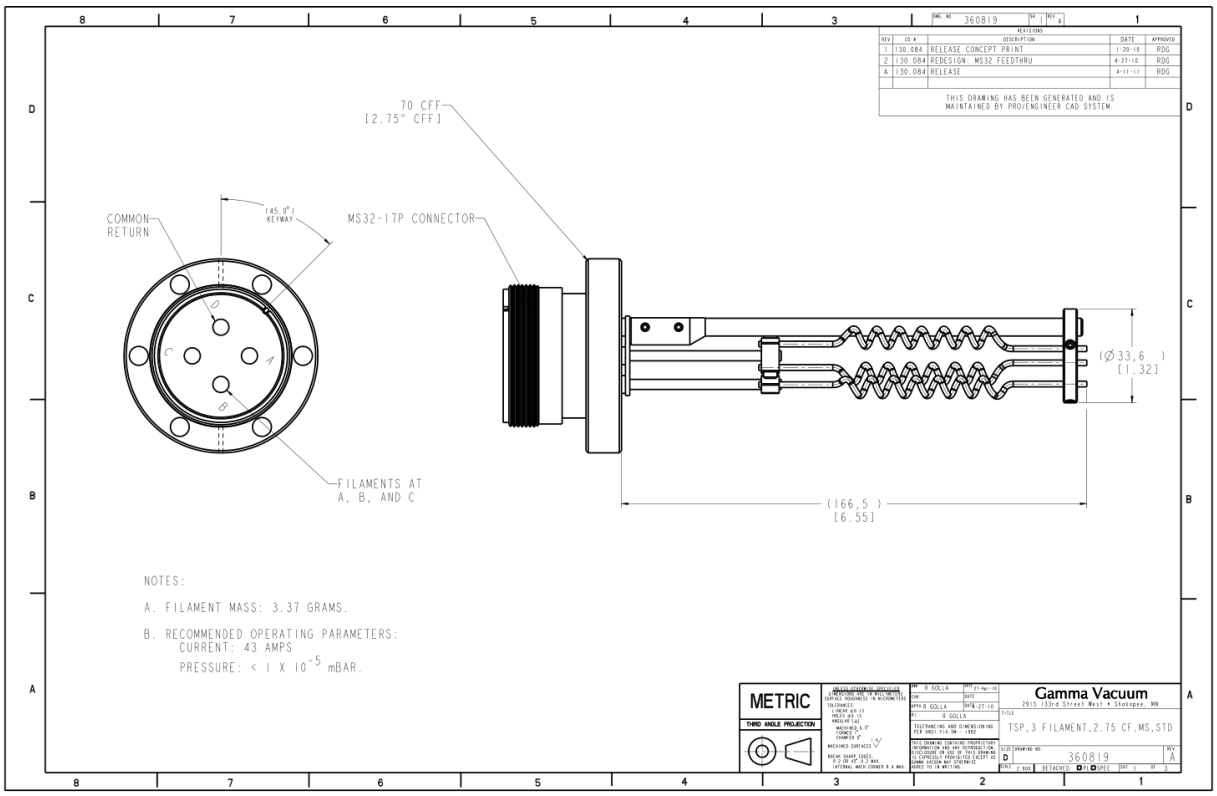
List of the SIP's already used at Solaris:

1. 100L-DI-6D-SC-N-N
2. 100L-DI-6S-SC-N-N
3. 150T-DI-6S-SC-N-N
4. 150TV-DI-6S-SC-220-N
5. 200L-DI-6D-SC-N-N
6. 200L-DI-8D-SC-220-N
7. 25S-DI-2V-SC-N-N
8. 300T-DI-8S-SC-220-N
9. 300TV-DI-8D-SC-220-N
10. 300TV-DI-8S-SC-220-N
11. 400L-DI-8S-SC-220-N
12. 400LX-DI-8P-SC-220-N
13. 45S-DI-2V-SC-N-N
14. 500T-DI-8S-SC-220-N
15. 600LX-DI-8S-SC-N-N
16. 600TV-DI-8P-SC-220-N
17. 600TV-DI-8S-SC-220-N
18. 75S-DI-2V-SC-N-N
19. 75S-DI-4D-SC-N-N
20. 75S-DI-4V-SC-N-N
21. 75S-DI-62-SC-N-N
22. 75S-DI-6S-SC-N-N

To reduce the number of spare components it is required for new projects to use one of the SIP listed above.

3.6. Titanium Sublimation Pumps

All Titanium Sublimation Pumps (TSPs) already used at Solaris have been equipped with cartridge produced by **Gamma Vacuum.** Typical cartridge contain 3- filaments, where each wire is composed from 85% of Titanium and 15% of Molybdenum. Dimensions of the cartridge has been presented below:



TSP cartridge from Gamma Vacuum

One type of controller has been foreseen to control of TSP at Solaris:

- Boostivac Controller

TSP-2-EC230-E-N-N

TSP Cables-MS-HC15-MS

MS Connector (Controller)

Bakeable MS Connector

TSPQ-2-US220-S-S-N

Gamma Vacuum TSP accessories with typical description

Depends from application one or two currents outputs are available. Depends of application provided by Gamma Vacuum shields may be used:

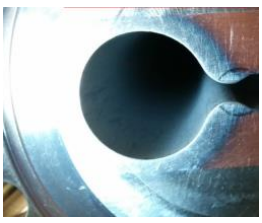
- Liquid Cryoshroud (150CF/40CF)
- Ambient Sputter Shield (100CF/40CF, 150CF/40CF)

In case of communication only Ethernet computer networking technologies shall be used at Solaris.

3.7. Non-Evaporable Getters: Strips, Coated Layers, Cartridges

The Non Evaporable Getter (NEG) pumps are build based on reactive metals or alloys which capture active gases, such as H_2O, CO, CO_2, O_2 and N_2 by a chemical reaction on their active surface. The getter material can be in the form of a thin film on a surface (NEG coated chambers), Strips or Cartridges.

Strips



Coated Layers

Cartridges

Types of Non-Evaporable Getters pumps

Size of the surface define both capacity and pumping speed. Conditioning and activation process is required, where parameters depends from type of material. Depends from the type of NEG two types of activation process are available:

- DC current (Strips and Cartridges)
- Heating Tapes (NEG Coated Layers)

NEG pumps will require a secondary pump for regeneration. The preferred choice will be to use mobile pumping station equipped with TMP and suitable dry fore vacuum pump. Additional equipment like DC power supply or heating controllers are required. In case of thermal deformation monitoring of thermal distribution is required.

Typical NEG pumps used at Solaris:

- SAES, NEG Strips (ST707 alloy composition Zr-V-Fe), activation: ~450°C/45min.
- SAES, NEG coated Undulator Vacuum Chamber (alloy Ti-Zr-V) , activation: ~180°C/24h.
- Gamma Vacuum, NEG Cartridges (alloy Zr-V-Fe), activation: ~450°C/1h.

In case of installation of NEG pumps at Solaris it is required to provide type of NEG material and activation procedure. All necessary equipment for activation can be provided by Solaris.

3.8. Vacuum Valves

Different kind of valves may be used at Solaris. The specific requirements of each will depends on specific application. Preferred type of valves are valves from VAT Company. UHV valves should be all metal valves. Viton sealed valves should be used in UHV level when Halogens or high radiation is not expected. The range of valves types and configuration can be categorized as follow:

- Type: Gate, Angle, Solenoid, Fast
- Actuation: Manual, Pneumatic with/without (solenoid or position indicator)
- Sealing system: Metal, Elastomer
- RF shields: To provide a continuous RF path, RF apertures specified by Solaris
- Valve mounting arrangements: CF, KF,

Special features defined by particular application may concern information regarding:

- Operating temperature
- Radiation levels
- Operating cycles
- Gate differential pressure

Cleanliness requirements shall be met, particulate generation during operation of the valve needs to be reduce to an absolute minimum.

Local controller should be provided to be able to open/close the valve in service mode.

Typical VAT valves used at Solaris:

- Manual all metal right angle valve (**Easy close VAT Series 541**) :
  CF16 (54124-GE02-0001)
  CF40 (54132-GE02-0001)
  CF63 (54136-GE02-0001)
- Gate all metal valve
  CF40 (48132-CE44-AHJ1)
  CF40 (48132-CE44-AOO1)
- Special gate all metal valve
  CF63 RF (47236-CE44-AIW1)
- Fast all metal gate valve
  CF40 (75232-CE44-0006)
- O-ring gate valve
  CF40 (01032-CE44-0005)
- O-ring gate valve CF40 manual with window
  CF40 (01032-CE01-AAV2)
  CF40 (01032-CE08-AAV2)

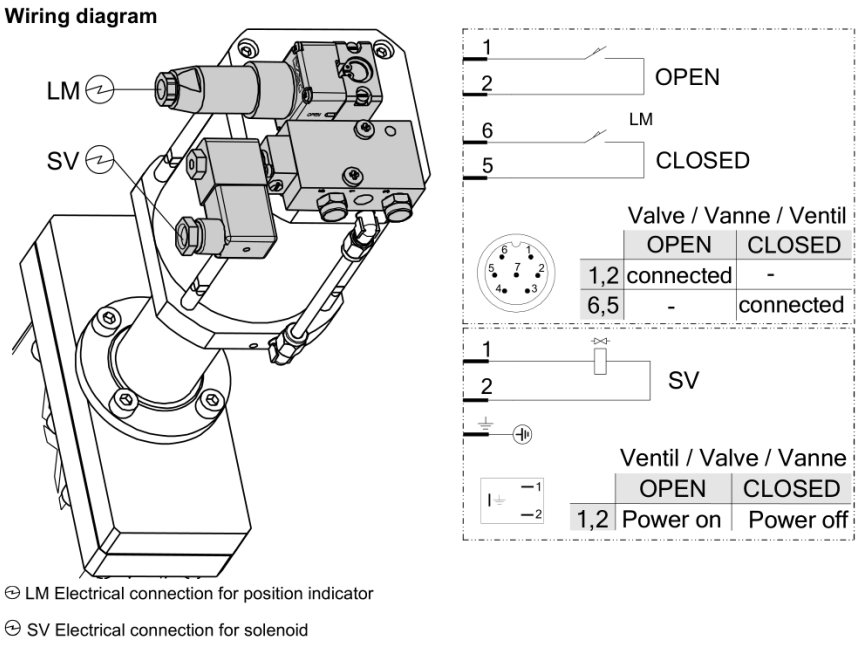
For Fast valves controller with vacuum gauge need to be provided:
Typical set up used at Solaris:

- Controller: VF-2 770VF-16NN-AAG6
- Gauge: IKR 070

In the case of electrically controlled valves with pneumatic actuator and valve position indicator, it is necessary to make a proper connection between the solenoid and the position indicator to allow for remote control of the valve via one 7-wire cable. The connection should be made according to the table:

Valve position indicator (pins) [**LM**]	Solenoid (pins) [**SV**]
1 LM – OPEN	
2 LM – OPEN	
3 LM – (1 SV) (24V)	1 SV – (3 LM)
4 LM – (2 SV) (GND SV)	2 SV – (4 LM)
5 LM – CLOSED	
6 LM – CLOSED	

Graphic illustration of the required connection.



In case of communication only Ethernet computer networking technologies shall be used at Solaris. Interface for PLC logic need to be provided.

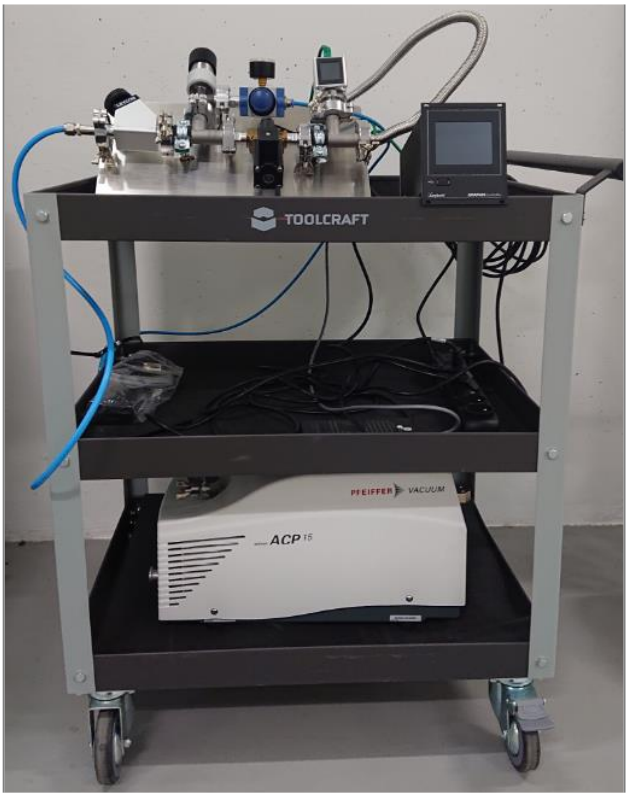
3.9. Vent Filters and Units

All vacuum system that may suffer performance degradation in case of particle transfer during venting process shall be vented with use of particle filters. This filter should be connected at the last position of venting line. For venting purpose only dry Nitrogen shall be used class 5 cleanliness or higher, preferred BIP technology. Periodic verification of the performance of the vent filter is required with use of particle counter.

Typical vent filter used at Solaris:

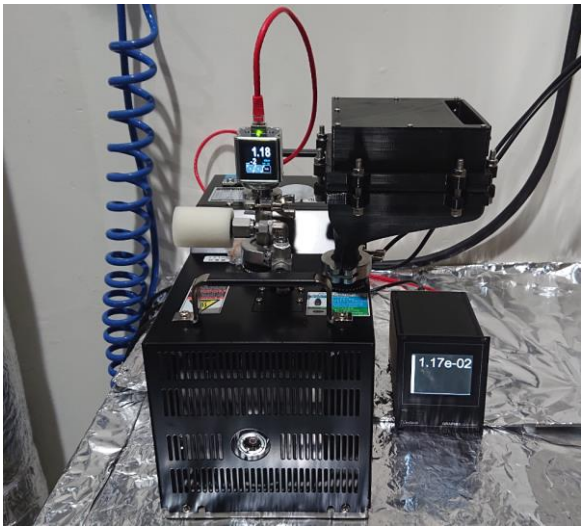
- Pleated Capsule Filter, sterile, 0.2um

In case of precise venting of vacuum system equipped with sensitive vacuum components like beryllium windows, it is required to use dedicated venting unit containing the interlock system.

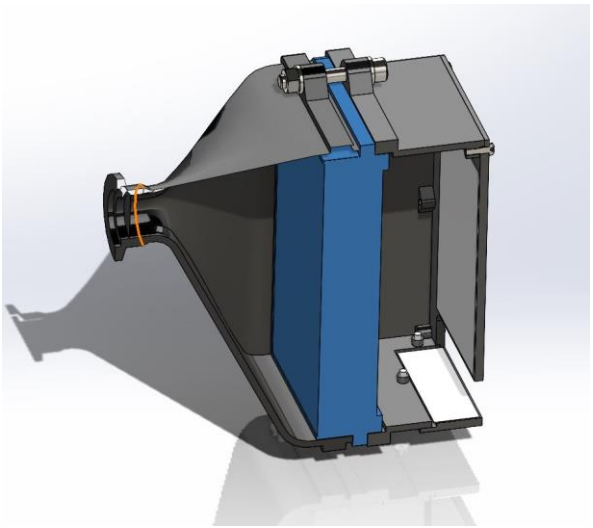


Solaris Venting Unit

To comply with Occupational Health and Safety regulations it is required to use HEPA 14 filters at the outlet of fore pump in case of damage of beryllium windows during installation and maintenance process.



Fore pump with HEPA filter



Solaris HEPA filter for fore pump

4 . Acceptance Tests

Tests shall be performed for all vacuum sectors containing all vacuum components defined by the project.

4.1. Base pressure

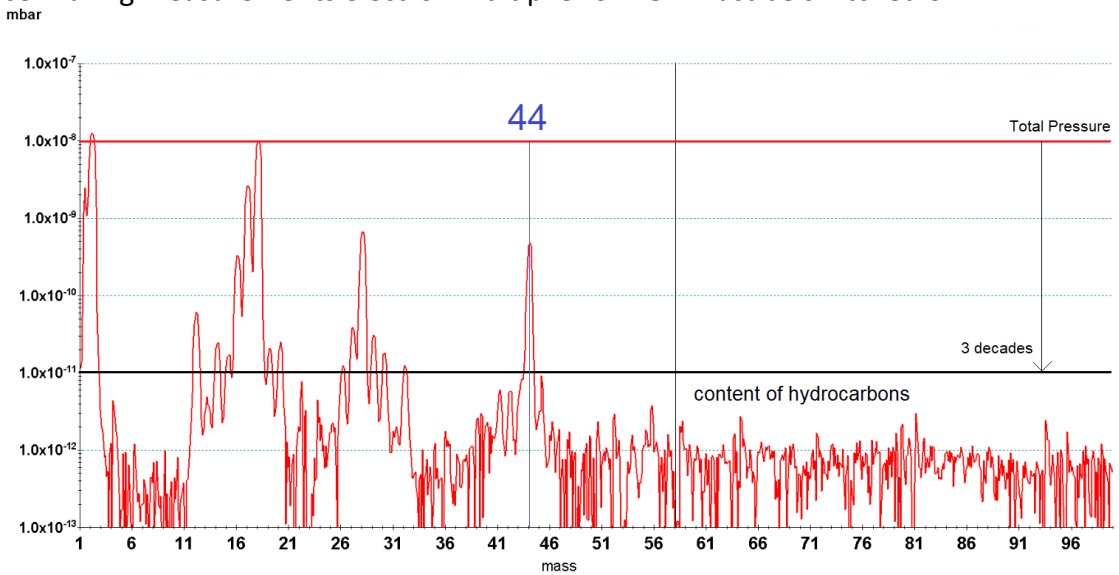
Base pressure is pressure obtained in a leak-free vacuum chamber without beam after conditioning (bakeout and activation of the TSP/NEG) of the sputter ion pump and the vacuum chamber. Acceptable level of the base pressure ≤ $5 \cdot 10^{-10}$ mbar shall be measured based on all sputter ion pumps and vacuum gauges in the range of vacuum sector when all valves are closed.

4.2. Leak check

The integral leak rate (sum of all leaks) has to be equal or lower than $2 \cdot 10^{-10}$ mbarl/s.

4.3. Residual Gas Analysis (content of hydrocarbons)

Vacuum components are considered free of hydrocarbons if in a leak-free system with a total pressure below $1 \cdot 10^{-7}$ mbar the sum of the partial pressures of masses above mass 44 up to 100 is less than 10^{-3} of the total pressure. RGA test shall be performed for static state of the chamber (no movements of moving elements) and for dynamic state of the chamber (during movements of moving elements like: slit, diffraction gratings, mask, in vacuum motors, etc.). During the RGA test all sputter ion pumps shall be switched off to not cover the contamination source. During measurements electron multiplier of RGA must be switched on.



RGA spectrum must be consistent with a contamination-free vacuum. Specifically, the residual gases should be hydrogen (M=2), methane (M=12 to 16), water (M=16 to 18), nitrogen (M=14, and 28), carbon monoxide (M=28) and carbon dioxide (M=44). In unbaked systems, the predominate masses will be at M=2, 18, and 28. In baked systems, the predominate masses will

be at M=2, 16, 18, 28, and 44. If the RGA spectrum includes mass M=40 (argon) or mass M=32 (oxygen), this indicates that the system probably has a leak. Because the halides, chlorine and fluorine (M=19, 35, or 37), will poison NEG pumps in storage ring, the RGA spectrum must be free of these masses prior to opening the front-end exit valve to the beamline. If the spectrum includes masses at M=39, 41, 55, and 57, the beamline is probably contaminated by organic material, and a mass at M=36 indicates that hydrogen sulfide is present**.**

For windowless operation the front-end exit valve to the beamline will be opened only after the RGA test described here has been fulfilled!

4.4. Outgassing rate

The outgassing test for all vacuum sectors or chambers, from valve to valve, provide additional information regarding quality of delivered equipment. Vacuum sector or chambers, during the outgassing test, shall contain all vacuum components defined by the project. The outgassing rate of the completed and cleaned chamber must be equal or below $1 \cdot 10^{-12}$ mbar·l/(sec·cm^2) after cooling down to room temperatures from the bakeout process. Procedure regarding measurements of outgassing rate must be presented and accepted by Solaris vacuum group.

4.5. Flaking or peel-offs

The lack of any flaking or peel-offs within the NEG coating shall be tested and the results shall be presented. Procedure regarding measurement of flaking or peel-offs must be presented and accepted by Solaris vacuum group.

4.6. Leak check of the manual angle valves

Test of the leak tightness of each angle valves performed after the bakeout of the systems, when criteria regarding based pressure has been fulfilled. During disconnection of the pump station from the manual angle valve it is required to use Nitrogen as venting gas. Pressure read out based on sputter ion pumps from the vacuum system shall remain at the same level before and after the venting process. Information regarding pressure levels before and after venting process must be presented and accepted by Solaris vacuum group.