The US Particle Accelerator School
Non-evaporable Getter Pumps

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Lawrence Livermore National Laboratory
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Non-evaporable Getters (NEG)

- NEG is available only from:
  SAES Getters S.p.A.
  Via Gallarate, 215
  20151 Milano Italy

  SAES Getters U.S.A., Inc.
  1122 E. Cheyenne Mountain Blvd.
  Colorado Springs, CO 80906

Non-evaporable Getters (NEG)

- Bulk Getters - gases diffuse into the interior of the getter material.

- Gases are categorized into four families based on their interactions with NEGs:
  1. Hydrogen and its isotopes - sorbed reversibly.
  2. CO, CO_2, O_2, and N_2 - sorbed irreversibly.
  3. H_2O, hydrocarbons - sorbed in a combination of reversible and irreversible processes. Hydrocarbons are sorbed very slowly.
  4. Rare gases - not sorbed at all.

NEG Pumping Characteristics

Hydrogen

- Hydrogen does not form a stable chemical composition with a NEG alloy. It diffuses rapidly into the bulk of the getter and is stored as a solid solution.

- Sievert's Law describes the relationship between H_2 concentration within its NEG and its equilibrium pressure.

$$\text{Log}\, P = A + 2 \log q - \frac{B}{T}$$

q = H_2 concentration in NEG, Torr - liters/gram

p = H_2 equilibrium pressure, Torr

T = getter temperature, K

A, B constants for different NEG alloys

NEG Pumping Characteristics

CO, CO_2, O_2, N_2

- Active gases are chemisorbed irreversibly by NEGs.
- The chemical bonds of the gas molecules are broken on the surface of the NEG.
- Then the various gas atoms are chemisorbed forming oxides, nitrides, and carbides.
- High temperatures do not break these chemical bonds. High temperatures promote diffusion into the bulk of the NEG.

NEG Pumping Characteristics

H_2O and Hydrocarbons

- Water vapor and hydrocarbons are "cracked" on the surface of the NEG.
- H_2, O_2, and C are chemisorbed irreversibly.
- However, hydrocarbons sorption efficiency below 500°C is extremely small.

NEG Pumping Characteristics

Rare gases

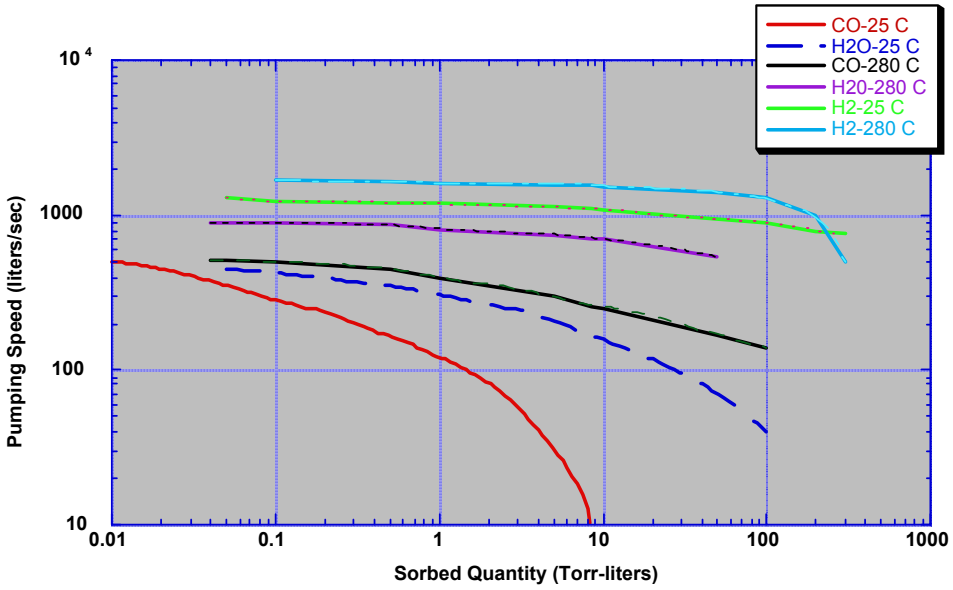
- NEGs do not sorb Ar, He, Kr, Xe.

- Ion pumps are required in combination with NEGs for pumping rare gases.

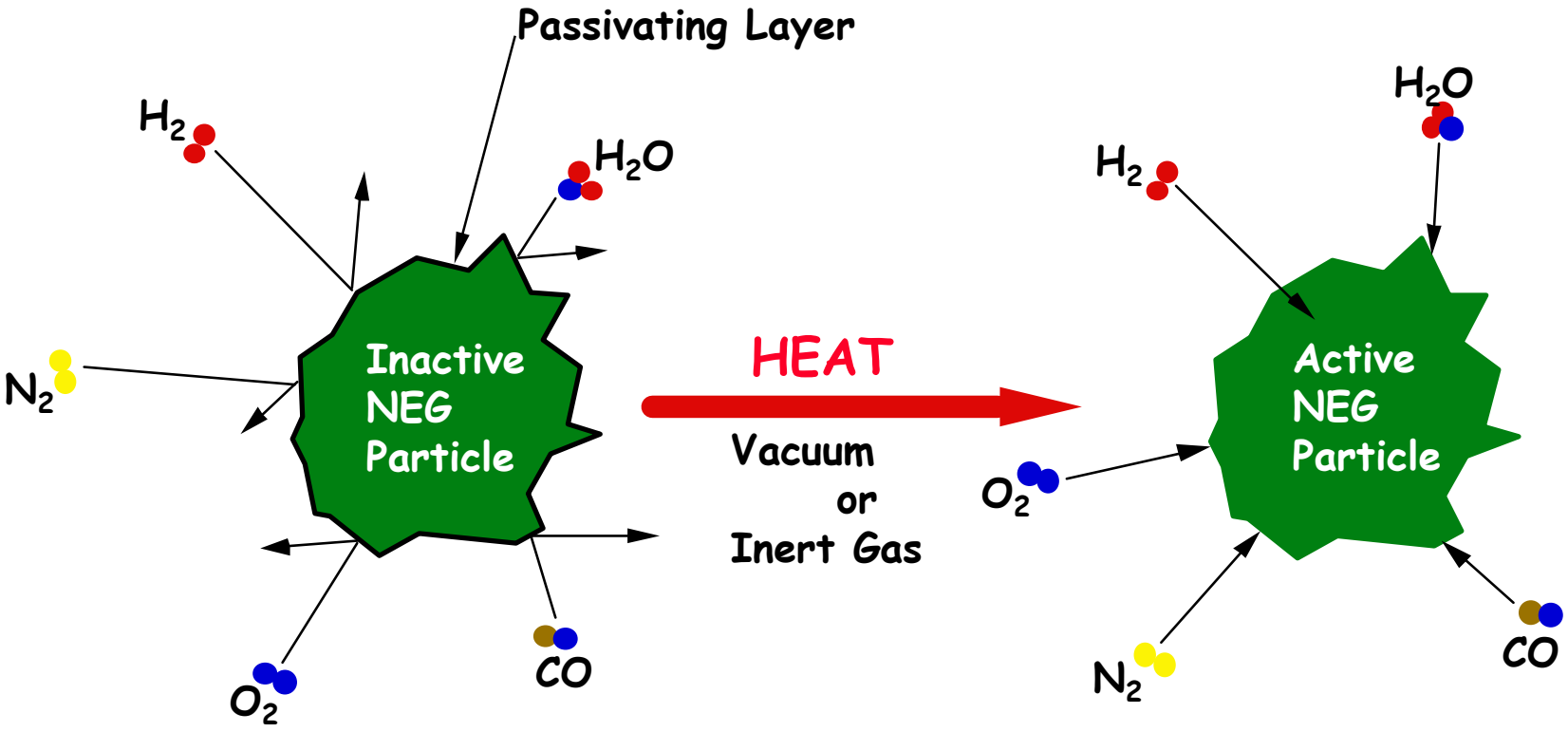
NEG Pumping Characteristics

- Below pressures of 10^{-5} Torr, NEG pumping speeds do not vary.

- Pumping speeds do, however, vary with NEG temperature.

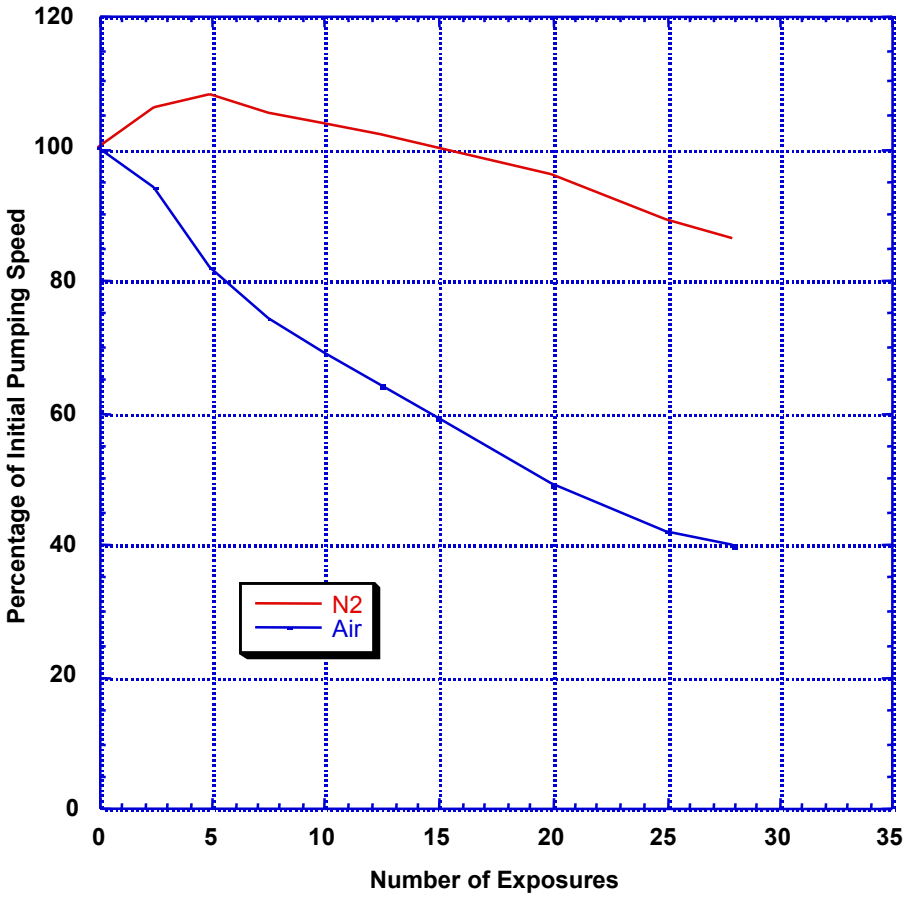


Activation Process for NEG



Venting NEG Pumps

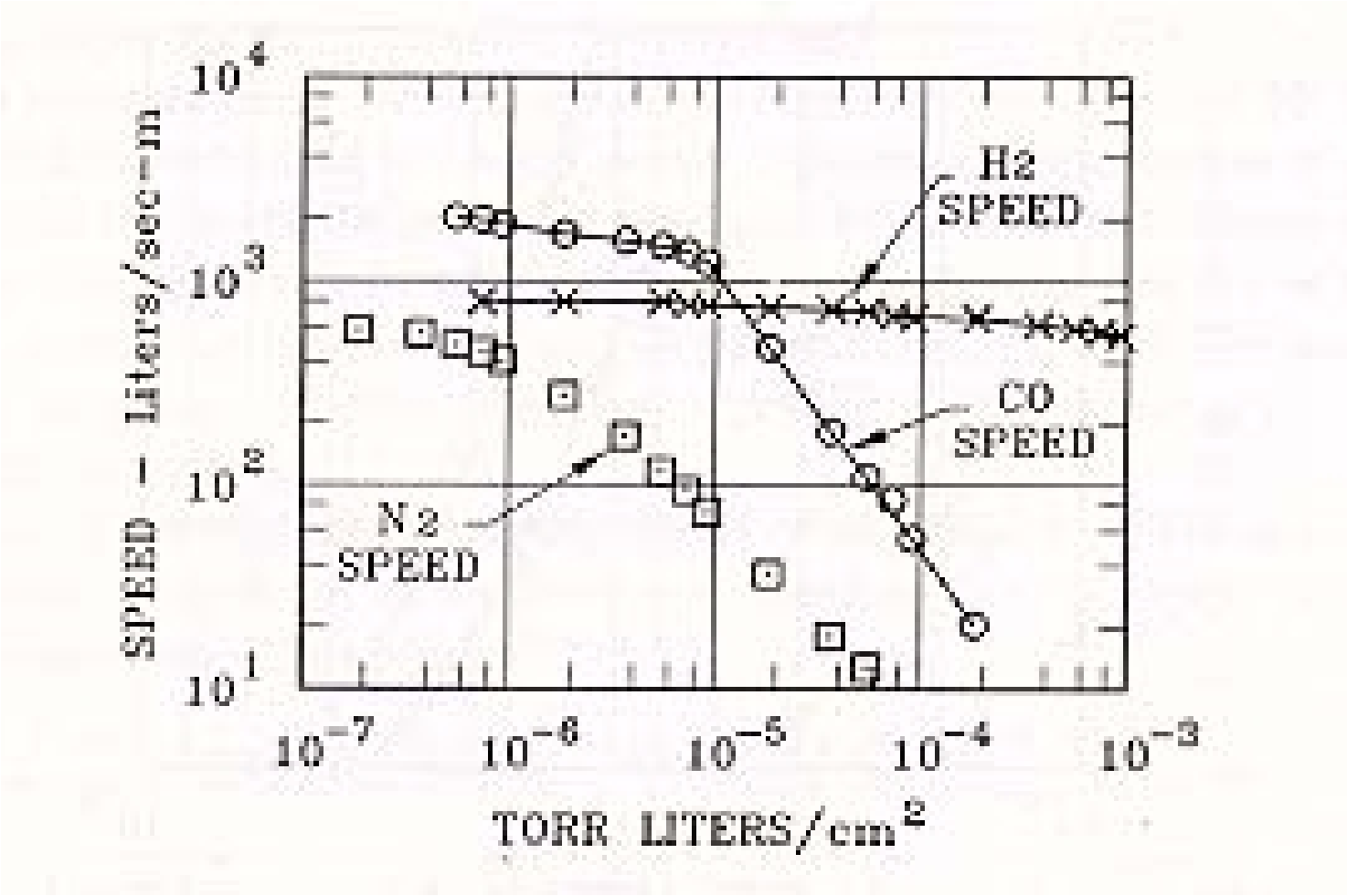
- NEG pumping speed deteriorates due to successive exposures to air or N_2.
- Further improvement can be obtained if Argon is used as a protective gas.
- NEG pumps should never be exposed to air while at temperatures greater than 50°C.



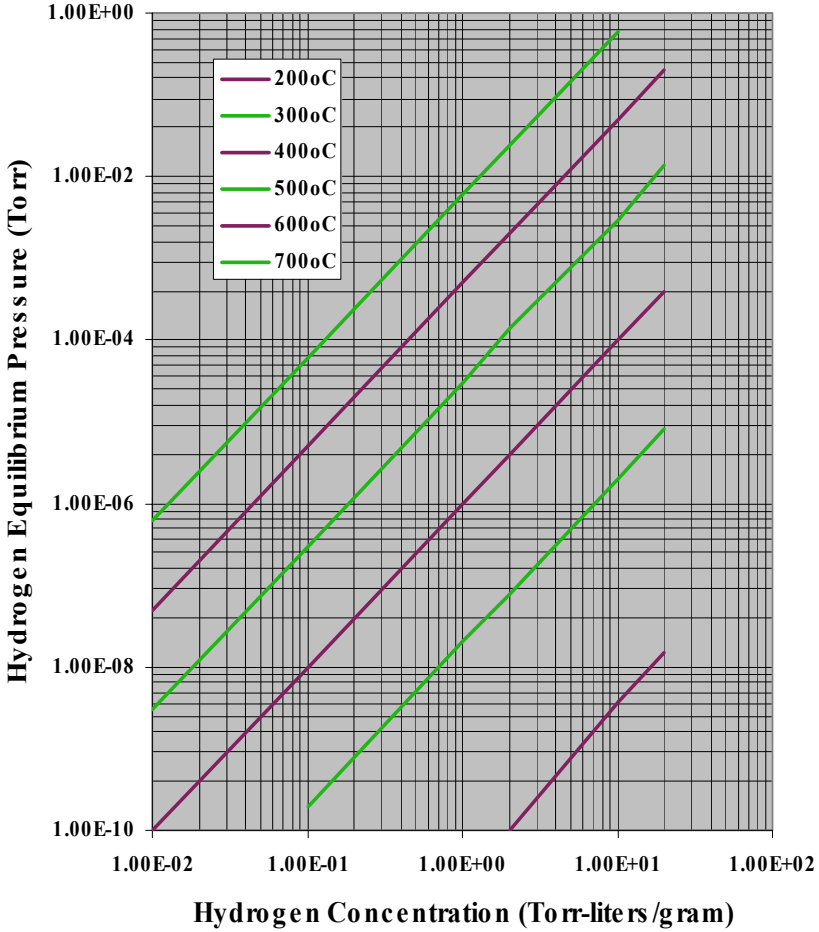
SAES ST101® Non-evaporable Getter

- Metal alloy made up of 84% Zr, 16% Al.
- First Zirconium based getters alloy introduced and still widely used today after 30 years.
- The operating temperature range of ST101 is 0 to 450°C.
- ST101 chemisorbs CO, CO_2, H_2O, N_2, and O_2 at high rates.
- ST101 activates at temperatures from 550 to 900°C.

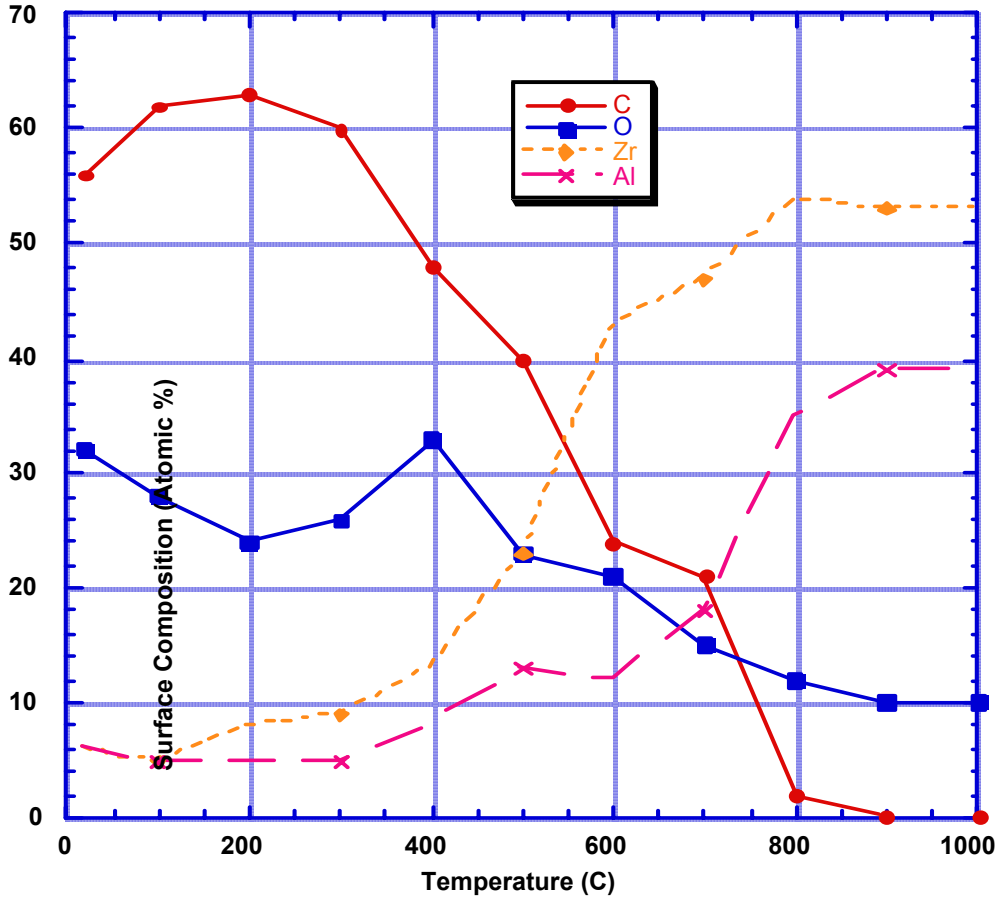
SAES ST101® Non-evaporable Getter Sorption Plot



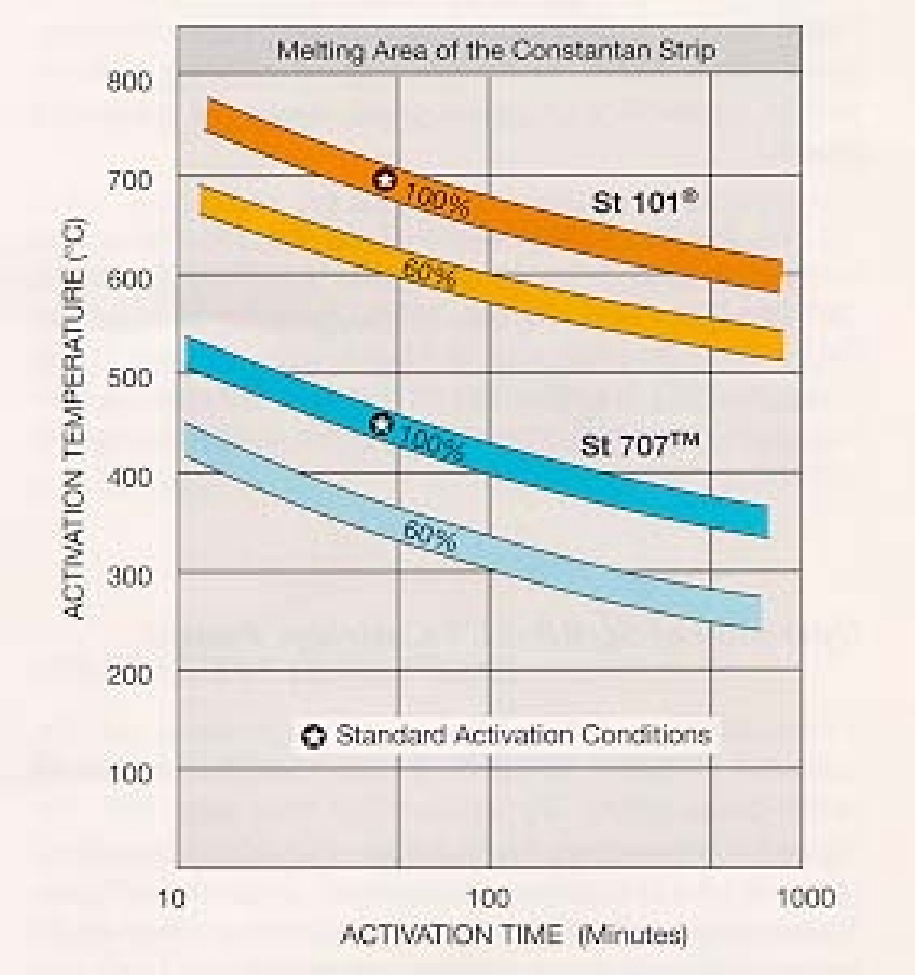
SAES ST101® Non-evaporable Getter Hydrogen Equilibrium Pressure



SAES ST101® Surface Composition vs. Activation Temperature



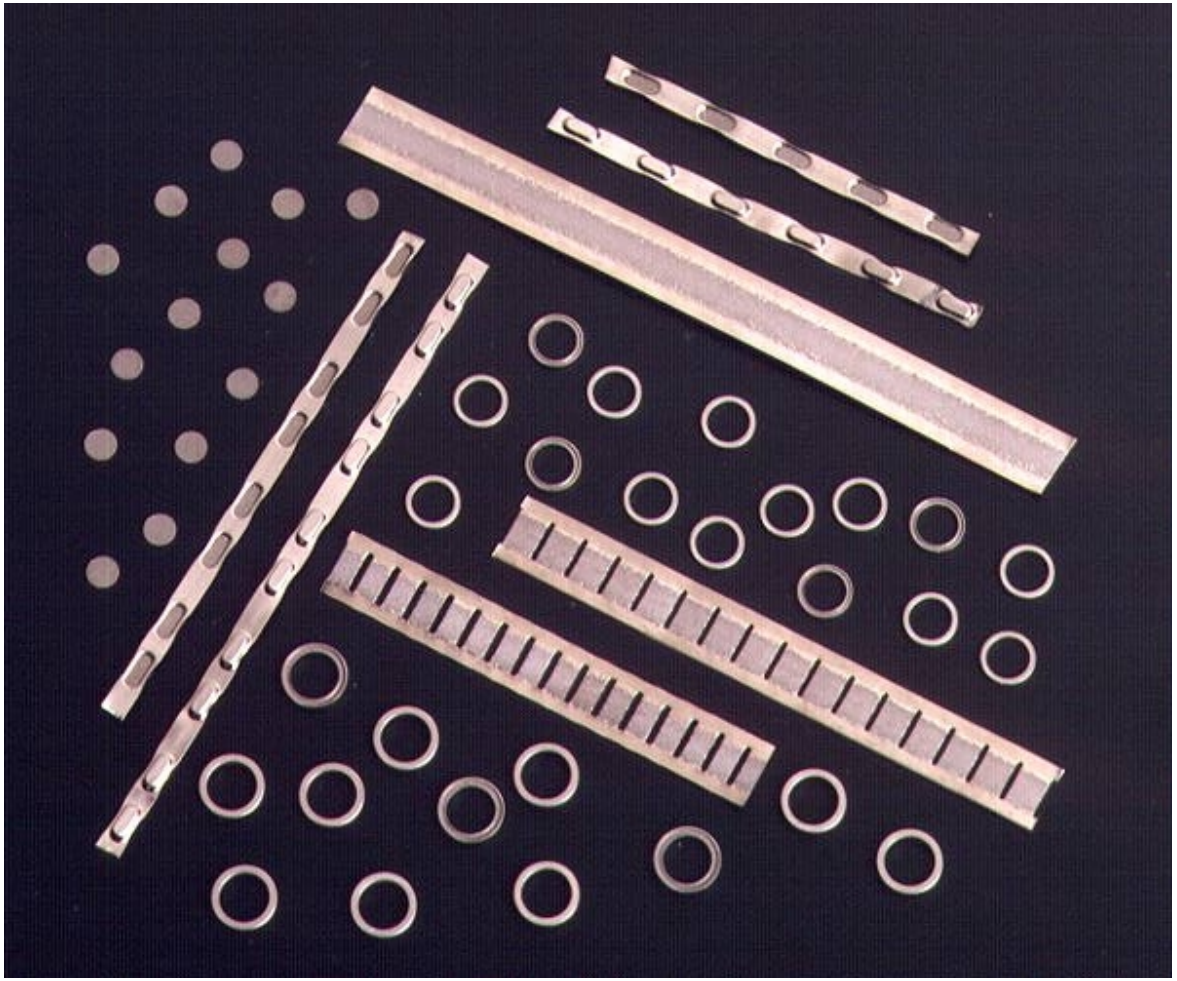
Activation Efficiency for ST101® and ST707™



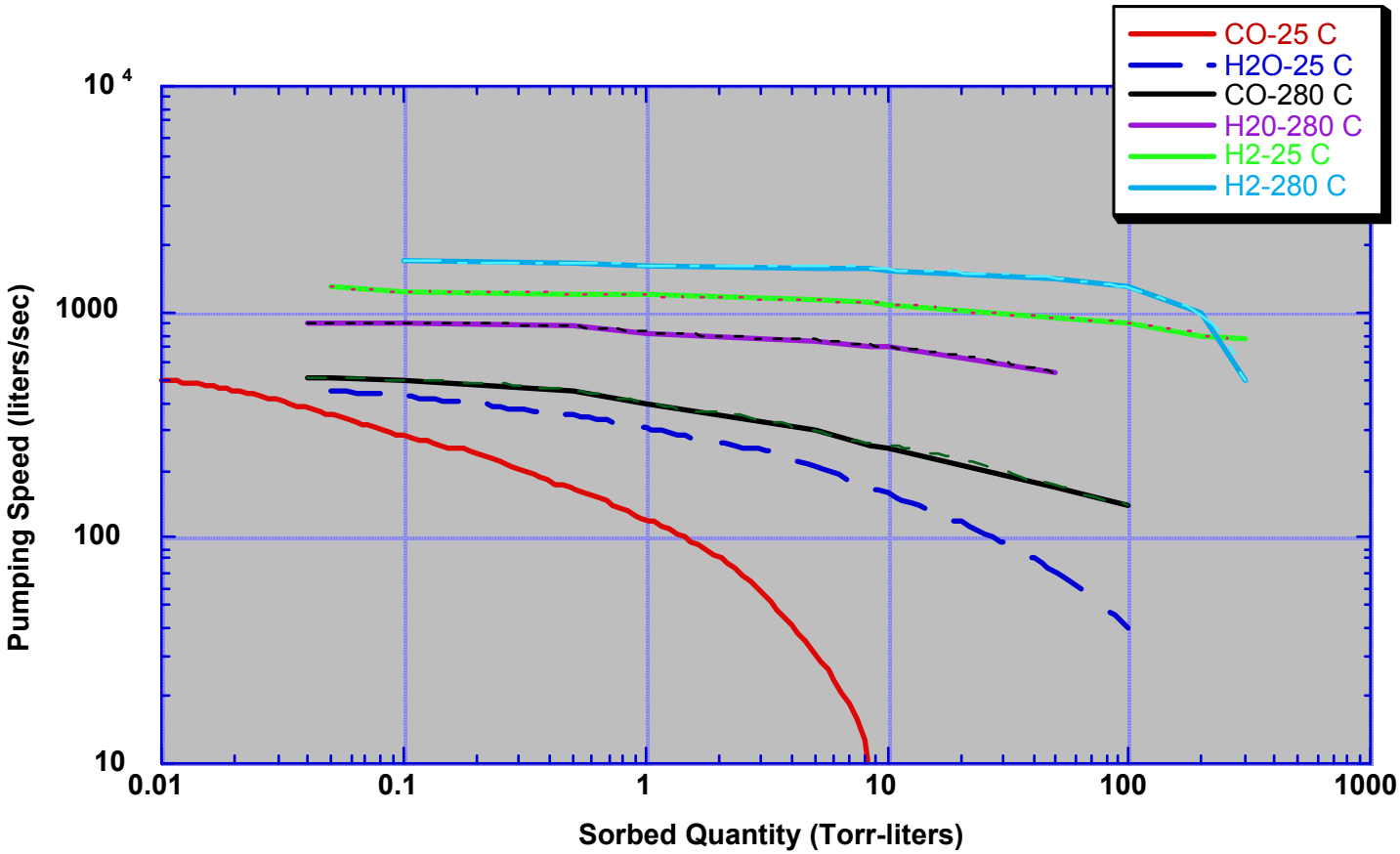
SAES ST707™ Non-evaporable Getter

- Metal alloy made up of 70% Zr, 24.6% Va, and 5.4% Fe.
- The operating temperature range of ST707 is 20 to 100°C.
- ST707 chemisorbs CO, CO_2, H_2O, N_2, and O_2 at high rates.
- ST707 comes in a variety of forms (pills, washes, strips).

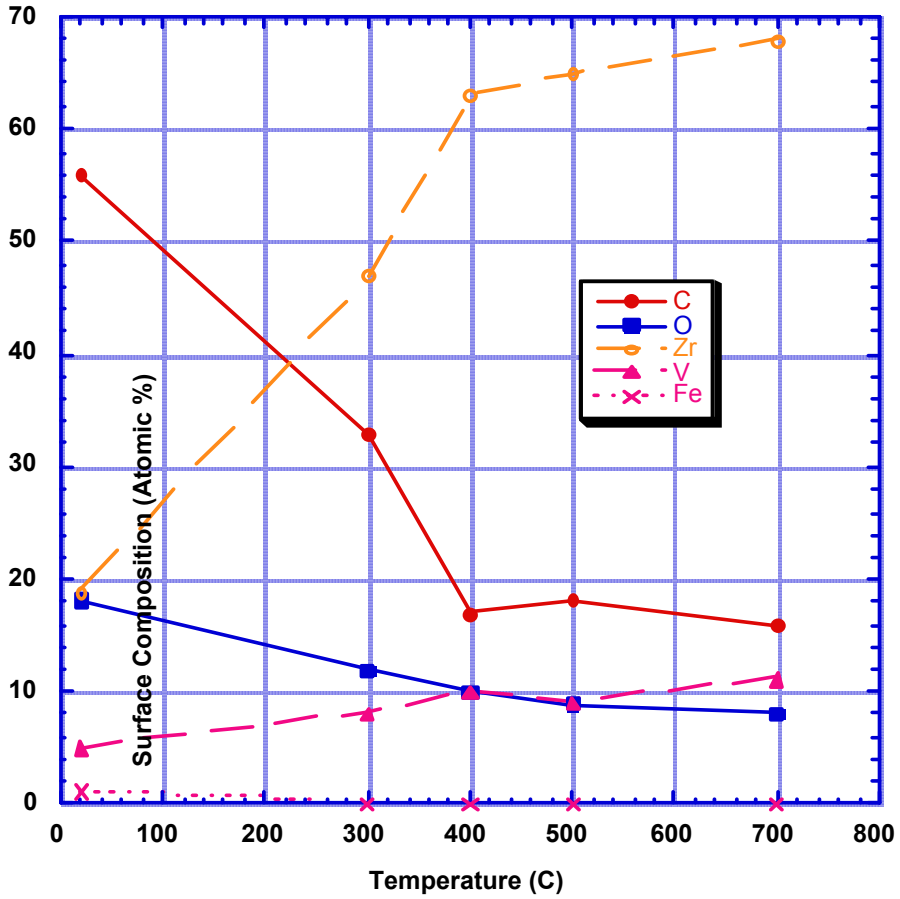
SAES ST707™ Non-evaporable Getter



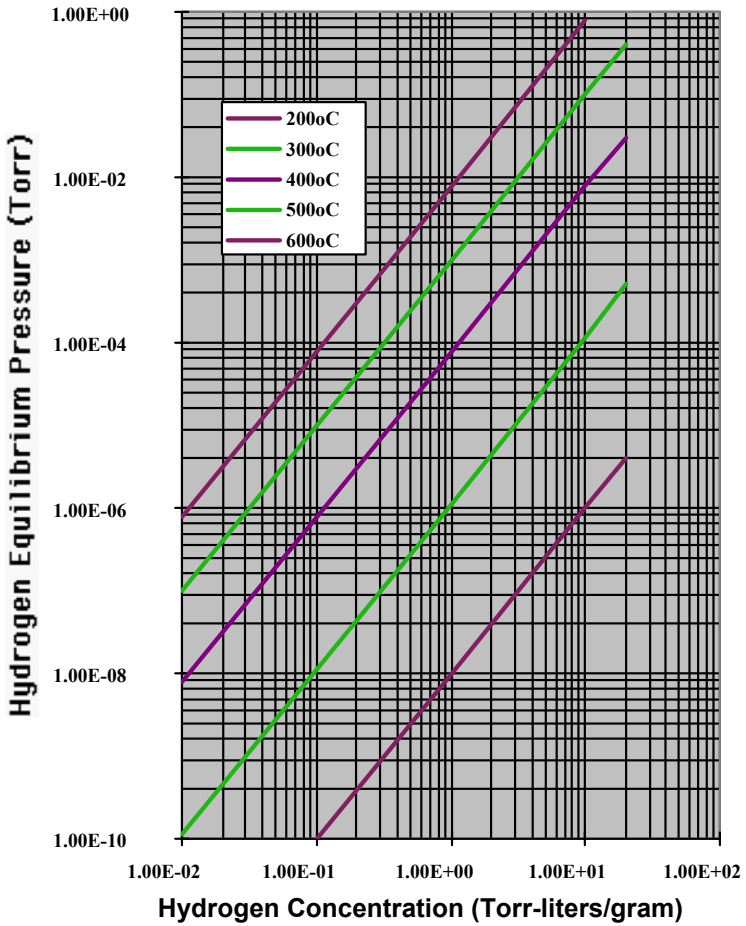
SAES ST707™ Non-evaporable Getter Sorption Plot



SAES ST707™ Surface Composition vs. Activation Temperature



SAES ST707™ Non-evaporable Getters
Hydrogen Equilibrium Pressure



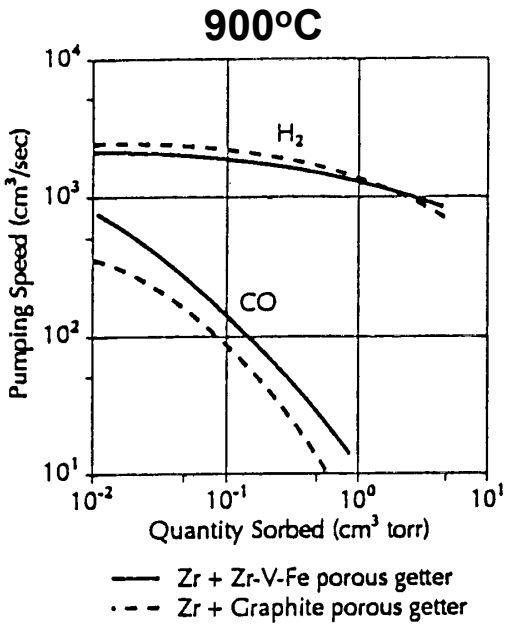
SAES ST172® Non-evaporable Getters

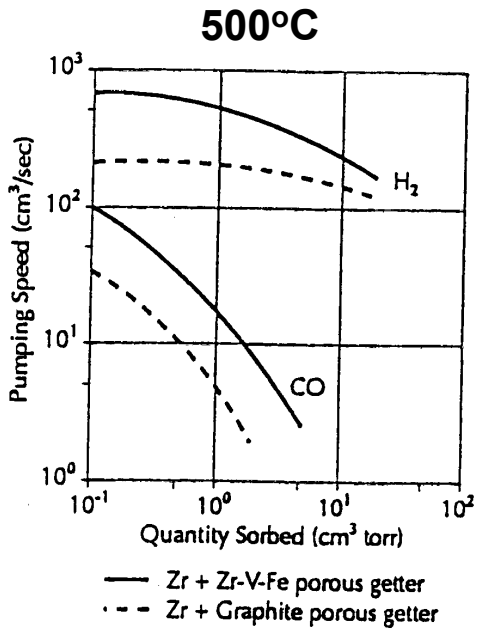
- A porous sintered structure based on a mixture of Zr and ST707 alloy (Zr-V-Fe).
- Sintering process produces a getter with large amounts of surface area, high porosity, and good mechanical strength (less likely to produce dust).
- The alloy is characterized by high diffusity of sorbed gas species.

SAES ST172® Non-evaporable Getters

- Highest pumping speeds and capacity are achieved at 800 to 900°C activation temperatures.

- However, ST172 can be activated as low as 400 to 500°C.

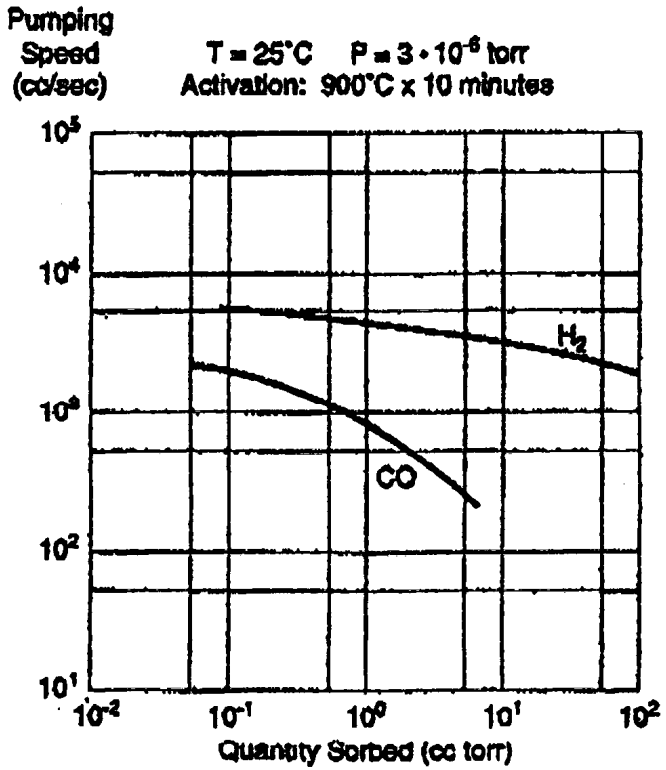


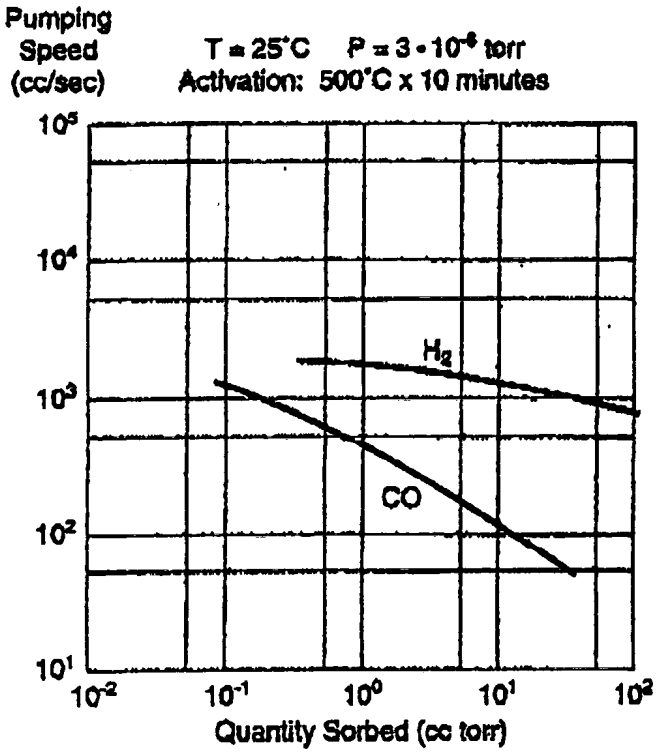


SAES ST175® Non-evaporable Getters

- A porous, sintered structure based on a mixture Titanium and Molybdenum powders.
- Sintering process produces a getter with large surface areas, high porosity, and good mechanical strength.
- This alloy has even higher diffusing of sorbed gases than ST172.

SAES ST175® Non-evaporable Getter



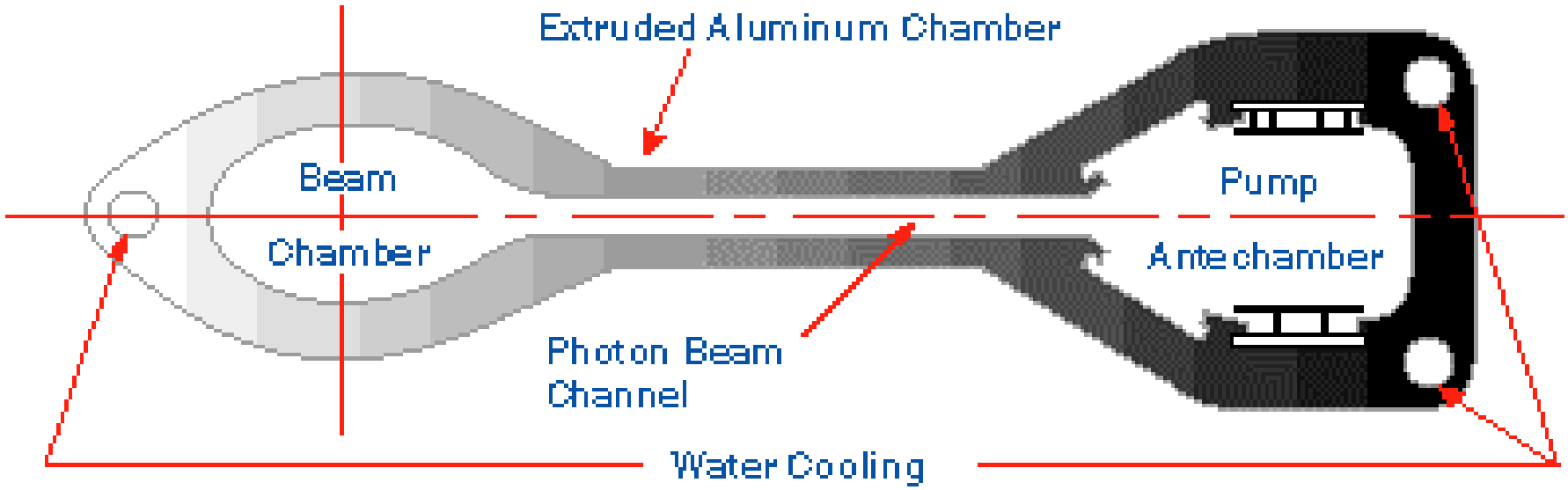


NEG Cartridge Pumps Using ST101® Strip

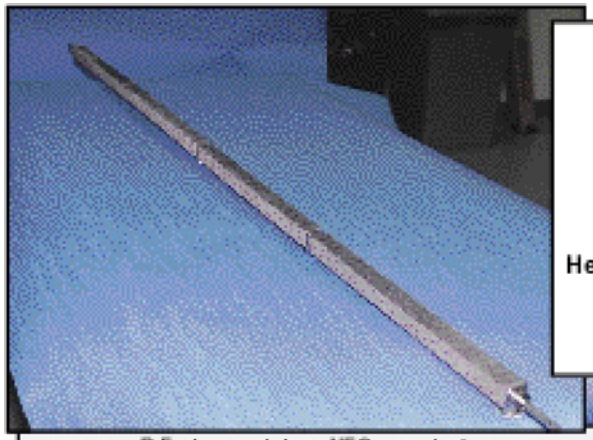
NEG Cartridge Pumps Using Sintered Plates

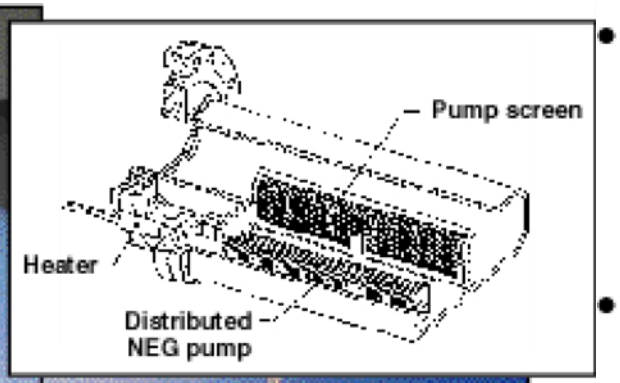
NEG Cartridge Pumps for use in Ion Pumps

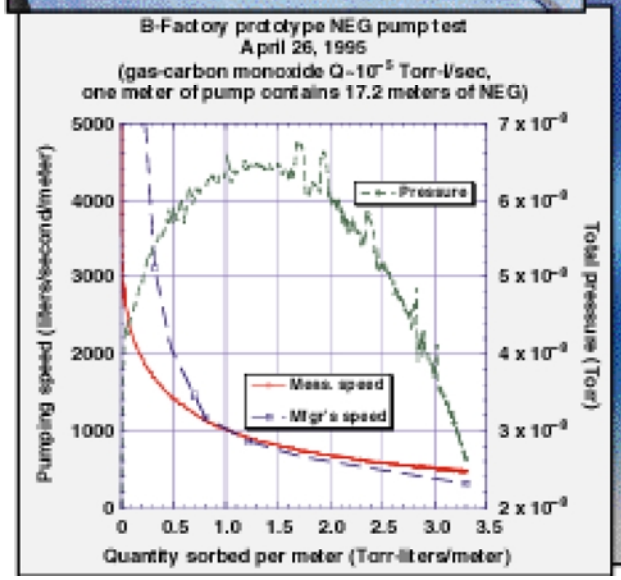
APS Beampipe with NEG strips



LLNL NEG Pump Design

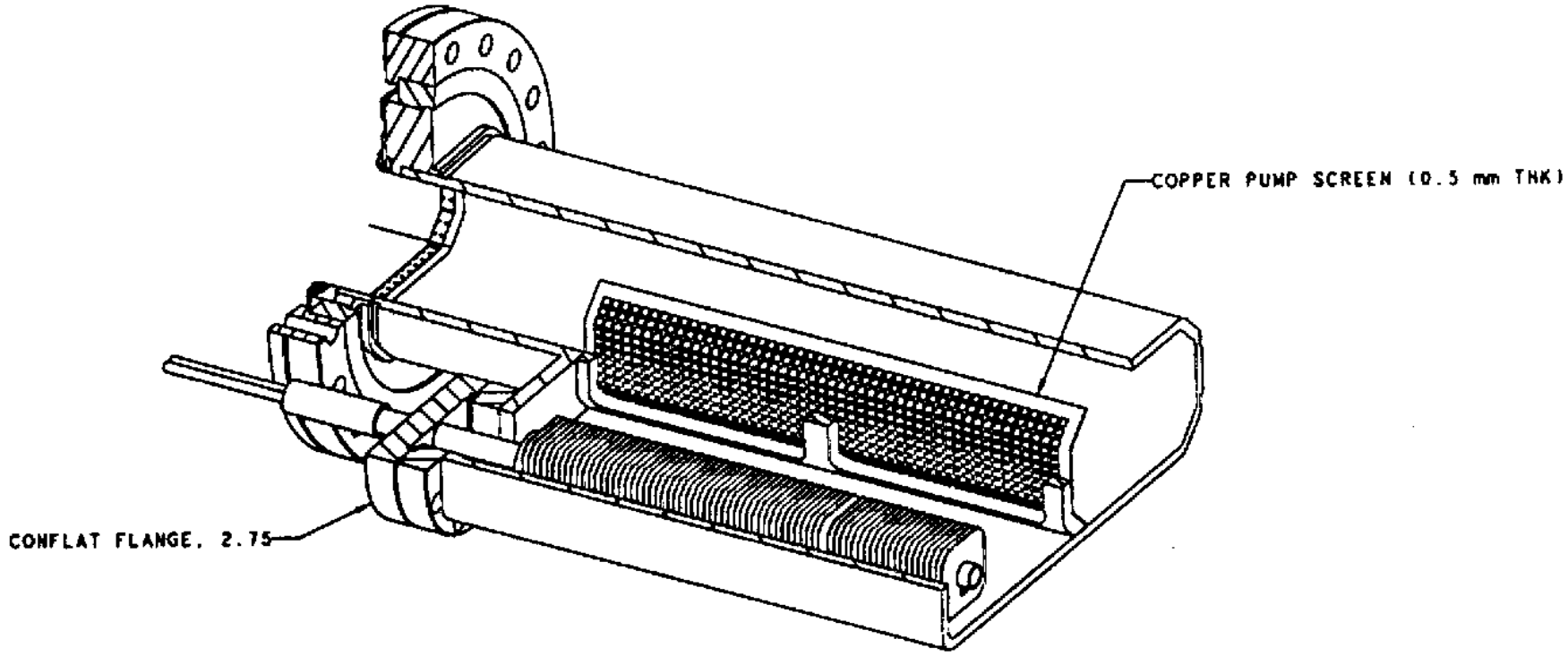




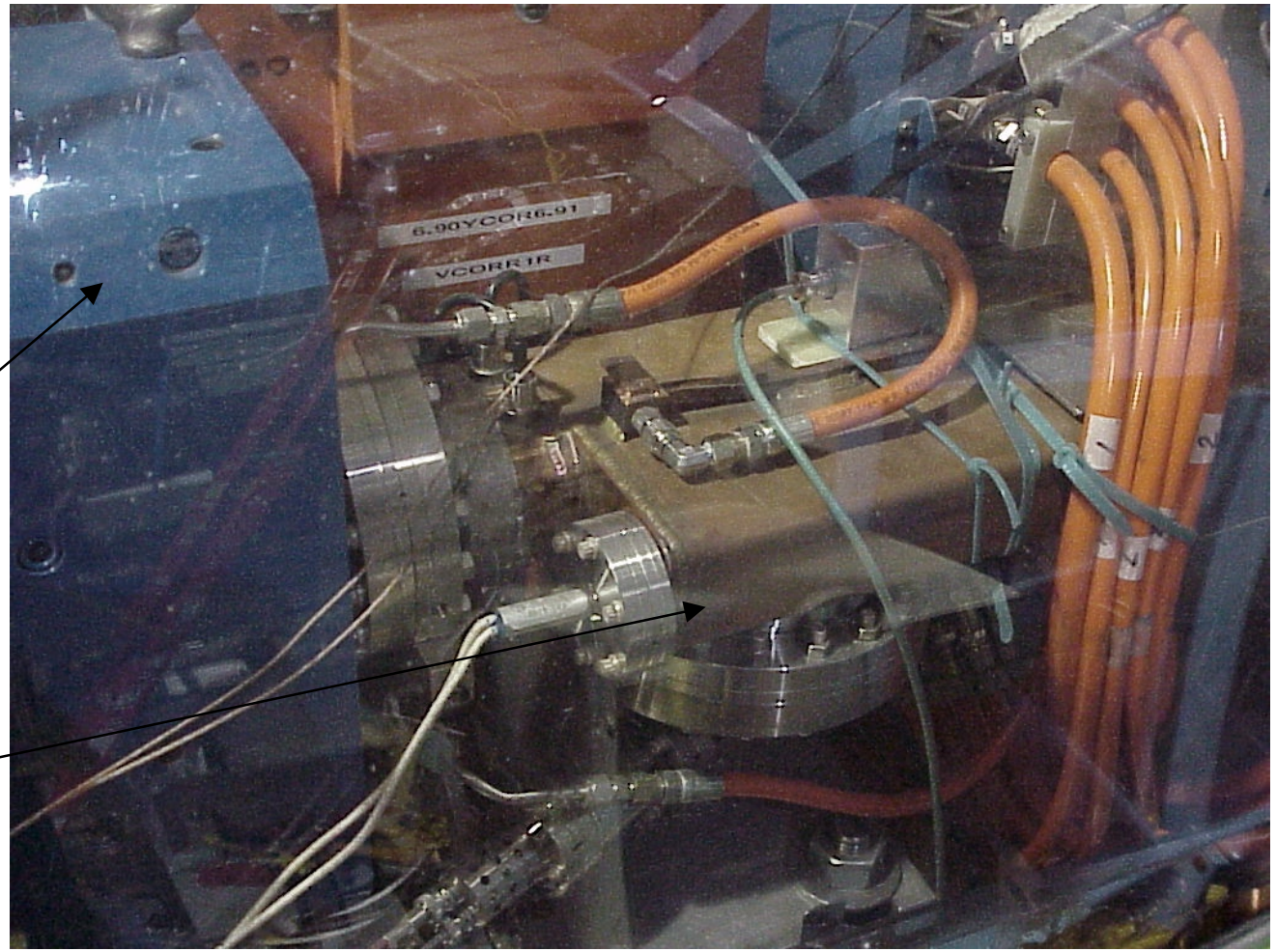


- "Finned" NEG design produces high pumping speeds and high sorption capacity
- Regeneration accomplished with external commercial heater
- Variable fin spacing allows for pump speed adjustment
- Laser is used to cut NEG fins

LLNL NEG Pump in a PEP-II Vacuum Chamber



PEP-II Interaction Region Copper Vacuum Chamber



Combination Pumping . . .
Ion Pumps with TSP or NEG

- Combination pumping produces greater pumping speeds for all gases.
  - TSP and NEG provide high pumping speeds for getterable gases.
  - Ion Pumps provide pumping of argon and light hydrocarbons (usually Noble Diode pumps are chosen).

- Combination pumping can be attained by:
  - Commercial combination pumps
  - Custom built combination pumps
  - Use of multiple types of pumps

- NEGs are used on systems where high constant pump speeds are required.

- TSPs are used on systems with sudden large gas bursts and/or frequent venting takes place.

Commercial Combination Pumps . . .
Ion Pumps with TSP or NEG

Ion Pump with TSP filaments

Ion Pump with NEG cartrdge