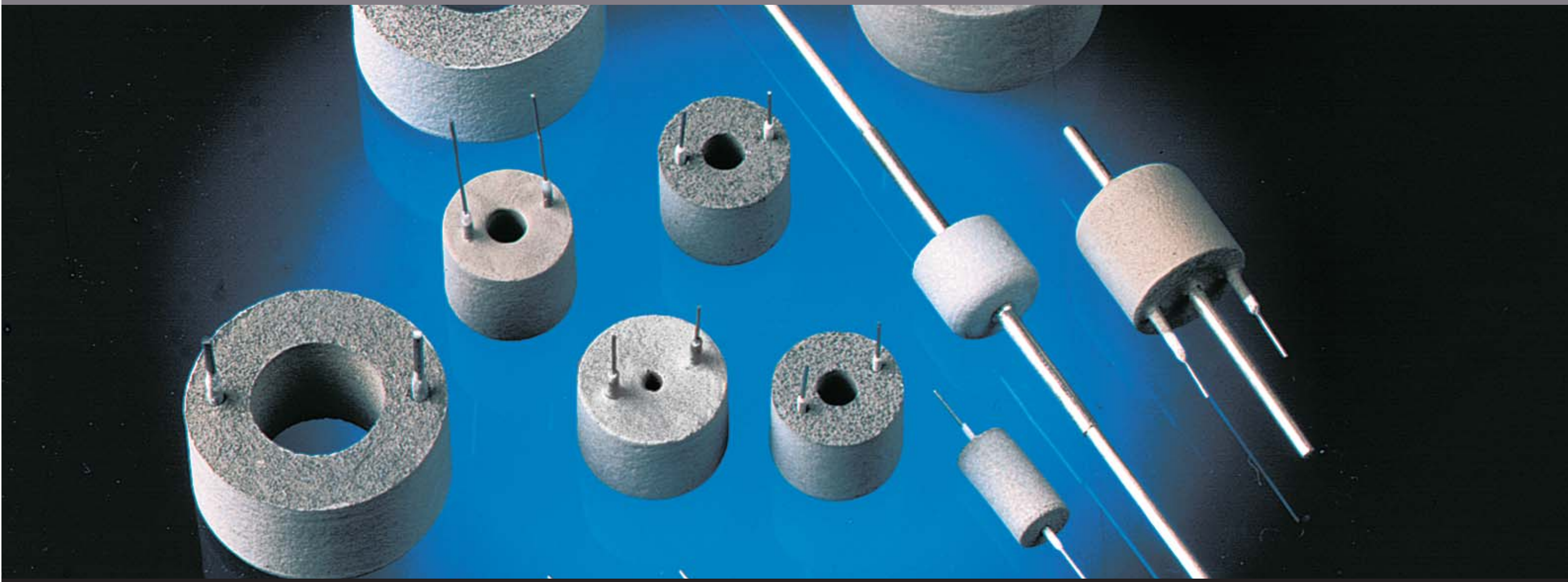

St 171® and St 172 - Sintered Porous Getters

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saes getters

Introduction

Why Sintered Porous Getters?

The increased market demand for nonevaporable getters with enhanced sorption characteristics at lower temperatures triggered SAES Getters' development of gettering structures characterized by high porosity and large surface area.

Porous structures allow the gases to diffuse through the pores inside the getter mass thus involving the inner parts of the getter body in the sorption process. This results in a dramatic increase of the sorption characteristics for N_2, CO and other oxygenated gases at low temperatures. See Figure 1 for the sorption characteristics and the superior performance of the St 171® getter as compared to a zirconium strip.

As with any nonevaporable getter, much better gettering performance for these gases are achieved at high temperatures. In fact, at operation temperatures where gases sorbed on the surface can diffuse into the bulk of the gettering material all the getter mass will be exploited thus drastically increasing the total amount of gas that can be sorbed. H_2 sorption involves a free diffusion into the getter bulk even at room temperature allowing very large amounts of H_2 to be sorbed at low temperature.

Sintered porous getters may be used in sophisticated devices where:

- a barium film cannot be deposited or it is undesirable
- a large getter mass in a small volume is needed
- loose particles cannot be tolerated
- a getter acting as internal minipump is needed during either the tube processing or the tube operation
- a good gettering activity at room temperature is required
- extremely large amounts of H_2 are to be reversibly sorbed

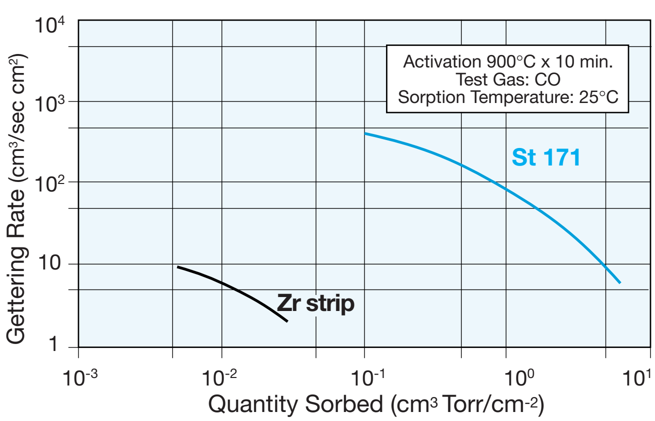


Figure 1: A comparison of sorption characteristics for a Zr strip and a St 171 sintered porous Zr-based getter.

What are Sintered Porous Getters?

Sintered porous getters are typically based on the nonevaporable getter zirconium powder mixed with other special powders and then sintered at high temperature under high vacuum. The sintering process binds together all the zirconium particles resulting in getters with excellent mechanical strength and minimal release of loose particles, even under the most severe enviromental conditions. The getter mass can be sintered around an internal heater made of a refractory metal coated by an insulating alumina coating (see Figure 2). The heater allows an easy and reproducible passage of electrical current and the heater leads can act as suitable supports to hold the getter in place.

Zirconium Based Sintered Porous Getters

St 171 is a zirconium - graphite getter requiring high activation temperatures, typically around 900°C. St 171 getters are preferred when:

- high temperature activation does not cause any problem
- the getter must withstand high processing temperatures without becoming active
- the getter is used in glass tubes and is mounted close to the sealing area

St 172 is a zirconium - St 707® getter that can reach an appreciable degree of activation at 450-500°C. St 172 getters are preferred when:

- the activation temperature cannot exceed 450-500°C
- the getter cannot be directly heated and the bakeout temperature must be used for its activation
- the getter temperature during the device operation is 150-300°C
- an active getter is needed during the bakeout to help the main pumping system

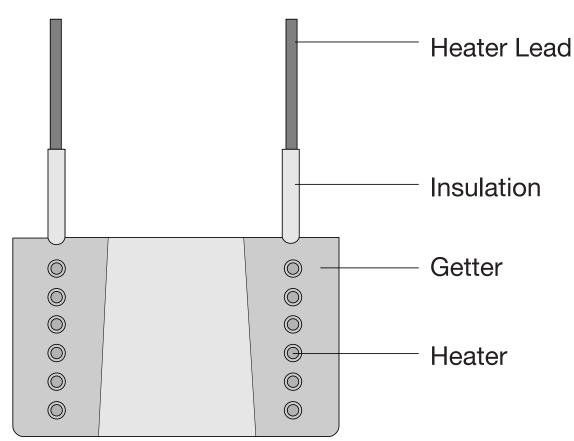


Figure 2: A typical configuration of a zirconium based sintered porous getter.

General Characteristics

Activation

The surface of St 171 and St 172 is covered by a thin but compact passivating layer of oxides that prevents any sorption of gases. This passivating layer is formed when the getters are first exposed to the atmosphere after the sintering process.

To activate the getters the passivating layer must be eliminated through an adequate heating process under a vacuum better than 10^{-3} Torr or under an atmosphere of extremely pure rare gases (i.e. at the atmospheric pressure oxygenated impurities should not exceed 1 ppm). This activation diffuses the passivating layer into the bulk thus leaving the getter surface clean and available for gas sorption.

During the activation process a gas evolution from the getter is always observed that may cause a rise of pressure in the getter chamber. This is mainly due to the release of part of the hydrogen originally present in the gettering material. This hydrogen can be easily re-pumped by the getter once the activation process is over and the getter cools down thus allowing a quick recovery of the internal pressure.

Traces of other gases are always observed during the first activation. The getter surface releasing all the gases previously physisorbed and, more importantly, the outgassing of the internal components of the device overheated during the activation process are the sources of these gases.

Reactivation

The pumping speed of a porous, sintered, nonevaporable getter tends to decrease with the progressive sorption of gaseous species and it can eventually become too low to cope with the outgassing rate of the device. Through a new heating treatment or reactivation an adequate pumping efficiency can be recovered.

Reactivations are typically performed by heating the getter at a temperature equal to or slightly lower than the activation temperature and using times equal or slightly shorter than the activation times. Getters operating at room temperature and not re-exposed to the atmosphere can be reactivated several times. After each reactivation process they will show sorption characteristics comparable to those of a fresh getter after its first activation. Reactivation of getters operating at high temperatures may only partially recover the original gettering performance. Reactivation can be carried out in a sealed device whenever necessary and it is a quite effective way to recover the required vacuum level during its life.

Sorption Characteristics

Sorption mechanisms and characteristics of St 171 and St 172 are summarized in Tables 1 and 2.

Sorption Mechanisms

Gas	Low Temperature	High Temperature
H_2	Diffusion	Diffusion
CO, CO_2, N_2, O_2	Surface Sorption	Diffusion

Table 1.

CO - CO_2 - O_2 - N_2

These gases are sorbed by St 171 and St 172 getters forming very stable chemical compounds like zirconium carbides, oxides and nitrides that cannot decompose even at temperatures well above 1000° C. Their sorption is therefore irreversible. While at room temperature these gases are sorbed only on the surface, at higher temperatures they can diffuse from the surface into the bulk of the gettering material. Therefore the sorption capacity for these gases increases considerably by increasing the sorption temperature.

H_2

This gas can diffuse into the bulk at room temperature forming a solid solution. Its sorption is therefore reversible depending upon the temperature and the H_2 pressure. H_2 sorption follows the Sieverts law (see Figure 3). At room temperature the equilibrium pressure of H_2 is absolutely negligible and therefore the sorption of H_2 is limited only by the embrittlement phenomena taking place at concentrations of 20 LTorr/g or higher. At higher temperatures H_2 can be sorbed only up to the concentration at which the equilibrium pressure becomes equal to the sorption pressure. Therefore sorption capacity for H_2 at high temperature is typically lower than at room temperature.

H_2O

Water vapor is sorbed through a dissociation into O_2 and H_2 taking place on the getter surface. O_2 and H_2 are then sorbed according to their specific sorption mechanisms.

Hydrocarbons

CH_4 as well as other hydrocarbons are sorbed only at temperatures around 300°C. In fact the sorption mechanism involves, as a first step, the cracking of the hydrocarbon molecules into C and H_2 and the kinetics of this reaction are extremely slow until 300°C. The cracking by-products are then easily sorbed by the getter.

Rare Gases

These gases cannot be sorbed by any kind of nonevaporable getter including the sintered porous type.

Sorption Characteristics

CO, CO_2, N_2, O_2	Irreversible
H_2	Reversible
H_2O	As Hydrogen and Oxygen
Hydrocarbons	As Hydrogen and Carbon T≥300°C
Rare Gases	No pumping

Table 2.

Sievert's Law: $$\log P = A + 2 \log Q - \frac{B}{T}$$

Where:

P is the H_2 equilibrium pressure in Torr

Q is the H_2 concentration in LTorr/g

T is the temperature in Kelvin

A and **B** are coefficients related to the gettering material

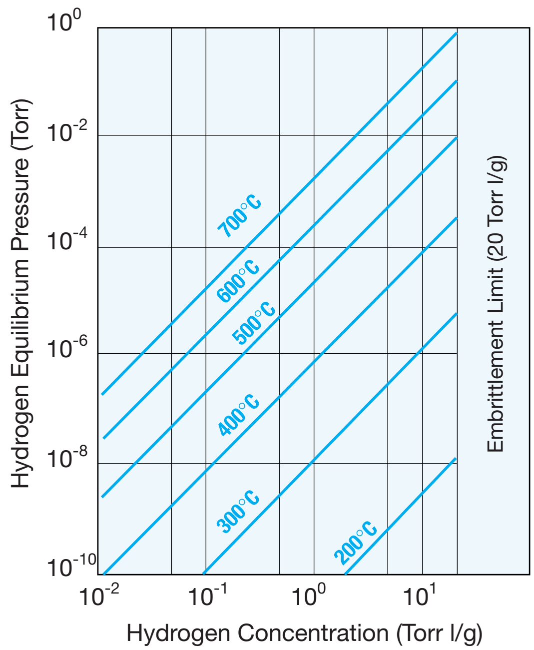


Figure 3: Sievert's Law Illustrated

Standard Porous Getter Configurations

Table 3 shows the standard configurations available.

St 171 and St 172 Configurations	Available with Mounting Support	Typical Method of Activation
Cylindrical bodies with an internal resistance heating element (see Figure 1)	Some types	Electrical current
Heaterless cylindrical bodies	All types	RF Heating

Table 3.

Storage and Packing

Sintered porous getters are packed in sealed cans under protective dry nitrogen at a pressure slightly higher than atmospheric pressure. This method of packing can allow for long storage times. The guaranteed shelf life of these getters in the original sealed cans is 5 years from the packing date stamped on the can. Once the original packing is opened it is advisable to avoid long exposures to the ambient atmosphere. This will prevent contamination by foreign particles and humidity. Prolonged storage of getters out of their original packing is not recommended. However, if necessary it should always be in containers under vacuum or a dry atmosphere.

Handling

Sintered porous getters can be safely handled in the atmosphere during mounting operations. Their handling requires some basic precautions. As with any other UHV component any contact with bare fingers must be avoided. The use of latex or rubber finger cots is strongly recommended. Cotton or synthetic fibre gloves should be avoided.

St 171 Getters

St 171 getters use a fine zirconium powder as the active material. The zirconium powder is mixed with graphite powder and then sintered at high temperatures under high vacuum. The getter mass obtained at the end of the sintering process has a porosity of 50% and extremely good mechanical strength. The zirconium content is about 83% by weight.

After a proper activation (typically at 900°C for 10 minutes) sorption characteristics at room temperature of St 171 are excellent for H_2 and quite good for oxygenated gases and N_2. To drastically enhance St 171 sorption characteristics for oxygenated gases and N_2 the getter must operate at a temperature higher than 300°C. In this range of temperatures gas sorption is no longer limited only to the surface of the zirconium grains. A diffusive process into the bulk takes place resulting in much better gettering performances.

Activation

Recommended activation conditions for St 171 are 900°C for 10 minutes under a vacuum better than 10^{-3} Torr or an extremely pure rare gas atmosphere. Full activation can also be achieved thru heating at higher temperatures for shorter times (for example 950°C for 5 minutes) or at lower temperatures for longer times (i.e. 850°C for 60 minutes). When practical reasons allow only short activation times or low heating temperatures partial activations can be achieved. Partial activations are sometimes adequate for those applications where high gettering rates are not required. At temperatures lower than 450°C St 171 cannot reach any measurable degree of activation.

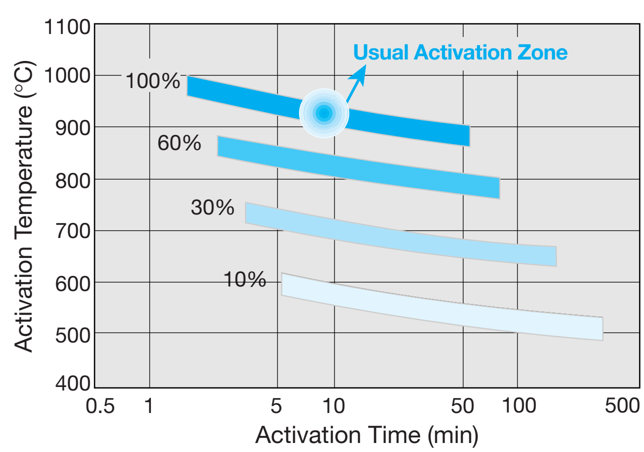


Figure 4: The gettering efficiency of St171 (expressed as a percentage of the initial gettering rate of a fully activated getter) after various activation conditions.

Activation temperatures in excess of 1000°C and heating times longer than 30 minutes (when the activation temperature is 900°C) are to be avoided to prevent oversintering phenomena that would irreversibly damage the St 171 porous structure. Activation can also be achieved through an intermittent heating of the getter. The cumulative heating time at the activation temperature must be the same as that of a continuous activation. This type of "pulse" activation is recommended for devices with heat sensitive internal components that can be severely damaged by the heat radiated from the getter during the activation process.

Reactivation

Reactivation conditions may change depending on the getter history:

Getters Re-exposed to the Atmosphere

After exposure to the atmosphere recommended reactivation conditions are 900°C for 10 minutes under a vacuum better than 10^{-3} torr or an extremely pure rare gas atmosphere.

Getters Still in the Original Sealed Device Under Vacuum or Rare Gas Atmosphere

When a getter is to be reactivated during the life of the device recommended activation conditions are 850°C for 5 minutes. Lower temperatures and shorter heating times will result in a less appreciable recovery of the original sorption performance. Temperatures lower than 450°C cannot even partially reactivate St 171.

Sorption Performance

Until about 300°C the sorption of CO takes place mainly on the surface of St 171. The impact of the sorption temperature on the amount of CO sorbed (sorption capacity) is quite limited. At temperatures higher than 300°C the bulk of St 171 starts to get heavily involved in the sorption process thus dramatically increasing the sorption capacity for CO (see Figure 5). This behavior also applies to the sorption of the other oxygenated gases and N_2.

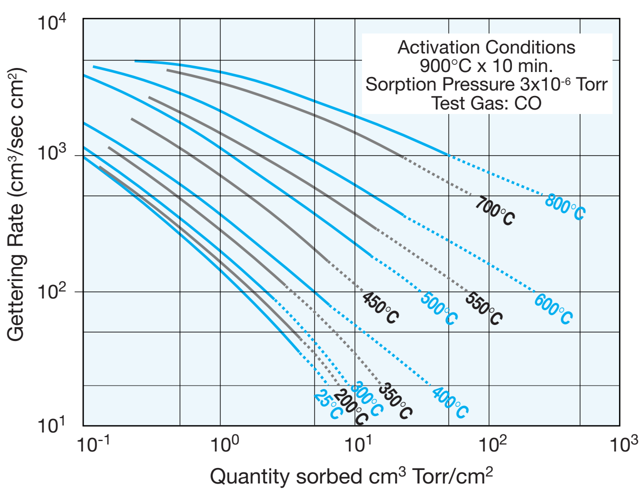


Figure 5: A family of sorption curves for CO at different operating temperatures after an activation at 900°C for 10 minutes.

H_2 is sorbed by St 171 following a mechanism completely different with respect to CO. Its sorption is reversible and a given concentration of H_2 inside the St 171 always generates an H_2 equilibrium pressure that is strongly dependent on the temperature. This dependence is described by Sieverts' law:

$$\log P = 3.6 + 2\log Q - \frac{5200}{T}$$

The flat part of the curves in Figure 6 indicates the regions of H_2 concentrations where hydrides are formed. At room temperature the equilibrium pressure of H_2 above St 171 is in the 10^{-12} Torr scale even with extremely high H_2 concentrations, 10-20 LTorr/g. On the contrary at an operation temperature of 400°C a H_2 concentration of about 1 LTorr/g can generate an H_2 pressure of about 10^{-4} Torr. This explains why St 171 sorption performances for H_2 are much better at room temperature than at 400°C. Figure 7 shows sorption curves for CO and H_2 at room temperature and 400°C after activation at 900°C for 10 minutes.

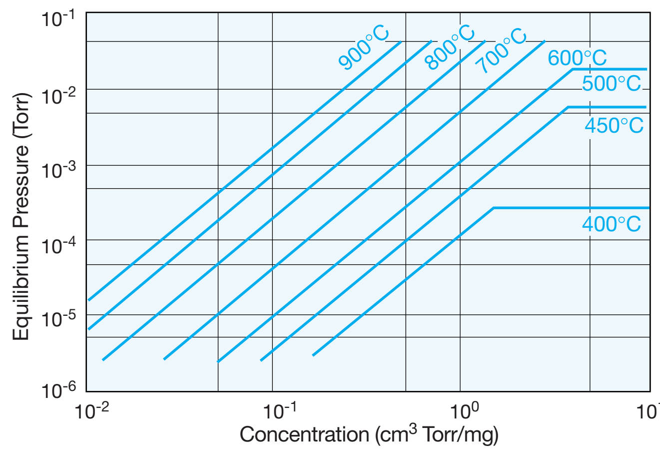


Figure 6: The H_2 equilibrium *pressures of St 171 as a function of the H_2 concentration in the gettering material at different working temperatures.*

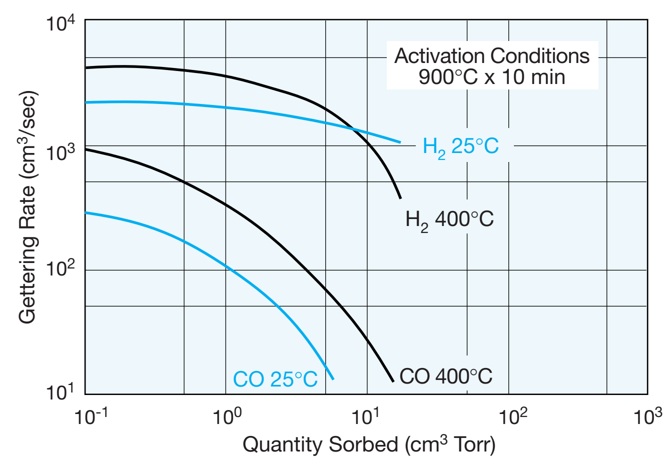


Figure 7: Sorption curves of St 171/LHI/4-7/200 for CO and H_2 at room temperature and at 400°C after an activation at 900°C for 10 minutes.

These sorption curves have been obtained using the test procedures described by the ASTM document F 798 - 82. The trend of these curves underlines the opposite effect of the temperature on the sorption performance for H_2 and CO. Figure 8 shows the gettering rate for CH_4 at different operating temperatures.

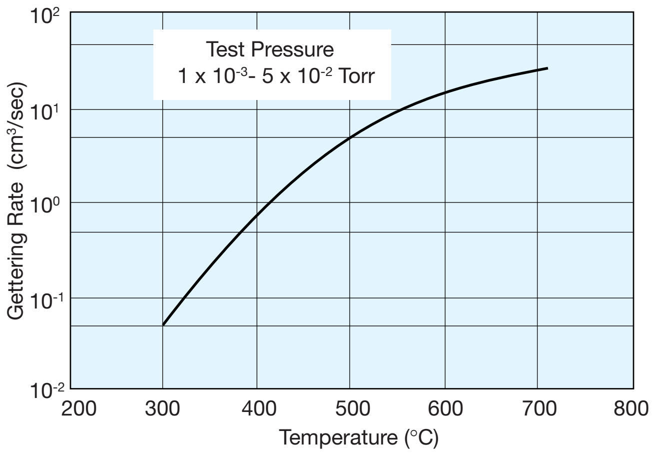


Figure 8: The gettering rates of St 171/LHI/4-7/200 for CH_4 at different temperatures.

At temperatures lower than 300°C the sorption rate is practically negligible. The kinetics of thermal cracking of the CH_4 molecule into C and H_2 on the St 171 surface is the limiting step of the sorption process.

Behavior of St 171 Getters During Bakeout

The bakeout process during the manufacuturing cycle of electronic tubes and evacuated devices is often several hours long and is performed at temperatures ranging from 85°C to 500°C. Such temperatures are not enough to appreciably activate the St 171 getter. The getter will not get contaminated by the high gas loads that are typically released during the first hours of the bakeout. Therefore, St 171 gettering material is recommended when the getter should sorb no or negligible amounts of gases during bakeout thus preserving all its gettering activity for the life of the electronic tube or evacuated device.

St 171 Getters As MiniPumps

The efficiency of main pumping systems used to evacuate electronic tubes and devices is often drastically limited by the small conductance of the typically long and narrow pumping tubulations. In such a situation a St 171 getter mounted inside the tube with no conductance limitations can assure pumping speeds comparable to or higher than the main pumping system if the getter is properly activated and operated at 400-500°C. Therefore, the St 171 getter can act as a very efficient internal mini pump providing the following advantages:

- to shorten bakeout times or to achieve a better final vacuum at the end of the bakeout process. In this case St 171 must be fully activated at the beginning of the bakeout process.
- to perform the final steps of the processing (such as the ageing process) with the device already removed from the main pumping system and the St 171 getter sorbing the gases released. In this case the St 171 activation must be carried out immediately before the tip-off/pinch-off of the tube.

NP version

In the NP (i.e. No Particles) version the surface of the St 171 is coated with a thin layer of sintered zirconium that further reduces the already low release of loose particles from the getter body.

This additional coating of zirconium requires a second sintering process. The coating is less porous, with a gettering rate that is about 35% lower than the St 171 gettering rate at room temperature. These getters may be recommended for applications were particles cannot be tolerated such as X-Ray Tubes, X-Ray Image Intensifiers and Infra Red Detector Dewars. However, it is important to note that in these tubes standard St 171 can also be successfully used.

The NP version is only available for certain models. In certain models with the internal heater, the insulating and, sometimes, quite brittle coating of alumina protruding from the getter body can be replaced by rigid sleeves of alumina thus preventing the generation of alumina loose particles during the bending of getter leads. Contact your SAES Getters engineer for more information.

Applications

St 171 getters are mainly intended for use in those applications where :

- high temperature activation does not cause any problem
- the getter must withstand high processing temperatures without becoming active
- the getter is used in glass tubes and is mounted close to the sealing area

Some Typical Applications of St 171 Getters Are:

- X-Ray Tubes (mainly glass type)
- Infra-Red Detectors Dewars
- X-Ray Image Intentifiers
- Capacitance Manometers
- Travelling Wave Tubes
- Industrial Microwave Tubes

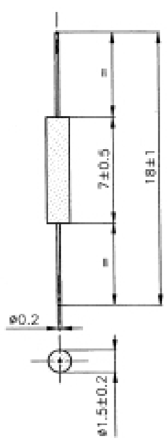
Standard Models

Official technical specifications with technical drawings, sorption curves and heating curves of each standard model are available on request. Standard support is made of Kovar with a diameter of 1.0 mm.

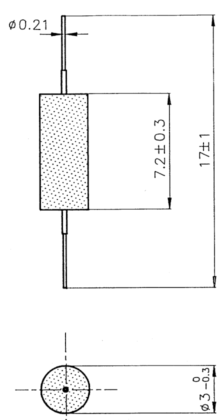
Specification Data							
Getter Type	External Diameter (mm)	Height (mm)	St 171 (mg)	Activation Current (900°C) (A)	Operating Current (400°C) (A)	Heater Material	Wire Diameter
LHI/1.5-7	1.50	7.00	38	6.3	3.7	Mo	0.20
LHI/3-7	3.00	7.10	120	4.3	2.2	W-Re	0.21
LHI/4-7	4.00	7.20	235	4.9	2.3	W-Re	0.21
HI/7.5-7	7.50	7.00	410	3.3	1.65	Mo	0.23
HI/7-6	8.20	8.00	800	3.8	2.0	Mo	0.25
HI/9.5-7.5	9.50	7.75	1350	4.3	2.1	Mo	0.25
HI/16-10	16.00	10.00	3300	10.0	4.7	Mo	0.55
HIS/7-6	8.20	8.10	850	3.8	2.0	Mo	0.25

Table 4: Dimensions, St 171 mass and material of the internal heater for each model.

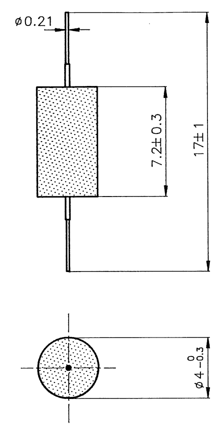
N.B. Activation and operating current values in Table 4 are purely indicative. To properly activate and operate St 171 getters please refer to the heating curves available on request and to the section **Practical Hints, Activation**.



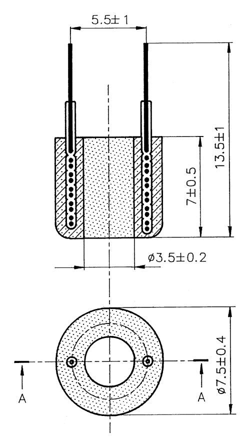
LHI/1.5-7



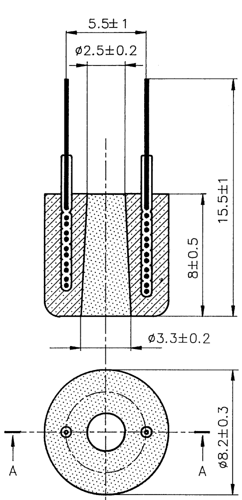
LHI/3-7



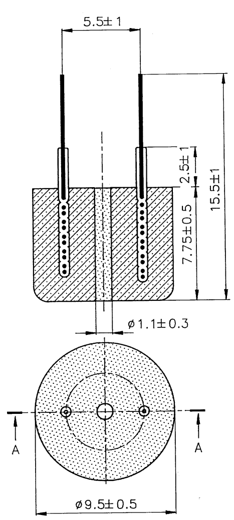
LHI/4-7



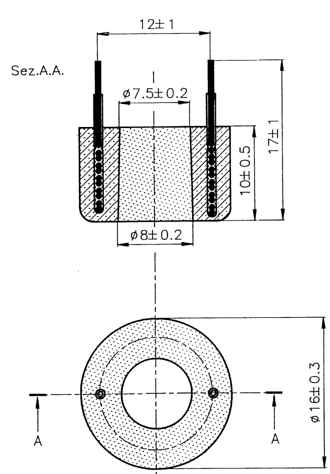
HI/7.5-7



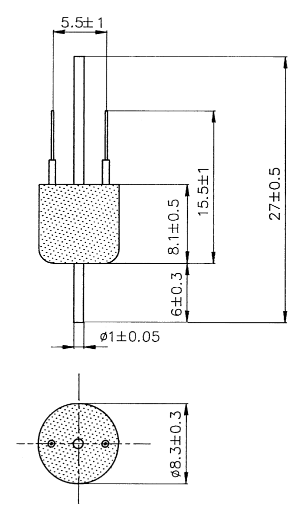
HI/7-6



HI/9.5-7.5



HI/16-10



HIS/7-6

St 172 Getters

St 172 nonevaporable getters have been developed by SAES Getters' R&D labs to fullfill the market needs for a sintered porous getter activatable at lower temperatures. Both components of St 172, zirconium powder and St 707 powder, are active materials. They are mixed together and sintered at high temperatures under high vacuum. St 172 gettering material has a 35% porosity and a very good mechanical strength.

The zirconium content is about 40% by weight. The use of a high diffusivity alloy like the St 707 means the St 172 can reach an appreciable degree of activation at only 450°C. For the same reason the diffusion into the bulk of oxygenated gases and N_2 sorbed on the getter surface takes place at 150-200°C.

Therefore sorption performance of St 172 for oxygenated gases and nitrogen can be dramatically enhanced by operating the getter in this range of relatively low temperatures. After a proper activation sorption performance for H_2 is excellent at room temperature.

Activation

Low Temperature Activation

In applications where the amount of heat radiated by the getter during the activation process must be minimized the recommended activation conditions for St 172 are 450° C for 10 minutes under a vacuum of better than 10^{-3} Torr or an extremely pure rare gas atmosphere. Through this heating treatment St 172 will reach a degree of activation of about 35% with respect to a fully activated getter. This level of activation has proven to be quite adequate for applications such as Infra Red Detector Dewars, Capacitance Manometers and Travelling Wave Tubes where there is no need for high gettering rates. Advantages coming from a low temperature activation are:

- less risk of damaging heat sensitive components surrounding the getter
- less outgassing of nearby walls and components
- less robust feedthroughs required

A similar degree of activation can be achieved at a temperature as low as 300°C with a heating time of about 90 minutes. No practical activation can be reached using a heating temperature lower than 200°C.

High Temperature Activation

In applications where the amount of heat radiated by the getter during the activation process is not a critical issue the recommended activation conditions for St 172 are 900°C for 10 minutes under a vacuum better than 10^{-3} Torr or an extremely pure rare gas atmosphere. This heating process will allow St 172 to reach a full activation. Full activations are also achieavable through different combinations of temperatures and times. Activation temperatures in excess of 1000°C and heating times longer than 30 minutes (when the activation temperature is 900°C) are to be avoided to prevent oversintering phenomena that would irreverisibly damage the St 172 porous structure.

Activation can also be achieved through an intermittent heating of the getter. The cumulative heating time at the activation temperature must be same as that of a continuous activation. This type of "pulse" activation is recommended for devices with heat sensitive internal components that cn be severely damaged by the heat radiated from the getter during the activation process.

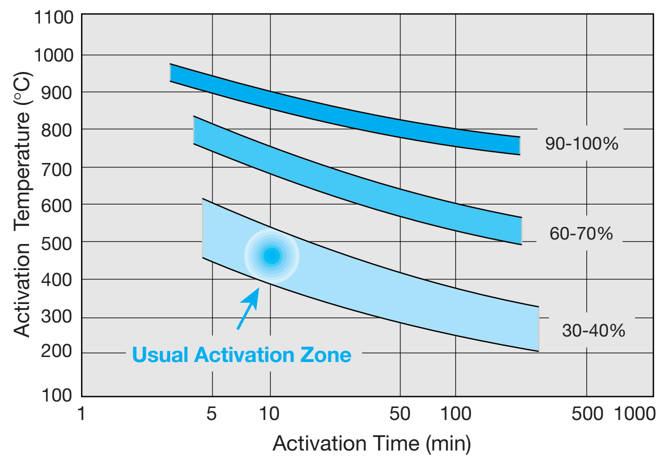


Figure 10: The gettering efficiency of St 172 (expressed as a percentage of the initial gettering rate of a fully activated getter) after various heating treatments.

Reactivation

Reactivation conditions depend upon the getter history:

Getters Previously Activated at Low Temperatures

The recommended reactivation conditions are always 450°C for 10 minutes.

Getters Previously Activated at High Temperatures

Getters re-exposed to the atmosphere: after exposure to the atmosphere recommended reactivation conditions are 900°C for 10 minutes under a vacuum better than 10^{-3} Torr or an extremely pure rare gas atmosphere.

Getters still in the original sealed device under vacuum or rare gas atmosphere: when a getter is to be reactivated during the life of the device recommended activation conditions are 800°C for 5 minutes.

Lower temperatures and shorter heating times will result in a less appreciable recovery of the original sorption performance. Temperatures lower than 200°C cannot even partially reactivate St 172.

Sorption Performance

While at room temperature the sorption of CO is limited to the St 172 surface, at 200°C the bulk of St 172 starts to get involved in the sorption process thus dramatically increasing the sorption capacity for CO. These diffusive processes are strongly favored by a temperature increase therefore, it is not surprising that sorption performance for CO at 400°C is much better than at 200°C (see Figure 11). This behavior also applies to the sorption of the other oxygenated gases and N_2.

H_2 is sorbed by St 172 following a mechanism completely different with respect to CO. Its sorption is reversible and a given concentration of H_2 inside the St 172 always generates an H_2 equilibrium pressure that is strongly dependent on the temperature. This dependence is described by Sieverts' law:

$$\log P = 4.45 + 2\log Q - \frac{5730}{T}$$

The flat part of the curves in Figure 12 indicates the region of H_2 concentrations where hydrides are formed. At room temperature the equilibrium pressure of H_2 above St 172 is in the 10^{-13} Torr scale even with extremely high H_2 concentrations, 10-20 LTorr/g.

At an operation temperature of 200°C and with a non negligible H_2 concentration of about 1 LTorr/g the equilibrium pressure of H_2 is still in the low 10^{-8} Torr scale. Such a low equilibrium pressure of H_2 combined with the excellent gettering performance for CO and other oxygenated gases make 200°C the ideal operating temperature for St 172 getters.

Curves of Figure 13 and 14, obtained using the test procedures describes by the ASTM document F798-82, show the sorption performance of St 172 for CO and H_2 after a low and high temperature activation. It is interesting to note that an increase of the working temperature from 25 to 200°C will have an extremely beneficial impact on the sorption performance for CO while it hardly affects the sorption performance for H_2.

Figure 15 shows gettering rates of St 172 for CH_4 at different operating temperatures. At temperatures lower than 300°C the sorption rate is practically negligible.The kinetics of thermal cracking of the CH_4 molecule into C and H_2 on the St 171 surface is the limiting step of the sorption.

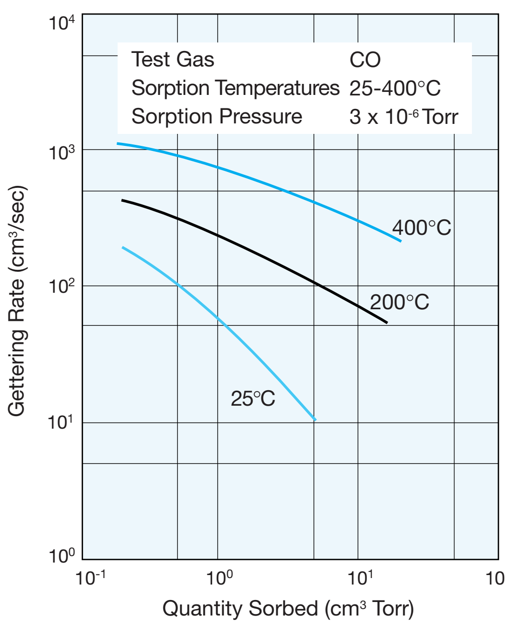


Figure 11: St 172/LHI/4-7/200 sorption curves for CO at room temperature, 200°C and 400°C after an activation at 900°C for 10 minutes.

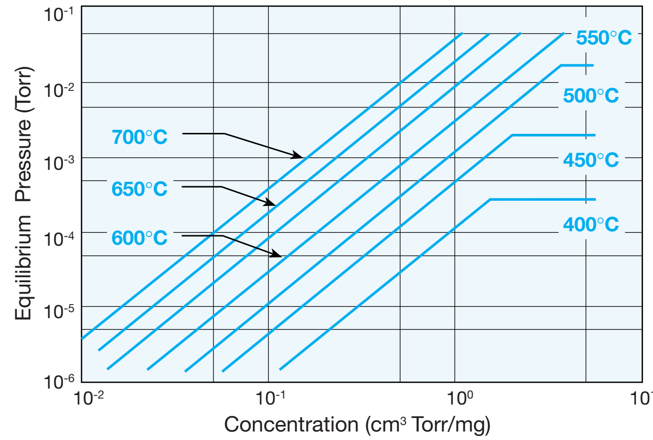


Figure 12: The H_2 equilibrium pressures of St 172 as a function of the H_2 concentration in the gettering material at different working temperatures.

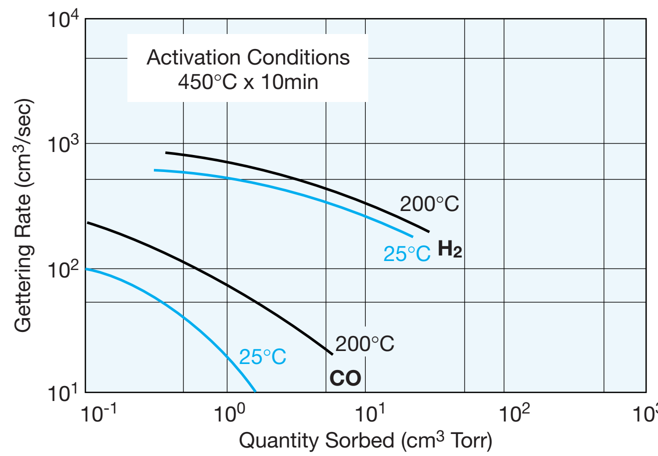


Figure 13: St 172/LHI/4-7/200 sorption curves for CO and H_2 at room temperature and 200°C after an activation at 450°C.

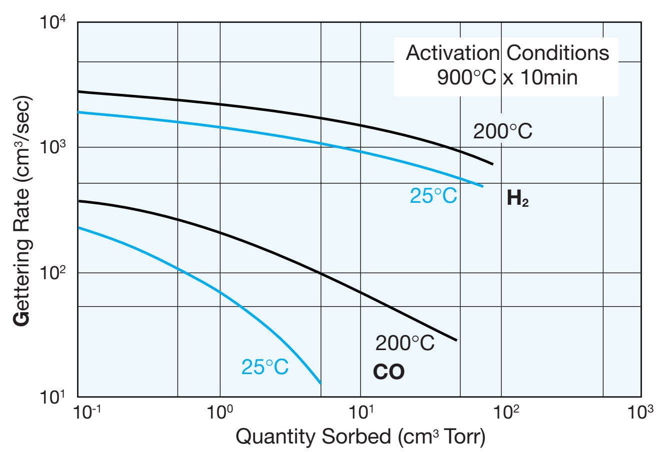


Figure 14: St 172/LHI/4-7/200 sorption curves for CO and H_2 at room temperature and 200°C after an activation at 900°C for 10 minutes.

Behaviour During Bakeout

The manufacturing cycle of electronic tubes and evacuated devices always include a bakeout process often several hours long and performed at temperatures ranging from 85°C to 500°C. The behavior of St 172 during this step of the process depends on the actual bakeout temperature.

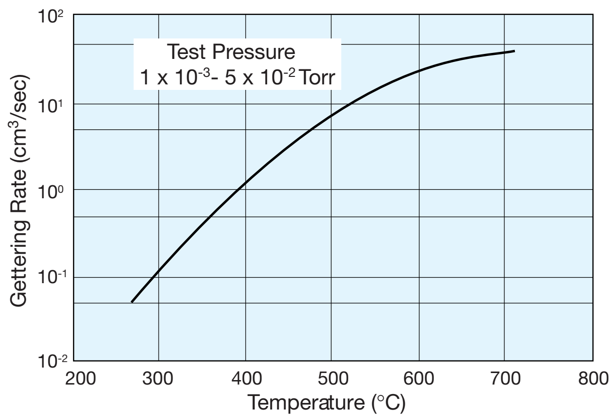


Figure 15: The St 172/LHI/4-7/200 gettering rates for CH_4 at different temperatures.

Low Temperature Bakeouts (temperatures < 250°C)

At these temperatures St 172 cannot become active even if the bakeout times are extremely long. Therefore, St 172 will not get contaminated by the high gas loads typically released during the first hours of this manufacturing step thus preserving all its sorption capacity for the life of the electronic tube or evacuated device. A direct activation of the St 172 after the bakeout process is always required to make the getter active.

High Temperature Bakeouts (temperatures > 250°C)

This range of temperatures is enough to at least partially activate St 172. The getter will contribute to the sorption of the gases released during the bakeout thus acting as an internal minipump. Under this scenario part of the St 172 sorption capacity will be spent during the bakeout process and this must be taken into account when defining the getter size. In fact, in order to have enough residual sorption capacity for the life of the electronic tube or evacuated device, it is sometimes necessary to use models with a larger getter mass.

If the final vacuum is better than 10^{-3} Torr and with bakeout times several hours long no direct activation of the St 172 is necessary. At the end of the bakeout the getter will have achieved at least a partial activation.

St 172 Getters as Minipumps

The efficiency of main pumping systems used to evacuate electronic tubes and devices is often drastically limited by the small conductance of the typically long and narrow pumping tubulations. In such a situation a St 172 getter mounted inside the tube with no conductance limitations (if properly activated and operated at temperatures higher than 150°C) can assure pumping speeds comparable or higher than the main pumping system. Therefore the St 172 getter can act as a very efficient internal mini pump providing following advantages:

- to shorten bakeout times or achieve a better final vacuum at the end of the bakeout process. How to achieve these targets depends upon the actual bakeout temperature (see following explanation).
- to perform the final steps of the processing (such as the ageing process, with the device already removed from the main pumping system and the St 172 getter sorbing the gases released. If not already active at the end of the bakeout the St 172 should be activated immediately before the tip off/pinch off of the tube.

Low Temperature Bakeouts (temperatures < 250°C)

Since this range of temperatures is not enough to activate the St 172 a direct activation occur at the beginning of the bakeout and then the St 172 must be kept at a working temperature of at least 150°C.

High Temperature Bakeouts (temperatures > 250°C)

These temperatures activate the St 172 that will automatically act as an internal mini pump with no need of any direct additional heating process.

NP Version

In the NP (i.e. No Particles) version the surface of the St 172 is coated with a thin layer of sintered zirconium that further reduces the already low release of loose particles from the getter body. This additional coating of zirconium requires a second sintering process and, being less porous, it lowers by about 35% the gettering rate of St 172 at room temperature.

The recommended activation for St 172 getters in NP version is a high temperature activation. These getters are recommended for applications were particles cannot be tolerated like X-Ray Tubes, X -Ray Image Intensifiers and Infra Red Detector dewars. It is important to note that in these tubes standard St 172 can also be successfully used.

The NP version is available for most of the models with and without internal heater. In the NP version of few models with internal heater the insulating and, sometimes, quite brittle coating of alumina protruding from the getter body can be replaced by rigid sleeves of alumina thus preventing the generation of alumina loose particles during the bending of the getter leads.

Applications

St 172 getters are mainly intended for use in those applications where:

- the activation temperature cannot exceed 450-500°C
- the getter cannot be directly heated and the bakeout temperature must be used for its activation
- the getter temperature during the device operation is 150-300°C
- an active getter is needed during the bakeout to help the main pumping system

Some Typical Applications of St 172 Getters Are:

- Infra-Red Detectors Dewars
- Capacitance Manometers
- X-Ray Tubes (ceramic-metallic and all metallic type)
- Argon Lasers
- Vacuum Interrupters
- Travelling Wave Tubes

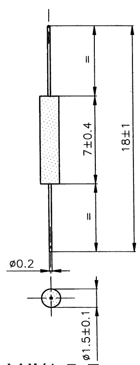
Standard Models

Official technical specifications with technical drawings, sorption curves and heating curves of each standard model are available on request. Standard support is made of Kovar wire with diameters ranging from 0.5-1.0 mm.

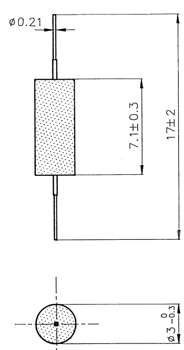
Specification Data								
Getter Type	External Diameter (mm)	Height (mm)	St 172 (mg)	Activation Current		Operating Current 200°C (A)	Heater Wire	
				900°C (A)	450°C(A)		Material	Diameter (mm)
LHI/1.5-7	1.50	7.00	46	6.3	4.0	2.5	Mo	0.20
LHI/3.7	3.00	7.10	230	4.3	2.4	1.4	W-Re	0.21
LHI/4-7	3.85	7.20	350	4.9	2.6	1.5	W-Re	0.21
HI/7.5-7	7.50	7.00	550	3.3	1.85	1.05	Mo	0.23
HI/7-6	8.20	8.00	1150	3.8	2.2	1.2	Mo	0.25
HI/9.5-7	9.50	7.75	1850	4.3	2.3	1.3	Mo	0.23
HI/16-10	16.00	10.00	4500	10.0	5.2	3.1	Mo	0.55
HIS/5-6	5.00	6.00	400	4.9	2.9	1.75	Mo	0.25
HIS/7.5-7	7.50	7.00	775	3.3	1.85	1.05	Mo	0.23
HIS/7-6	8.30	8.00	1400	3.8	2.2	1.2	Mo	0.25
WHC/3-7	2.85	7.10	205	RF Heating			No Internal Heater	
WHC/4-2	3.50	2.00	90	RF Heating			No Internal Heater	
WHC/6-2	5.90	1.90	200	RF Heating			No Internal Heater	

Table 5 Dimensions, St 172 mass, Activation/Operating currents and material of the internal heater for each model.

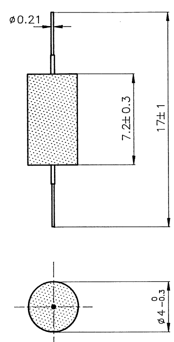
N.B. Activation and operating current values in Table 5 are purely indicative. To properly activate and operate St 171 getters please refer to the heating curves available on request and to the section **Practical Hints, Activation**.



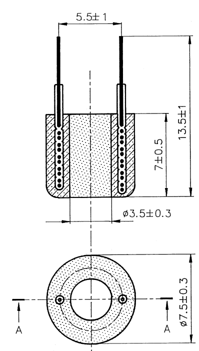
LHI/1.5-7



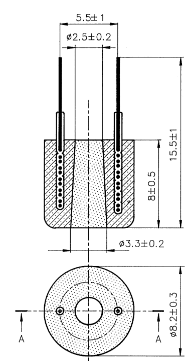
LHI/3-7



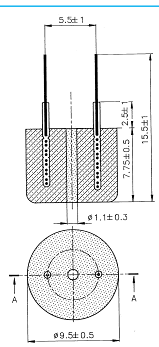
LHI/4-7



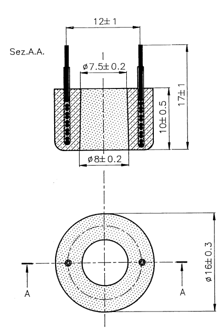
HI/7.5-7



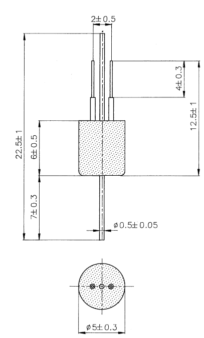
HI/7-6



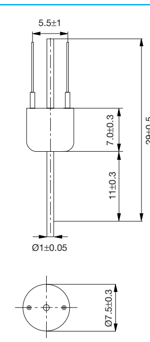
HI/9.5-7.5



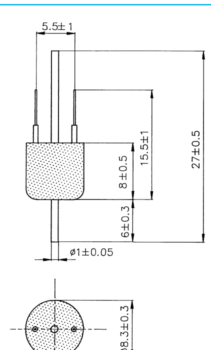
HI/16-10



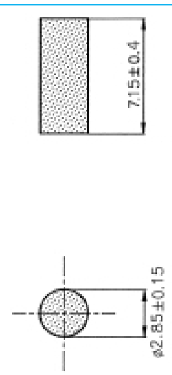
HIS/5-6



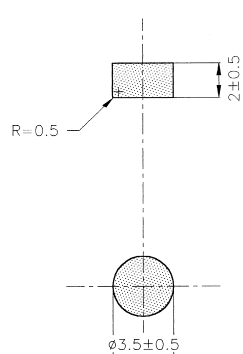
HIS/7.5-7



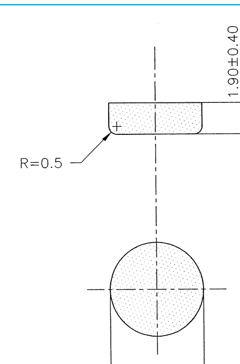
HIS/7-6



WHC/3-7



WHC/4-2



WHC/6-2

St 171 and St 172 Sorption Performance: a Direct Comparison

Figures 17, 18, 19 and 20 allow a quick comparison of the sorption performance of these two gettering materials.

- After an activation at 900°C St 171 and St 172 behave in a quite similar way. However, since St 172 getters have more active mass than St 171 getters (St 172 has a higher specific weight, 3.6 g/cc against 2.5 g/cc, and both its components are active while in St 171 one component, graphite, is only an antisintering element with no sorption activities) one can assume that at gettering rates lower than those measurable through the ASTM sorption test procedure St 172 can pump more gases than St 171.
- After an activation at 450°C the advantages shown by St 172 over St 171 are quite obvious.
- At operating temperatures higher than room temperature St 172 getters are preferred to St 171 getters due to their capability to sorb large amounts of oxygenated gases already at 200°C. Since at 200°C the sorption characteristics for H_2 are also extremely good St 172 is by far superior than St 171 in this range of temperatures.

In spite of the better sorption performance shown by St 172 under almost any scenario it must be pointed out that since St 172 can get more easily contaminated than St 171 very often St 171 is preferred for many applications.

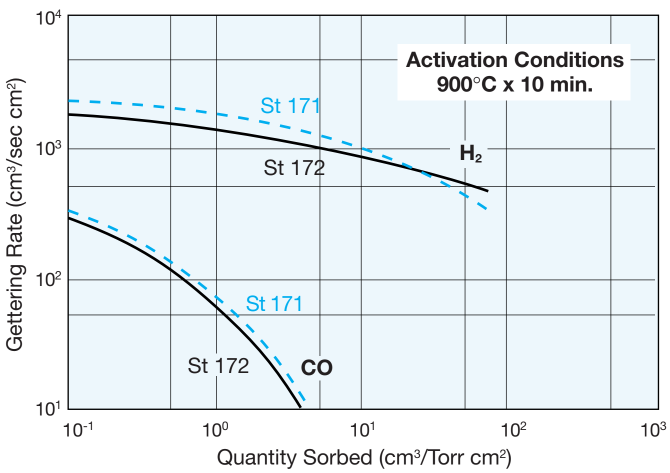


Figure 17: Room temperature comparison of St 171 and St 172 with activation conditions of 900°C for 10 minutes.

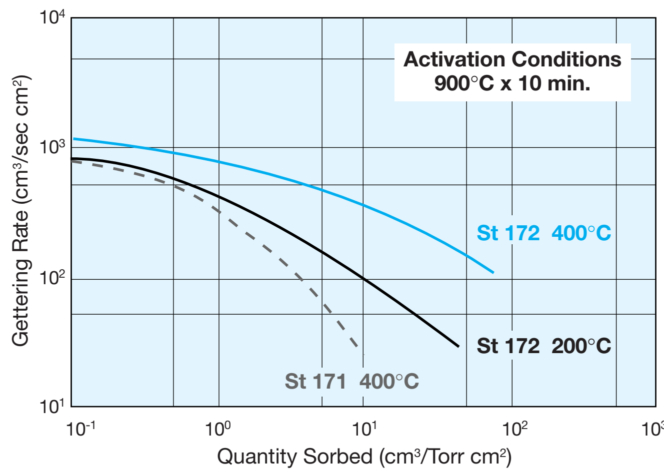


Figure 19: Comparison of St 171 and St 172 for CO at different sorption temperatures with activation conditions of 900°C for 10 minutes.

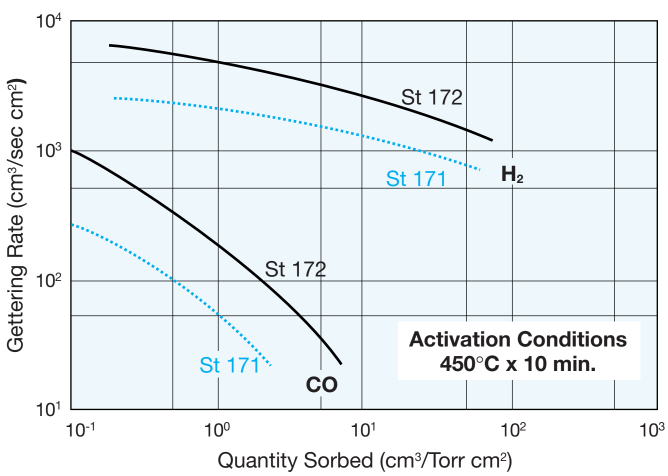


Figure 18: Room temperature comparison of St 171 and St 172 with activation conditions of 450°C for 10 minutes.

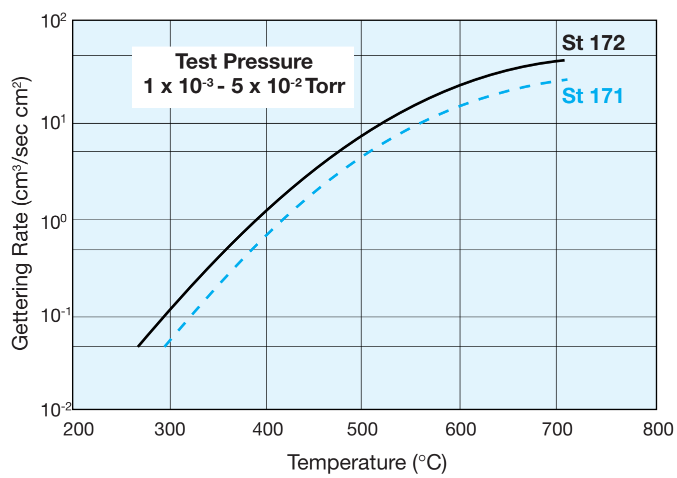


Figure 20: Comparison of St 171 and St 172 for CH4 with a test pressure of 1 x 10^{-3} - 5 x 10^{-2} Torr.

Practical Hints

Mounting Operations

Getter leads bending - In the models with an internal heater the bending of the getter leads should be performed with special care to prevent the breakage of the alumina coating protruding from the getter body. The use of two suitable pliers, one to firmly hold the lead immediately after the alumina coating and the other one to accomplish the bending, is strongly recommended. If the leads are to be bent very close to the getter body it is advisable to first remove the alumina coating. This operation is quite critical and special attention must be paid to avoid any direct contact between the bare metallic leads and the gettering material where the leads enter the getter body: in fact this would cause dangerous short circuits.

Special additional supports - In devices operating under severe shock and vibration conditions the getter leads alone are often not enough to assure a safe mounting. When SAES standard models with special metallic supports enbedded into the getter body cannot be used a special mounting involving the use of metallic strips or wires must be developed to prevent leads breakage or loose particles generation during the operational life of the device.

Welding - The getter leads can be safely welded to the feedthroughs by spot welding. Since the leads are made of refractory metals (either HT molybdenum or tungsten-renium) the best results are achieved by performing the welding under inert or reduced atmosphere and using nickel based feedthroughs much thicker than the leads. This will allow the leads to deeply penetrate into the melt.

Sealing

The sealing process of glass tubes and devices is a critical step of the assembly that if not kept under severe control, can irreversibly contaminate both St 171 and St 172 getters.

To prevent problems:

- the getter temperature must be as low as possible in the presence of either forming gas or air: St 172 temperature cannot exceed about 250°C while St 171 temperature must be lower than about 350°C.
- if the getter temperature cannot be properly controlled getters must be protected by means of a rare gas or nitrogen continuous flow.
- the protective gas flow must be directed so as to remove heat from the getter: it must reach the getter before passing through the flame.

Activation

Temperature - The activation temperature must always be directly checked by means of a thermocouple or using an optical pyrometer (NOTE: the emissivity of St 171 and St 172 is 0.63). This is particularly necessary in the case of high temperature activations where temperatures in excess of 1000°C can irreversibly damage the porous getter structure. In case of models with an internal heater one must bear in mind that the T/A curves supplied by SAES refer to heating tests performed in large glass systems with no reflective surfaces surrounding the getters. These conditions are quite different from those actually "seen" by the getters once mounted in the final device and therefore the activation temperature is very often reached at currents different, typically lower, than those reported on the official T/A graph. In conclusio, the activation temperature must also be directly controlled for the models with internal heater.

First Activation: When and How - The first activation should always be performed under pumping to allow most of the gases released in this step to be pumped away by the main pumping system. If the getter is not intended to be used as an internal minipump the first activation should be carried out immediately before the tube tip-off/pinch-off and tip-off should be performed when the getter is still hot. The activation temperature should be reached quite slowly to prevent generating too high a pressure inside the tube. The temperature increase rate will depend on the actual capability of the main pumping system to cope with the gas evolution (mostly H_2) typical of the first activation. Once the activation temperature is reached the getter should be kept at that temperature only for the time strictly necessary to achieve the required degree of activation. During the getter cool-down the pressure will show a strong recovery until a value equal or better than the original one is reached once the getter is at room temperature.

Preliminary Outgassing - If the main pumping system does not pump H_2 in an effective way the time involved to reach the activation temperature may become too long. To prevent this problem a preliminary outgassing of the getter is recommended. This outgassing process is to be performed during the final stage of the bakeout and at a temperature lower than the activation temperature but high enough to generate a high H_2 equilibrium pressure. The outgassing temperature is to be maintained until a full recovery of the original base pressure is achieved. For instance a getter requiring a 900°C activation and mounted in a tube submitted to a 6 hour bakeout should be outgassed at about 700°C. The outgassing process should start after the first 4 hours of bakeout.

H_2 Trap - Times required to reach the activation temperature can be drastically shortened by increasing the efficiency of the main pumping system for H_2. This can be easily done by mounting a SAES Getters Sorb-AC® getter pump on the manifold. Its excellent sorption characteristics for H_2 make the getter pump a very effective «**H_2 trap**» quickly sorbing the H_2 released during the first activation cycle and thus allowing the final activation temperature to be quickly reached. (Note: for more information on SAES Getters SORB-AC getter pumps please contact your SAES Getters engineer.)

When More Than One Getter.... - When more than one sintered porous getter is used in the same tube all the activation, and all the reactivation processes must be carried out on ALL the getters at the same time. In fact only a simultaneous heating process of all the getters mounted inside the tube can allow achievement of full activation.

AMD 920630.PDF

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