SCHOTT PTR®70 Receiver

Setting the benchmark
SCHOTT Solar, a subsidiary of SCHOTT AG, is a leading international supplier of high-quality solar technology. Customers, partners and financiers appreciate SCHOTT Solar products for their high quality and durability. This can all be attributed to the company’s experience that goes back as far as 1958, extensive R&D work and tests that are twice as stringent as the industry standard calls for.
SCHOTT Solar CSP develops, manufactures and markets highly efficient receivers, one of the key components for Concentrated Solar Power plants using parabolic trough technology. We rank as the world’s market and technology leader.
SCHOTT Solar CSP with its high performance receivers – which comprise the core of all solar power plants using parabolic trough technology – contributes decisively to making tomorrow’s energy production possible today.

To achieve this we provide technology which, with regard to economics, security of supply and climatic protection, provides numerous benefits.

SCHOTT Solar CSP – Your partner for sustainable profitability
Parabolic trough technology
The first choice for large-scale solar power generation

Concentrated Solar Power –
Clean and predictable electricity
generation around the clock

Concentrated Solar Power (CSP) technology uses energy from the sun to generate heat, which is used in steam cycles to produce electricity. The technology is particularly efficient in regions with high direct solar irradiation, encompassing the earth’s sunbelt on both sides of the equator to 35 degrees latitude.

CSP plants are used in a similar manner like conventional steam power plants. The key difference is that CSP plants use emission-free, clean solar radiation to produce heat instead of fossil or nuclear fuels. Amongst all CSP technologies, Parabolic Trough technology has the longest commercial track record of almost 30 years. Parabolic Trough power plants are suitable for large-scale use in the range of 10 to 300 MW electrical output and can replace conventional thermal power plants without any qualitative changes in the electricity grid structure. Due to the option of thermal storage or hybridization, the turbines of CSP plants can also produce power in low solar radiation periods and at night, delivering power reliably, on a planned schedule and in a way that keeps the grids stable.

In a CSP plant, the generation of heat mostly depends on the level of solar irradiation. In order to achieve the necessary temperatures, solar radiation is concentrated in parabolic trough arrays. These troughs are more than 400 meters (1,300 feet) in length and are made of parabolic shaped mirror segments. The troughs track the sun over the course of the day and focus the solar radiation along the focal point of the mirrors onto the “heart” of a CSP plant: specially coated, evacuated receiver tubes. The receiver tubes convert solar radiation into thermal energy, and therefore their durability and efficiency are crucial for the sustainable profitability of the entire solar plant. A heat transfer fluid, which is circulating through the receiver, is heated up and then used to generate steam.

Solar irradiation world map
The receiver, being the key component of a CSP plant, has a decisive influence on the overall efficiency of the plant and has to withstand dramatic temperature changes and mechanical stresses throughout its lifetime. The SCHOTT PTR®70 Receiver responds to this challenge and allows SCHOTT Solar CSP not only to claim technology leadership, but to also be the clear market leader in solar receivers.

More than 700,000 SCHOTT PTR®70 Receivers have been delivered to power plants all over the world. High solar absorptance, low thermal losses and a durable vacuum body are crucial and in all aspects, the SCHOTT PTR®70 Receiver delivers outstanding results. Another important factor is shading: the compact bellow design has been further improved to an active length of > 96.7% which can be increased even more if SCHOTT Solar CSP’s patented shield design is used.

SCHOTT Solar – Your partner for sustainable profitability
SCHOTT PTR®70 Receivers
Designed for maximum profitability of the power plant

Crucial for the performance of the collector field are the optical properties of the absorber coating. SCHOTT Solar CSP has developed and patented the absorber coating with remarkable optical values and long-term thermal stability. In addition, this absorber coating has proven to be stable for operating temperatures up to 450 °C and is prepared for new generations of heat transfer oils.

To minimize heat conduction losses, the absorber is vacuum insulated and enclosed by a glass tube. The durability of the vacuum depends on the mechanical strength and temperature resistance of the glass-to-metal seal. Due to the combination of materials with matching coefficients of thermal expansion, the glass-to-metal seal of the SCHOTT PTR®70 Receiver can handle significant temperature changes and ensures vacuum stability. For maximum quality assurance, every single glass-to-metal seal at SCHOTT Solar CSP undergoes a thermal shock test.
In the industry it is typical to coat the glass tubes of the concentrating solar thermal receivers with an anti-reflective (AR) film for improved solar transmittance. However, the weak point of most AR-coatings is their low adhesion to the borosilicate glass. Due to a patented production process, SCHOTT Solar CSP has been able to introduce a composition of the AR-layer with maximum adhesion and long-term abrasion resistance, achieving transmittance values of more than 96.5%.

The patented bellow design by SCHOTT Solar CSP increases the active aperture area of the receiver to more than 96.7% of the total area. In conjunction with SCHOTT Solar CSP’s patented innovative shields with reflector disks, the active length can be further increased. SCHOTT Solar CSP shields lead to higher power plant efficiency, especially during the winter.

Heat loss measurements in a round robin test performed by SCHOTT Solar CSP in cooperation with NREL (US National Renewable Energy Laboratory) and DLR (German Aerospace Centre) have confirmed a heat loss of less than 250 W/m at working temperatures (400 °C/750 °F).

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<thead>
<tr>
<th>Components</th>
<th>Specification</th>
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<tbody>
<tr>
<td><strong>Dimension</strong></td>
<td>• length: 4,060 mm at 20 °C ambient temperature (159.8 in. at 68 °F)&lt;br&gt;• aperture length: &gt;96.7% of the bulk length at working temperature (&gt;300 °C/&gt;572 °F)</td>
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<tr>
<td><strong>Absorber</strong></td>
<td>• outer diameter: 70 mm/2.75 in.&lt;br&gt;• steel type: DIN 1.4541 or similar&lt;br&gt;• solar absorptance: ( \alpha_{\text{ISO}} \geq 95.5% ); ( \alpha_{\text{ASTM}} \geq 96% )&lt;br&gt;• thermal emittance (at approx. 400 °C/approx. 752 °F): ( \varepsilon \leq 9.5% )</td>
</tr>
<tr>
<td><strong>Glass envelope</strong></td>
<td>• borosilicate glass&lt;br&gt;• outer diameter: 125 mm/4.9 in.&lt;br&gt;• anti-reflective coating&lt;br&gt;• solar transmittance: ( \tau \geq 96.5% )</td>
</tr>
<tr>
<td><strong>Thermal Losses</strong></td>
<td>• (&lt;250 \text{ W/m (400 °C)}; &lt;175 \text{ W/m (350 °C)}; &lt;125 \text{ W/m (300 °C)}) in conjunction with SCHOTT Solar’s patented shield design</td>
</tr>
<tr>
<td><strong>Vacuum</strong></td>
<td>• gas pressure ( \leq 10^{-3} \text{ mbar} )</td>
</tr>
<tr>
<td><strong>Operating pressure</strong></td>
<td>• ( \leq 40 \text{ bar (absolute)} )</td>
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SCHOTT PTR®70 Premium Receivers
Best performance with integrated lifetime insurance

The issue:
Efficiency gap during operation time due to degradation of vacuum

In addition to the benchmark characteristics of the SCHOTT PTR®70 Receiver the “Premium Receivers” carry an incorporated solution for a currently unsolved challenge: the “hot tube phenomenon” caused by the decomposition of the heat transfer fluid and accompanying hydrogen permeation into the vacuum of the receivers.

SCHOTT Solar receivers are equipped with sufficient getter material to capture the hydrogen for at least 25 years – but depending on how the quality of the thermo oil is being maintained during plant operation, the saturation of the getter might occur at earlier stages. This would result in a significantly reduced thermal efficiency of the receiver – and a reduced net electricity output of the CSP plant. Until now, receivers suffering from this “hot tube phenomenon” had to be replaced, and the OEM costs associated with these replacements along with the downtime of the power plant reduced the overall plant profitability.

The SCHOTT Solution:
Activation of Noble Gas Capsules

SCHOTT PTR®70 Premium Receivers include a new conceptual design patented by SCHOTT and are equipped with a Noble Gas Capsule to maintain excellent thermal properties over the full operation period. The heat loss of “hot tubes” is typically increased by a factor of ~6 compared to the vacuum. In such a case, the activation of the integrated Noble Gas Capsule can be carried out by the operator within minutes. With immediate success, a short laser pulse drills a hole into the capsule and the noble gas is released into the receiver annulus; thermal losses are reduced almost to the initial value and the temperature of the glass tube cools down accordingly. Without replacing affected receivers and without further reduction of the plant’s profitability, affected solar field loops can remain in operation without interruption.
SCHOTT PTR®70 Receivers are designed for a maximum performance and durability. SCHOTT Solar’s PTR®70 “Premium Receivers” further increase the expected lifetime beyond 25 years and integrate a technical lifetime insurance maximizing the profitability of the plant.

Simulations show that solar fields with activated Noble Gas Capsule receivers yield 10% more electricity output over 40 years of operating lifetime, as compared with conventional receivers which remain in the solar field when turning into hot tubes. Moreover, Noble Gas Capsule solar fields almost reach the output level of solar fields with new replacement receivers. These direct benefits of maximized output and minimized OEM costs reduce risks and increase the overall profitability of the power plant.
The installation of shields is necessary in order to protect the sensitive glass-to-metal seal of the receivers from direct irradiation. Unfortunately they represent a lost opportunity as the covered area of metal endings do not convert any solar radiation into thermal energy – until today. SCHOTT Solar shields convert inactive area into active area!

SCHOTT Solar’s patented shield design with attached reflectors increases the solar field by up to two percent – without any major effort! The reflectors re-direct solar radiation that would have hit the shield on the absorber tube, enlarging the effective absorber length with the reflectors.

The optical gain of the shield reflectors depends significantly on the size of the reflector as well as the incident sunlight angles, the latitude of the plant location, time of day and time of year. The development of the optical gain due to receiver shields during one day follows a specific curve; its detailed characteristics depend on the shield geometry (height-to-length ratio) and the time within one year corresponding to different incident sunlight angles. The optical gains in the summer are small, but in the summer the plant operates at its maximum, often dumping energy to prevent overheating of the heat transfer fluid. In the winter every single ray of sun counts – and here the shield reflectors achieve optical gains of up to 2.0%! SCHOTT Solar offers two types of shields, characterized by the size of their reflectors defined through their height-to-length ratio. The type of shield used is determined by the specific needs of the project.
Less capital expenditure, lower levelized cost of electricity (LCOE)! The optical gain offered by SCHOTT Solar’s patented shield design with reflector discs allows for solar-only power plants to reduce the number of additional collectors necessary for winter operation, which in turn reduces investment and financing needs and costs, as well as lowers the LCOE. For power plants with thermal storage, the optical gain contributes to an increase in annual energy yield and therefore also reduces the LCOE.

<table>
<thead>
<tr>
<th>Reflector type</th>
<th>Height-to-length ratio</th>
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<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>total</td>
<td>0.84 %</td>
</tr>
<tr>
<td>winter</td>
<td>1.38 %</td>
</tr>
<tr>
<td>summer</td>
<td>0.30 %</td>
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</table>

Optical gain during the day as illustrated by three representative days of the year

Optical gain shown against degree of latitude

Your benefit

Optical gain for Almería, Spain