

**TOPSØE
SECONDARY
REFORMING CATALYST
RKS-2-7H**



TOPSØE SECONDARY REFORMING CATALYST RKS-2-7H

In a traditional ammonia plant, secondary reforming involves continuation of the methane reforming reaction that began in the primary reformer, via the introduction of air to the reactor. The combustion of the oxygen in the air produces temperatures in the area of 1250°C (2300°F) which result in further reforming of methane, while the nitrogen is required for the eventual synthesis of ammonia product.

In methanol plants, secondary reforming is performed using pure oxygen, while in some synthesis gas (H₂/CO) plants, natural gas is heated in a fired heater, mixed with steam and oxygen or enriched air, and reformed in a reactor similar to a secondary reformer (autothermal reforming).

Obtaining a long and satisfactory run life at the high operating temperatures in a secondary reformer requires a catalyst with outstanding thermal stability and mechanical integrity. Such features are found in Topsøe's secondary reforming catalyst, RKS-2-7H.

Features of RKS-2-7H

No Heat Shield Required

RKS-2-7H catalyst is based on a magnesia alumina spinel (ceramic

type) carrier with a fusion point in excess of 2000°C (3600°F), well beyond the highest temperatures typically observed in secondary reformers. Consequently, there is no need for a special heat shield material on top of the catalyst bed. RKS-2-7H may be loaded in the entire reactor, topped off by target bricks or alumina lumps, which serve as a hold-down material to prevent agitation of the catalyst by the incoming process gas streams.

Long Catalyst Life

The superior thermal stability of RKS-2-7H catalyst has been well proven in the industry, as plants worldwide have operated the catalyst in excess of 10 years with fully satisfactory performance. Frequently, catalyst unloading only takes place when an inspection of the reactor internals is required, and it is often possible to screen the catalyst and reload the majority of the material into the reactor, where it operates successfully for many more years.

Excellent Resistance to Temperature Excursions

High thermal stability in a secondary reforming catalyst is critical, because of the potential for temperature excursions in the reactor. Mishaps such as

the interruption of process gas flow can result in very high temperatures. One such case is illustrated in Figure 1 below. A malfunctioning burner in this facility's secondary reformer resulted in extremely high localized temperatures which caused the burner tip to melt and fall into the catalyst bed. Despite these high temperatures, which almost certainly exceeded 1500°C, the RKS-2-7H catalyst remained intact. The plant performed a skim of the top layer to remove the burner debris, and the catalyst was put back into service, where it continued to operate fully satisfactorily.

Low Pressure Drop and Reactor Short-loading Potential

RKS-2-7H is a shape-optimized version of Topsøe's original secondary



Figure 1: Melted burner tip with undamaged secondary reforming catalyst RKS-2-7H

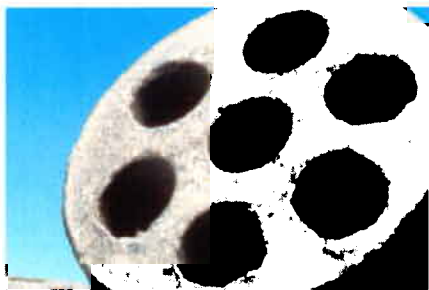
reforming catalyst, RKS-2. It is formed as a cylinder with seven axial holes and dished ends. This shape is unique amongst secondary reforming catalysts and provides a higher surface area and therefore a higher catalyst activity per unit volume than ordinary ring-shaped catalysts, as well as a substantially lower catalyst pressure drop. The high activity permits the short-loading of most reactors while maintaining fully satisfactory performance for the lifetime of the charge. Short-loading of the reactor often improves the performance of the secondary reformer by allowing a more

Designation	RKS-2-7H	RKS-2-7H	RKS-2-7H	RKS-2P-7H
Shape	Cylinders w/7 axial holes	Cylinders w/7 axial holes	Cylinders w/7 axial holes	Cylinders w/7 axial holes
Dimensions: Outer diameter, mm Hole diameter, mm Height, mm	16 (7x)3 11	20 (7x)4 18	30 (7x)6 20	30 (7x)6 20
Chemical composition: NiO, % by weight MgAl ₂ O ₄ , by weight	9 balance	9 balance	9 balance	0.5-1.0 balance
Impurities: S K + Na Si	less than 100 ppm less than 1000 ppm max. 0.1%			

Table 1: Properties of Secondary Reforming Catalysts RKS-2-7H/RKS-2P-7H

uniform mixing of the reactants above the catalyst bed. Short-loading also reduces the initial catalyst costs, and the savings can be substantial.

Table 1 gives the chemical composition of RKS-2-7H. The catalyst is manufactured from very pure raw materials and is fired at a temperature 200-300°C higher than normal operating temperatures, producing a very stable pore system. The catalyst will not shrink during operation, not even in the top layer. The catalyst contains less than 0.1 wt% silica, eliminating the potential of silica migration and downstream deposition. Likewise, the concentrations of sulphur and chlorine are virtually nil, thus avoiding poisoning of downstream catalysts.



RKS-2-7H, 20 x 18 mm

Catalyst Operation

Activation of RKS-2-7H

RKS-2-7H may be started up using any normal reformer system start-up procedure, such as preheating in circulating nitrogen or heating of the primary reformer in stagnant atmosphere followed by exposure to condensing steam. Reduction of the catalyst will occur following the introduction of feed gas or hydrogen to the primary reformer; no special actions are required. Air is generally introduced to the secondary reformer once the primary reformer outlet temperature has reached 700°C (1300°F).

Normal Operation of RKS-2-7H Catalyst

In most ammonia plants, the secondary reformer operation is adjusted to achieve the required stoichiometric ratio of nitrogen and hydrogen necessary for ammonia production. Typical catalyst bed inlet temperature is about 1250°C (2300°F) in a secondary reformer, and up to 1400°C (2550°F) in autothermal reformers.

Shut-down of RKS-2-7H Catalyst

The shut-down of the secondary reformer is normally dependent on the process constraints of the primary reformer shut-down. The catalyst may be maintained in the reduced state during the down period, or may be oxidized by steam or steam-air injection during the shut-down procedure. If access to the reactor is required during the down-period, oxidation of the catalyst is recommended.

Catalyst Poisons

The high operating temperatures in the secondary reformer make the catalyst resistant to poisoning. Consequently, poisoning of the secondary reforming catalyst is rarely of concern in the industry.

Autothermal Reformers: RKS-2P-7H Catalyst

Because autothermal reformers normally operate at higher temperatures than air-blown secondary reformers, they are often subject to deposition of foreign material (usually evaporated calcium aluminate from transfer lines or refractory material) onto the catalyst, causing an increase in pressure drop. In order to minimize this problem, Topsoe offers a special reforming catalyst, RKS-2P-7H.

RKS-2P-7H is a larger size catalyst with a lower nickel content than RKS-2-7H (see Table 1). These features combine to give the catalyst a relatively low reforming activity compared to RKS-2-7H, which retards the deposition of the foreign matter onto the top of the catalyst. We recommend that a 30-centimeter (one-foot) layer of RKS-2P-7H catalyst be loaded on top of RKS-2-7H in autothermal reformers or any secondary reformer experiencing frequent pressure drop build-up caused by the deposition of foreign matter onto the catalyst.

Technical Assistance

Detailed written procedures for catalyst loading, start-up, operation and shut-down are provided upon order of Topsoe secondary reforming catalyst. Topsoe also offers ongoing service in the form of performance checks and trouble-shooting, if required, throughout the catalyst lifetime.

Packing

RKS-2-7H and RKS-2P-7H catalysts are shipped in polyethylene-lined drums, each containing 100 kg (220 lbs) of catalyst. As long as they are kept sealed and sheltered from the weather, the drums may be stored for many years before use.

**Topsoe Burner Technology
Optimal Process Gas Mixing**

A critical parameter for satisfactory secondary or autothermal reformer performance is efficient mixing of the process gas and air or oxygen. Uneven mixing can result in large temperature variations above and into the catalyst bed, causing variations in the degree of methane reforming achieved and often yielding a poor overall approach to reforming equilibrium, even with a highly active secondary reforming catalyst. The efficiency of gas mixing is primarily a function of the burner design. In addition to causing inefficient gas mixing, a poorly designed burner can damage the vessel walls, refractory or even the burner itself, when there is impingement of hot gas and/or flame in these areas.

Haldor Topsoe A/S has done extensive research to optimize burner design to eliminate the problems described above, and offers two special burners. For air-blown secondary reformers in ammonia plants, we offer a ring-type burner with a specialized nozzle shape that eliminates back-flow of hot gas onto the nozzles themselves, thereby reducing mechanical wear and damage to the burner. Figure 2 illustrates a Computational Fluid Dynamics (CFD) model of a conventional burner nozzle and the Topsoe design. The Topsoe nozzle does not experience impingement of hot gas back-flow and therefore is able to operate for much longer periods without need for repair or replacement.

In autothermal and oxygen-blown secondary reformers, the enriched air or oxygen is typically supplied at high pressures, thereby allowing for the possibility of a higher pressure drop across the reactor burner. For these services, Topsoe offers the CTS burner.

Figure 3 illustrates CFD profiles of a CTS burner, illustrating the maintenance of low temperatures at the vessel walls and an efficient gas circulation pattern, thereby producing optimal mixing and minimizing reactor damage.

For more information on Topsoe burner technology and modelling capabilities, please contact your Topsoe representative.

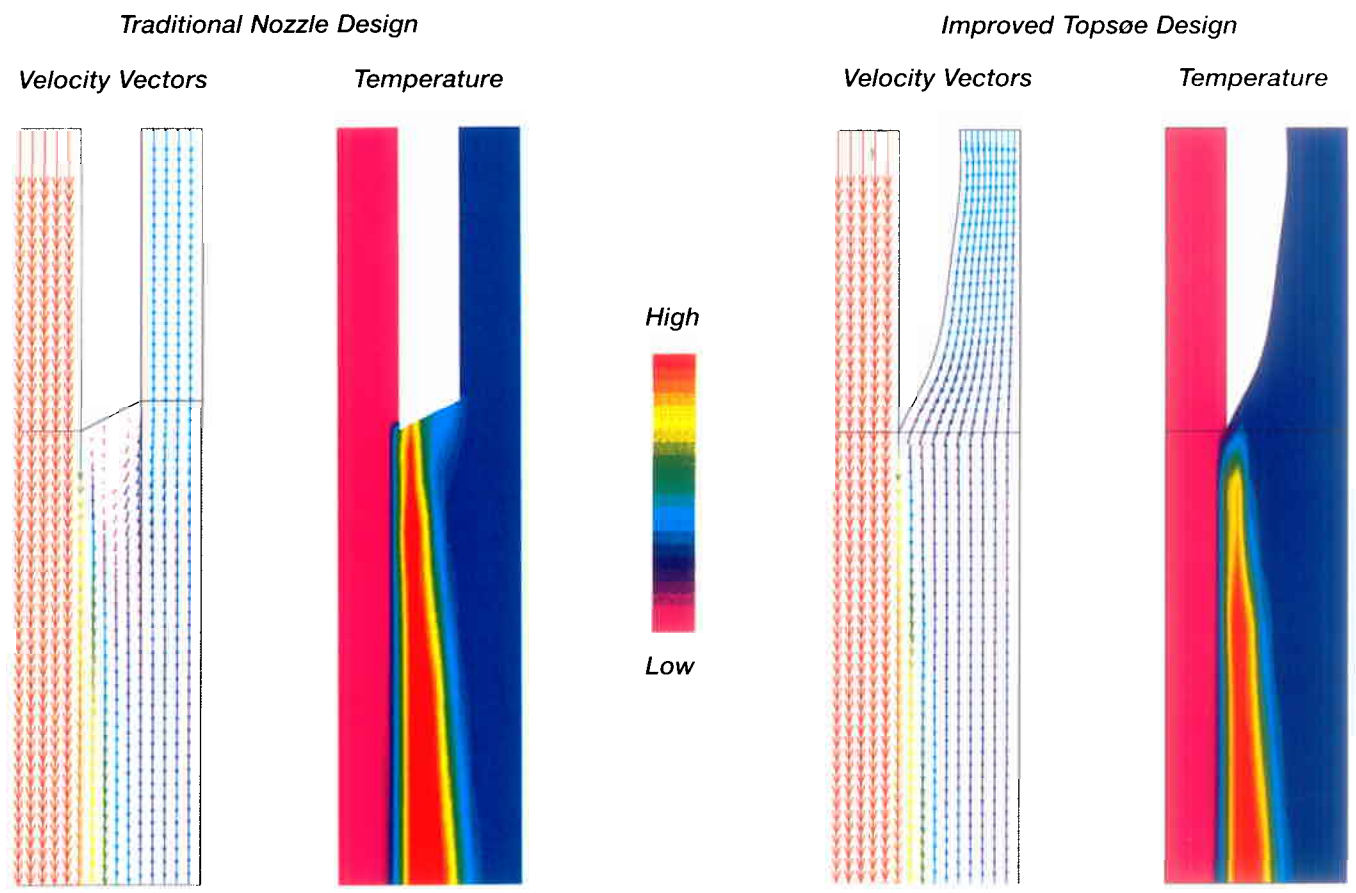


Figure 2: CFD Comparison of Traditional Nozzle and Topsoe Design



Topsøe CTS Burner for an oxygen-blown autothermal reformer

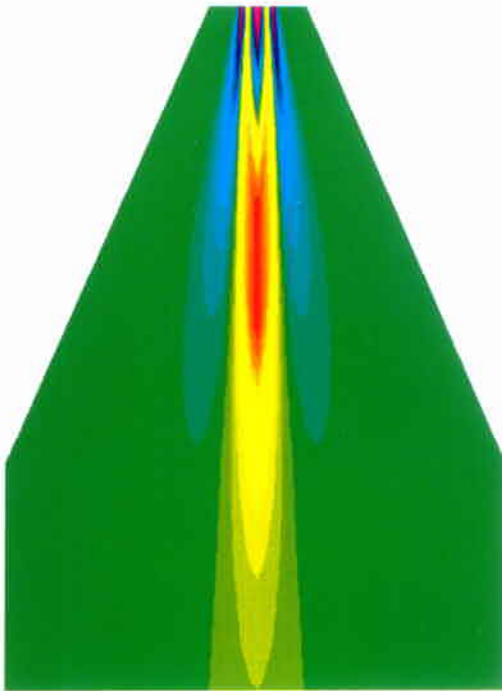


Figure 3: CFD simulation of the temperature distribution in an autothermal reformer using a Topsøe CTS burner.

