



Adsorbent Solutions for Natural Gas Treatment

Customized for better performance

 **BASF**

We create chemistry

BASF Solutions for Natural Gas Treatment

BASF offers a broad range of technical solutions for natural gas treatment based on the appropriate absorbent (solvent), adsorbent, and catalyst. BASF supports its customers in the design and operation of gas treatment plants by providing process design and engineering support and a range of technical services such as debottlenecking and process optimization, troubleshooting and revamps, analytics, and training.

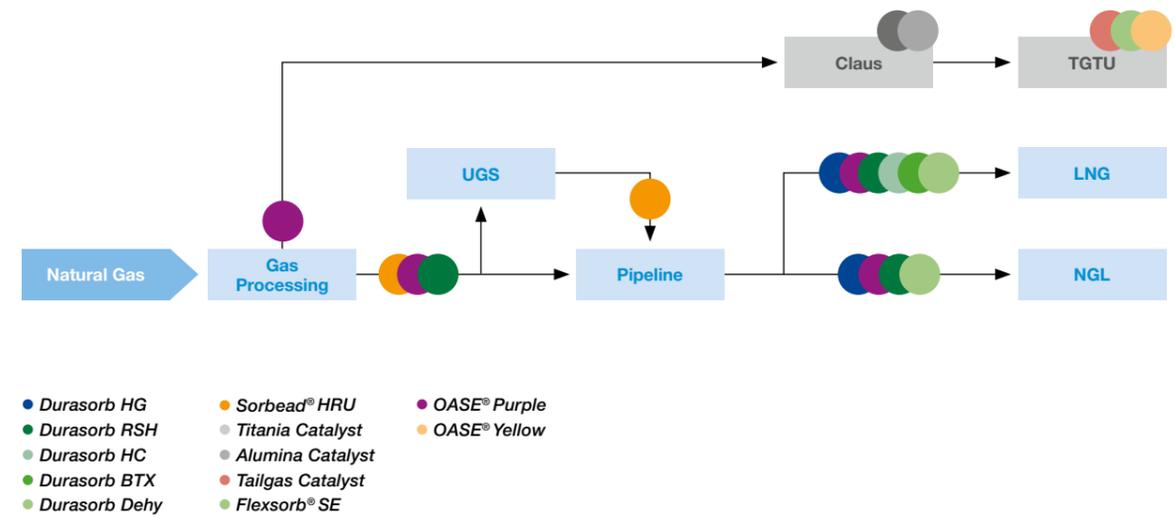
Table 1 Technology and Products Portfolio for Natural Gas Treatment

| Upstream | | |
|-------------------------------|---|---|
| Process/Application | Contaminants | Product/Technology |
| Pipeline Dewpoint Control | H ₂ O (-10°C to -60°C dewpoint) C6+ (CCT of 5°C to -20°C) | Sorbead® Dehy Sorbead® HRU |
| Underground Storage (UGS) | H ₂ O Hydrocarbons | Sorbead® Dehy Sorbead® HRU |
| Mercaptans Removal | RSH | Durasorb RSH |
| Membrane Protection | C6+, BTX, H ₂ O | Durasorb HRU/Dehy |
| Midstream | | |
| Process/Application | Contaminants | Product/Technology |
| Mercury Removal | Mercury | Durasorb HG |
| Mercaptans Removal | RSH | Durasorb RSH |
| Acid Gas Removal (Sweetening) | H ₂ S, CO ₂ (bulk), COS | OASE® yellow OASE® purple |
| | H ₂ S, CO ₂ (trace) | Durasorb |
| BTX Removal | Benzene, Toluene, Xylene | Durasorb BTX |
| Heavy Hydrocarbon Removal | C6+ | Durasorb HRU |
| Dehydration | H ₂ O (-110°C dewpoint) | Durasorb Dehy |
| Emissions Control | | |
| Process/Application | Contaminants | Product/Technology |
| Sulfur Recovery | H ₂ S, COS, CS ₂ | BASF Claus & Tail Gas Catalysts OASE® yellow |

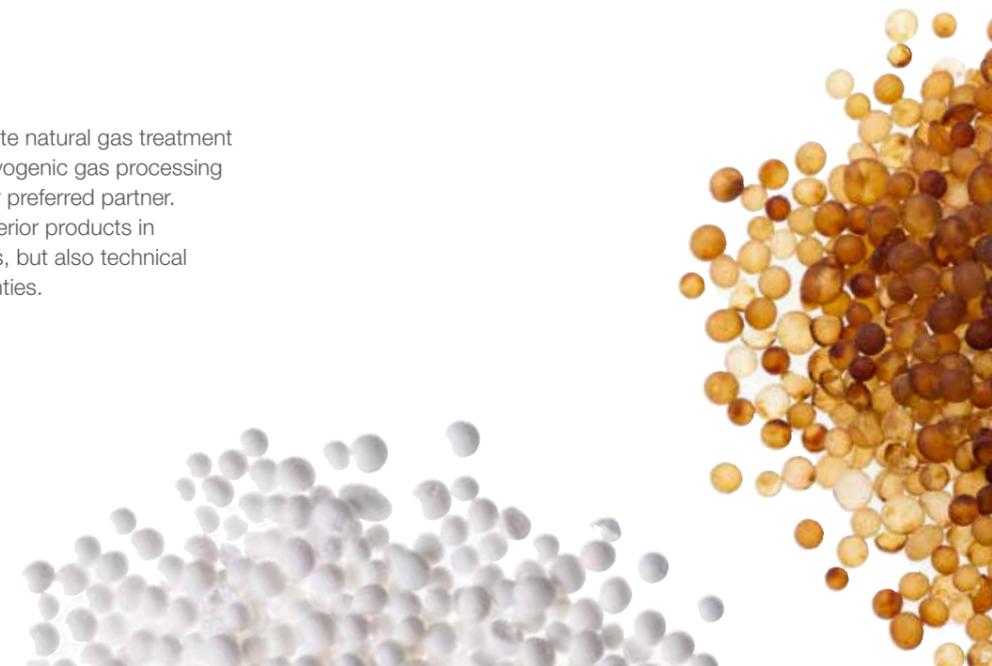
OASE®: Gas Treating Excellence
 Sorbead®: alumino-silica gel adsorbent
 Durasorb™: Customer tailored products for natural gas treatment
 CCT: cricondentherm
 BTX: Benzene, Toluene, Xylenes



Figure 1 BASF Products for Natural Gas Treatment



BASF products serve the complete natural gas treatment value chain. From wellhead to cryogenic gas processing to emission control, BASF is your preferred partner. Not only does BASF provide superior products in customer-tailored, expert designs, but also technical services and performance warranties.



BASF Upstream Solutions

Hydrocarbon and Water Dewpoint Control

Natural gas streams contain species of heavy hydrocarbons that may condense on pressure or temperature decrease. These heavy hydrocarbons can cause plugging of downstream valves and pipes or lead to potential malperformance of other equipment (e.g. membranes).

The temperature at which condensation of hydrocarbons occur is called the hydrocarbon dewpoint. Sorbead® HRU technology prevents hydrocarbon condensation and offers other advantages such as simultaneous water dewpoint control, minimal differential pressure and high operational flexibility (wide range of dewpoint temperatures and feed gas flows). Removed hydrocarbons end up in the recycle condensate for further use as fuel or downstream operations (petrochemical, refining). Water in natural gas can form hydrates which can result in blockage of pipes and valves. Sorbead® Dehy technology reliably provides water dewpoints over a broad range down to -60 °C at operating pressure.

Underground Storage (UGS)

Underground storage facilities use salt caverns and partially depleted oil or gas fields. They provide a balance between the supply of natural gas by the producer and the demand pattern by the final customer. While natural gas is stored underground it picks up water and/or heavy hydrocarbons which needs to be removed to meet transmission specification. Sorbead® Dehy and Sorbead® HRU technologies provide ideal solutions for water and hydrocarbon dewpointing respectively since both technologies are suited for intermittent operation, very rapid response times. Sorbead® technology requires minimal maintenance and can be operated remotely.

Mercaptans Removal

Mercaptans pose operational challenges for acid gas removal, sulfur removal, and LNG units. Durasorb™ RSH technology removes mercaptans to pipeline specifications.

Membrane Protection

Some sour natural gas streams contain CO₂ at levels that make the combination of membrane technology and subsequent solvent-based gas treatment economic (hybrid system). Membranes are sensitive to condensed hydrocarbons and BTX on the cold surfaces of the membrane. Durasorb technology removes BTX and adjusts hydrocarbon & water dewpoint to the required level leading to extended life of the membrane system.

BASF Midstream Solutions

Supply of natural gas in form of Liquefied Natural Gas (LNG) has become an important way to transport gas to the point of demand. LNG is produced by cooling natural gas to less than minus 160°C. To meet LNG product specification and ensure trouble-free operation of the cold section of the plant, impurities in natural gas need to be removed prior to cryogenic processing. These impurities are varied and dependent on geographical location. BASF offers the broadest portfolio of products and technologies to remove these impurities. OASE® purple technology removes CO₂, H₂S and COS, Durasorb HG removes mercury, Durasorb HRU technology purifies the gas from heavy hydrocarbons and BTX, and Durasorb Dehy technology addresses the removal of water and trace quantities of CO₂ and H₂S. All technologies can be designed for operation on tilting or rolling surfaces and are therefore suitable for offshore and floating applications.

Mercury Removal

Mercury is a contaminant in natural gas that needs to be removed early in the gas treatment process. Durasorb HG removes mercury in natural gas streams to levels below 0.01 µg/Nm³, protecting downstream piping and machinery and providing a natural gas stream that complies with environmental regulations. Durasorb HG is a mechanically robust adsorbent with fast kinetics for process efficiency.

Mercaptans Removal

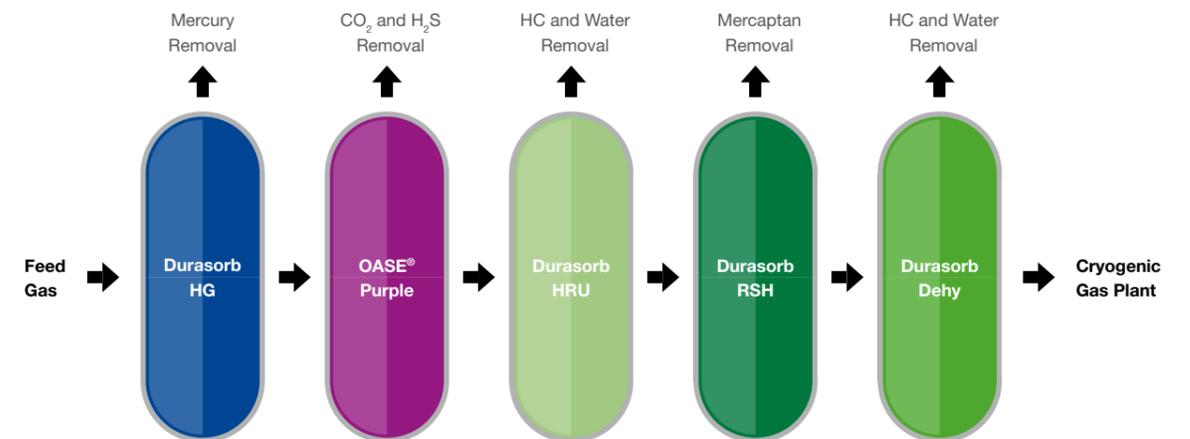
Mercaptans pose operational challenges for acid gas removal, sulfur removal, and LNG units. Durasorb RSH technology removes mercaptans to cryogenic specifications.

Acid Gas Removal (Sweetening)

Utilized in the removal of high concentrations of acid gases such as carbon dioxide (CO₂), hydrogen sulfide (H₂S) and carbonyl sulfide (COS) OASE® technologies have proven their versatility and reliability in natural gas applications. BASF's solutions portfolio ranges from selective removal of sulfur components for sales gas (OASE® yellow) to deep removal of acid gases for LNG applications (OASE® purple). Our customers appreciate this highly efficient and environmentally friendly technology for its flexibility and low capital expenditure (CAPEX).

Additionally, the low energy demand of the process combined with the non-corrosive nature of the solvent keeps operating and maintenance costs (OPEX) low. The process also provides a high level of gas purity and product gas recovery while keeping solvent losses to a minimum. For the removal of trace amounts of H₂S and CO₂ BASF offers a range of Durasorb Molecular Sieve adsorbents that are employed in fixed bed adsorbers which are thermally regenerated.

Figure 2 BASF Product Portfolio for LNG Pre-Treatment.



BASF offers the full package of customized, high-performance technologies for the treatment of natural gas for liquefaction. Durasorb adsorbents remove mercury, mercaptans, hydrocarbons, and water. OASE® technology is employed for the removal of acid gas

Heavy Hydrocarbon Removal

Heavy hydrocarbons (HHC), defined as C6+ chain length, and benzene, toluene and xylenes (BTX) can be present in natural gas and can lead to operational challenges if not removed early in the process of a gas treatment plant. In LNG production HHC and BTX need to be removed to prevent freezing in the cryogenic part of the process. Durasorb HRU and BTX technology can be tailored to remove these contaminants in the gas pretreatment processes, reducing the risk of downstream dropout and equipment freezing.

Dehydration

BASF Durasorb Dehy technology is used (down to -110 °C) for cryogenic processing in liquefaction and NGL recovery plants. Combination bed designs, using Durasorb HD water resistant adsorbent and Durasorb HR specialized molecular sieve, leverage the complementary nature of the two products to provide a more efficient bed leading to reduced OPEX and longer lifetime.



Emissions Control

Sulfur Recovery

Sulfur Recovery Units (SRU) convert unwanted hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) to elemental sulfur. This is done most often using the Claus process.

SRUs are essential parts of natural gas plants, refineries and smelters, where large amounts of H_2S is produced. The quality of the Claus Catalyst is critical for maximizing

the performance of the SRU. BASF has the most extensive line of Claus Catalysts in the industry. In addition to non-promoted and promoted activated alumina, we offer titania catalysts along with an alumina/titania composite catalyst. Our product portfolio also includes a CoMo catalysts and OASE® yellow absorbent for SRU Tail Gas Treatment Unit (TGTU) applications.



Benefits of BASF Products

Sorbead®

Sorbead® is a specialty alumino-silica gel adsorbent with a pore structure tailored to the adsorption of hydrocarbons such as C6+, BTX, and mercaptans. Advantages include high water adsorption capacity, low water desorption energy and high mechanical strength resulting in low energy demand and extended service life (low OPEX).

Sorbead® WS is the only liquid water-stable, high moisture capacity alumino-silica gel and therefore particularly suited as guard bed for all upstream natural gas applications. In fact, Sorbead® WS contributes to reducing the water load significantly resulting in improved margins for the subsequent adsorbent bed. Furthermore, Sorbead® WS is highly acid-resistant and therefore the preferred guard bed or adsorbent for sour gas treatment.

Durasorb™

Durasorb is a new family of adsorption solutions based on Sorbead® technology. Durasorb Technology combines the recognized advantages of Sorbead® with BASF natural gas reflux resistant grade high performance Molecular Sieves to achieve cryogenic dewpoints with a robust, long-lasting bed lifetime. It provides gas processing plant operators, especially Liquefied Natural Gas (LNG) plants, with more reliable severe dehydration capabilities.

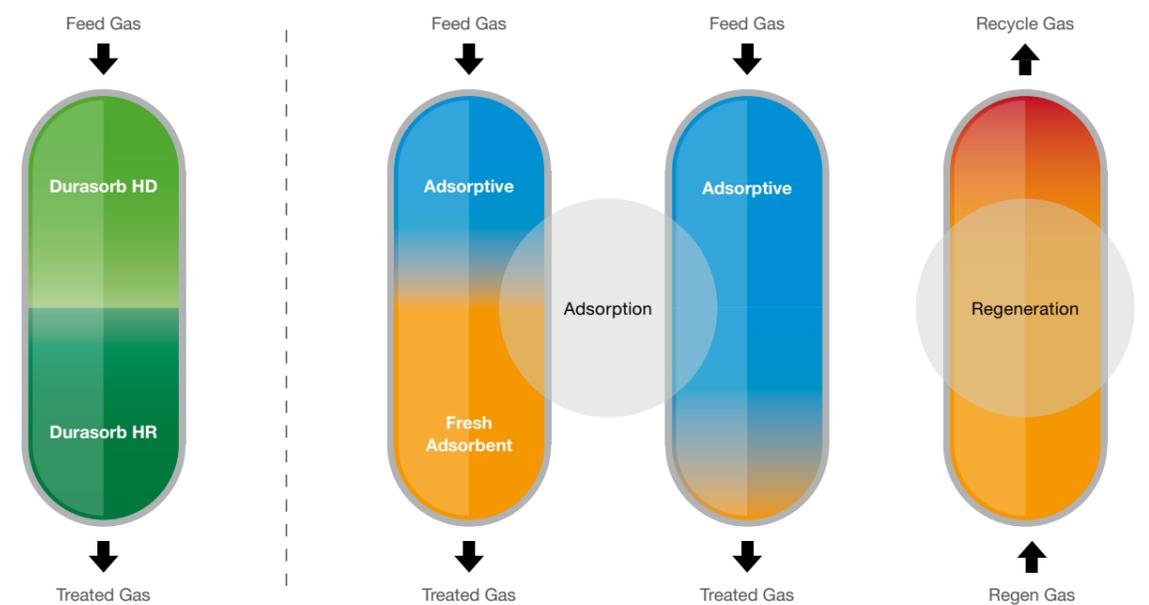
The new technology uses proprietary design software to calculate the performance of the adsorbents in all parts of the dehydration vessel and maximize the overall performance and life of the bed.

Process Design

Sorbead® and Durasorb designs are composed of a multi-tower adsorber design for continuous operation that, compared to other natural gas dehydration processes, offers advantages such as high operational flexibility (e.g. wide dewpoint and flow range at minimal pressure drop, intermittent operation), low maintenance (no rotating equipment), ease of operation including the possibility of remote operation, and zero-emissions of volatile drying agent. Furthermore, expertly designed Sorbead® and Durasorb beds provide significant CAPEX savings compared to low temperature technologies that require hydrate inhibition or dehydration.

The technology is adjusted for specific adsorbent mass and cycle time such that the desired contaminant is preferably removed. The principle of operation is shown below; while one or more tower is in adsorption mode, one or two towers are being regenerated, which involves a first step of heating followed by a cooling step. Feed gas is commonly used as regeneration gas which is then recycled to the tower in adsorption.

Figure 3 Three Tower Dynamic Adsorption Process with Two Vessels in Staggered Adsorption Mode at All Times



Americas

BASF Corporation
25 Middlesex/Essex Turnpike
Iselin, New Jersey 08830, USA
Tel: +1-732-205-5000
Fax: +1-732-205-5687
Email: catalysts-america@basf.com

Asia Pacific

BASF (China) Company Limited
300 Jiang Xin Sha Road,
Pudong, Shanghai 200137
P.R. China
Tel: +86-21-2039 2549
Fax: +86-21-2039 4800-2549
Email: catalysts-asia@basf.com

Europe, Middle East, Africa

BASF De Meern BV Catalysts
The Netherlands
Tel: +31-30-666 9437
Email: catalysts-europe@basf.com

About Us

BASF's Catalysts division is the world's leading supplier of environmental and process catalysts. The group offers exceptional expertise in the development of technologies that protect the air we breathe, produce the fuels that power our world and ensure efficient production of a wide variety of chemicals, plastics and other products, including advanced battery materials. By leveraging our industry-leading R&D platforms, passion for innovation and deep knowledge of precious and base metals, BASF's Catalysts division develops unique, proprietary solutions that drive customer success.

BASF – We create chemistry

www.catalysts.basf.com/adsorbents
www.oase.basf.com



OASE®, Durasorb and Sorbead® are trademarks of BASF.

Although all statements and information in this publication are believed to be accurate and reliable, they are presented gratis and for guidance only, and risks and liability for results obtained by use of the products or application of the suggestions described are assumed by the user. NO WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE MADE REGARDING PRODUCTS DESCRIBED OR DESIGNS, DATA OR INFORMATION SET FORTH. Statements or suggestions concerning possible use of the products are made without representation or warranty that any such use is free of patent infringement and are not recommendations to infringe any patent. The user should not assume that toxicity data and safety measures are indicated or that other measures may not be required. © 2015 BASF

