

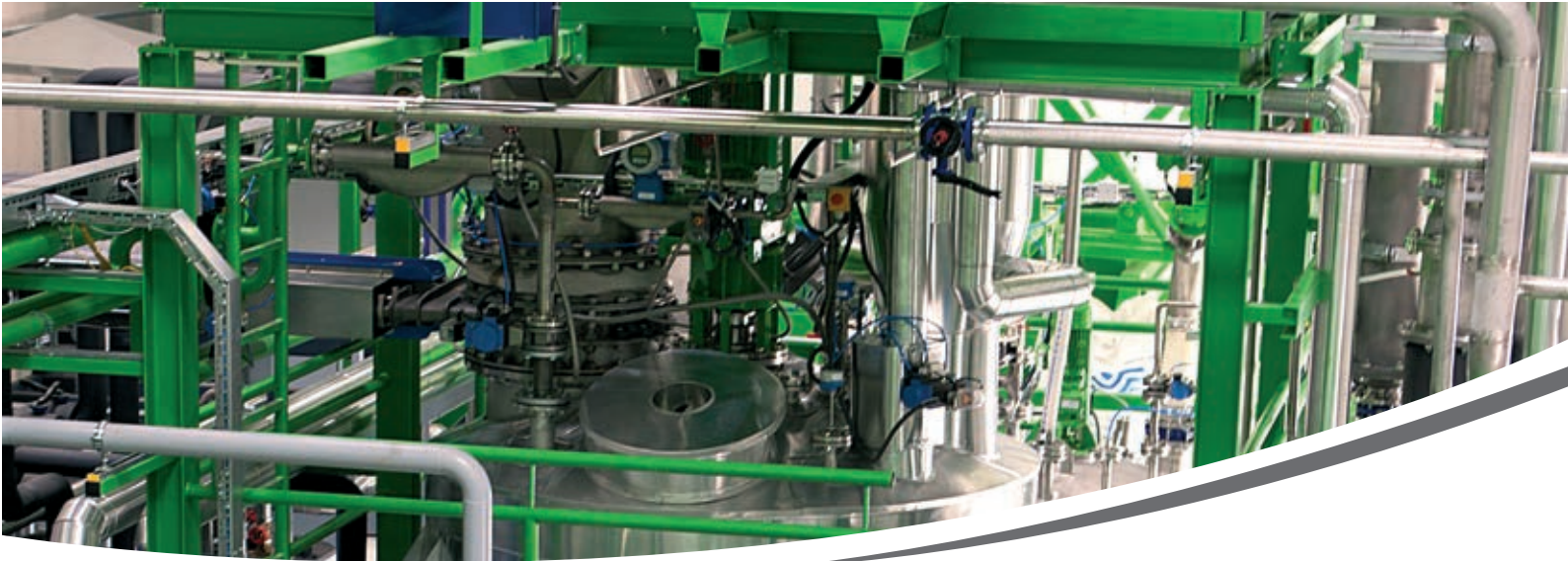


Your specialist for PUR

recycling, blending, storing







## The company

H&S Anlagentechnik develops equipment and processing technologies for the efficient, flexible, reliable and environmentally friendly storage, metering, mixing and formulation of polyurethanes as well as equipment for the chemical recycling of polyurethane residues and generating polyester polyol based on PET and PA. One of our main advantages is the combination of chemical and technical production expertise. We have enjoyed a reputation as a high-performing and reliable partner for the polyurethane manufacturing industry for in excess of more than 25 years.

We are specialized in the development of individual solutions to reflect the fact that our customers manufacture a variety of products incorporating a wide range of demands. Each project is planned and implemented in line with specific customer requirements.

It goes without saying that our equipment complies with the relevant statutory provision at all times.

Our engineers are trained to the highest level and bring a wealth of technical know-how and many years of international experience to the table. Modern production facilities and a worldwide network of distribution partners guarantee the high quality of our products and ensure that our customers receive attentive on-site service. We have successfully completed over 300 projects thus far. Our export quota of 70% also makes us a leading market supplier internationally.





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The demands made on companies are growing. Globalising markets, increasing competition, more discerning consumers and changing legal regulations all require innovative solutions and a particular performance capacity. This is why we are developing the opportunities to facilitate efficient production, a high degree of flexibility and speed, sustainable use of natural resources and high quality product manufacture.

For our customers, this means that H&S Anlagentechnik provides specific added value and realises significant advantages over the competition – now and in the future.

## 1. Reactors

Our reactors for the recycling of polyurethanes (rigid and soft foams) as well as generating polyester polyols based on PET and PA bring a significant reduction in the raw material costs for our customers and facilitate the sustainable and environmentally friendly use of natural resources. The outstanding quality of the recovered polyol properties also means that further processing is easily possible.

## 2. Blending Stations

Our mixing, metering and formulation systems make our customers more independent of fluctuating raw materials markets and increase the flexibility of production. Closed cycles also minimise the risk to humans and nature.

## 3. Tank farms

Our tank farms guarantee the storage of raw materials under stable and controlled conditions. This facilitates efficient procurement and avoids unnecessary costs caused by residual amounts and disposal.

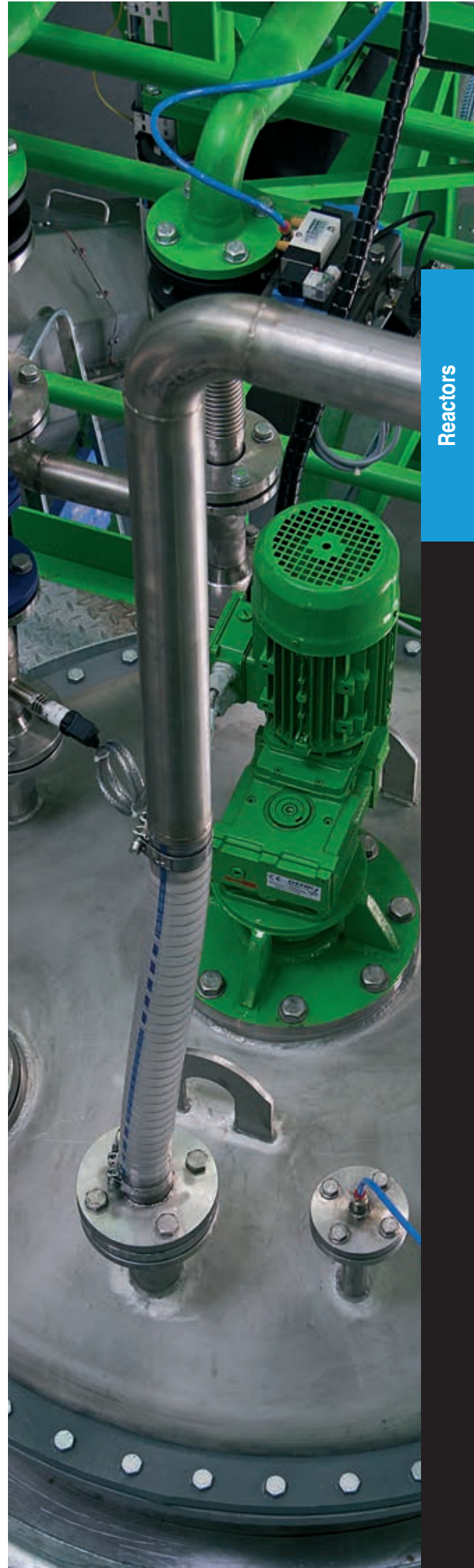


## Reactors

H&S Anlagentechnik has developed an innovative technology and reactor installations for the chemical conversion of flexible and rigid polyurethane foam residues into polyol. The technologies enable to produce high-quality recovered polyols on a suitable production scale.

Polyurethane foam manufacturers of both rigid or flexible types are showing a lot of interest in recycling technology. For flexible foam, this is because the methods previously used, such as rebound foam for carpet underlay and sports mats, are no longer efficient. Prices for flexible foam scrap has being decreased permanently.

Chemical recycling is a more efficient way to convert residues. Another factor is that polyol prices are rising permanently. Moreover, the 'green' aspect of recycling is increasingly important, as everyone is pushed to decrease CO2 emissions. Recycling is also one of the ways to cut greenhouse gas emissions and a closed production loop is also a highly sustainable route.



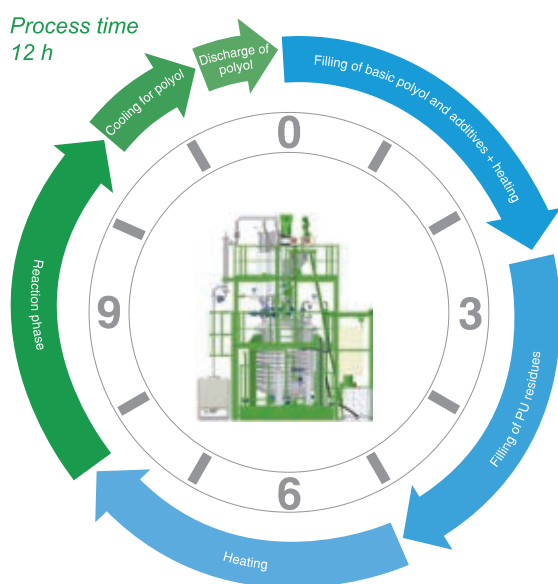
Reactors

# Recycling reactors for flexible PU foam residues

## Technology

H&S technology for flexible PU foam recycling is based on optimized acidolysis method where PU residues are being dissolved in a mixture of carboxylic acids and basic polyol. In comparison to previous conversion methods, polyols generated by H&S technology have good reactivity and do not contain primary aromatic amines (methylene and toluene diamine) which are hazardous and not acceptable in bedding and upholstery foams.

## Process sequence and duration



## Example recipe

Raw Materials	%
PU foam industrial waste	42
Basic Polyol	44
Acids	12
Catalysts	2

## Properties of the recovered polyol (based on conventional foam)

Hydroxyl number	48 ± 4 mg KOH/g
Acid number	< 1,1 mg KOH/g
Amine number	< 7 mg KOH/g
Viscosity	4.000 - 7.500 mPas
Appearance	viscous liquid of light brown to dark brown color - depending on the color of the foam residues

**No primary aromatic amines (no TDA or MDA)!**

## Raw materials required for the process

### • Flexible PU foam residues

Clean shredded residues from slabstock production (industrial waste):

- The residues must be free from contaminations of other polymers, paper or metals.
- The residues should be separated in case of essential chemical differences, for example MDI and TDI foam, conventional and HR foams, etc.

### • Basic polyether polyol for flexible foam

Molar mass: 2.000 – 6.000 g/Mol

Viscosity: 600 – 3.000 mPas

Hydroxyl number: 36 – 56 mgKOH/g

Water content: < 0,2 %

### • Carboxylic acids

2 dicarboxylic acids

### • Catalyst

### Recovered polyol can substitute

- up to 25% of conventional polyol for production of bedding and furniture PU foam
- higher percentage for technical foams

All parameters like compression set, hardness, resilience, support factor, tensile strength and elongation at break are in the range of the control samples.

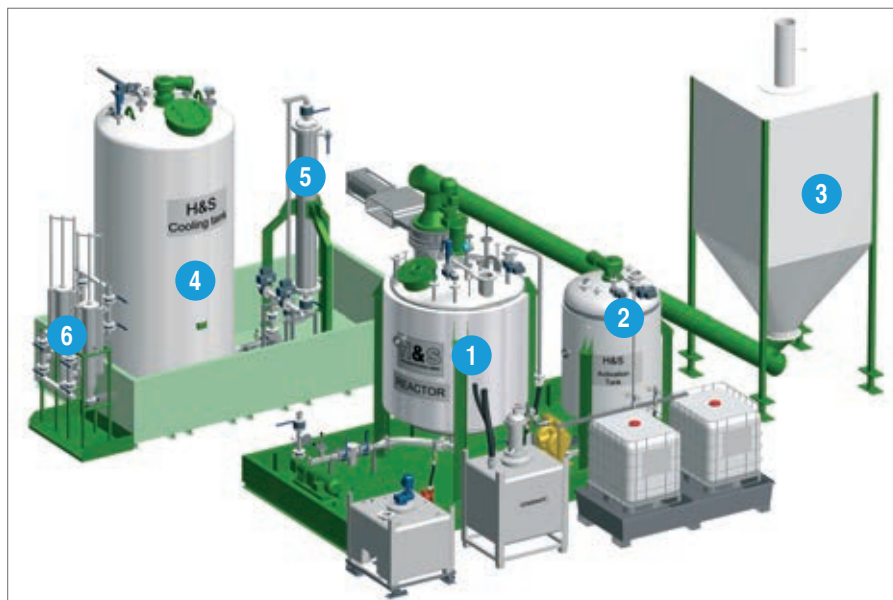
without any influence on the physical and mechanical properties of the PU foam.

Properties of the conventional PU foam produced with 20% recovered polyol on a continuous slabstock line (example)

	Foam density 23 kg/m <sup>3</sup>		Foam density 40 kg/m <sup>3</sup>	
	Master sample (foam without recovered polyol)	Foam with 20% recovered polyol	Master sample (foam without recovered polyol)	Foam with 20% recovered polyol
Resilience, %	42,6	44,3	47,2	48,7
Hardness, [N]	148,75	146,68	167,3	165,46
Support factor	2,2	2,3	2,3	2,2
Compression set (50%)	2,3	2,4	1,88	1,91
Tensile strength, [kPa]	156	152	158	157
Elongation at break, %	241	238	214	214

The costs to manufacture recovered polyol are 25-30% percent lower than the market price of the original basic polyether polyol.

### Reactor and peripheral equipment core unit



1. Reactor
2. Activation tank
3. Silo and feeding System for PU residues
4. Cooling tank
5. Heat exchanger
6. Filtration system

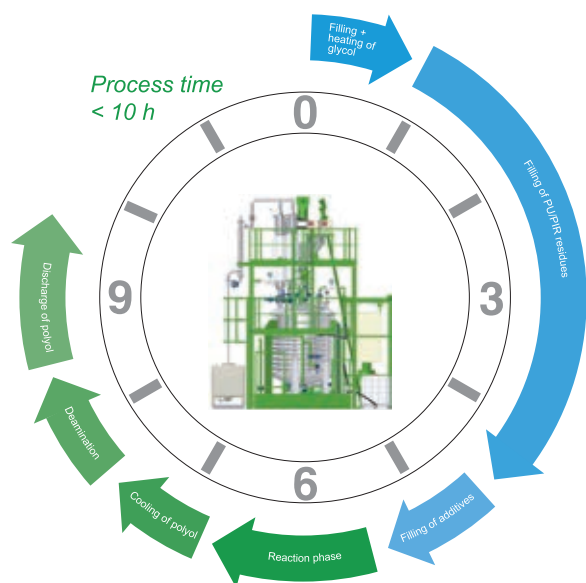
Flexible foam reactors can be supplied with batch capacity from 1t to 5t.

# Recycling reactors for rigid PU foam residues

## Technology

H&S technology for rigid PU foam recycling is based on the glycolysis method where PU residues are being dissolved in a mixture of glycol and catalysts. The highlight of H&S method is that in comparison to previously known glycolysis technologies recovered polyols do not contain hazardous primary aromatic amines which is being achieved through a deamination phase.

## Process sequence and duration



## Raw materials required for the process

### • PU/PIR residues

Grind residues from rigid PU/PIR foam production (insulating panels, shells, blocks etc.). Residues might contain paper, aluminum or fiber glass in the acceptable range. Often the residues should be purified/separated prior to the processing. H&S offers solutions for separation of the PU/PIR foam particles from facers. The remaining percentage of the impurities is being removed from the recycling polyol by means of the filtration.

### • Diethylene glycol

is an organic compound. DEG is widely used in production of unsaturated polyester resins, plasticizers, acrylate and methacrylate resins and urethanes.

### • Catalyst, additives

## Example recipe

Raw Materials	%
PU foam industrial waste	44
DEG	50
Catalysts, additives	6

## Properties of the recovered polyol

Hydroxyl number	350 - 600 mg KOH/g
Acid number	3 - 15 mg KOH/g
Amine number	20 - 40 mg KOH/g
Viscosity	2.000 – 8.000 mPas
Appearance	viscous liquid of dark-brown color

## Recovered polyol can substitute

- up to 30% of the basic polyol

without any influence on the physical and mechanical properties of the PU foam.

In spite of that OH number of recovered polyol is higher than the OH number of the original basic polyol it is not necessary to increase the isocyanate index in the formulation when adding recovered polyol. It can be explained by the fact that polyols based on H&S technology already contain parts of polyisocyanurate and polyurethane molecules originating from PU foam. In some cases it is even possible to reduce the isocyanate index.



The manufacturing costs of the recycled polyol are approximately 30% lower than the market price of the original polyol.

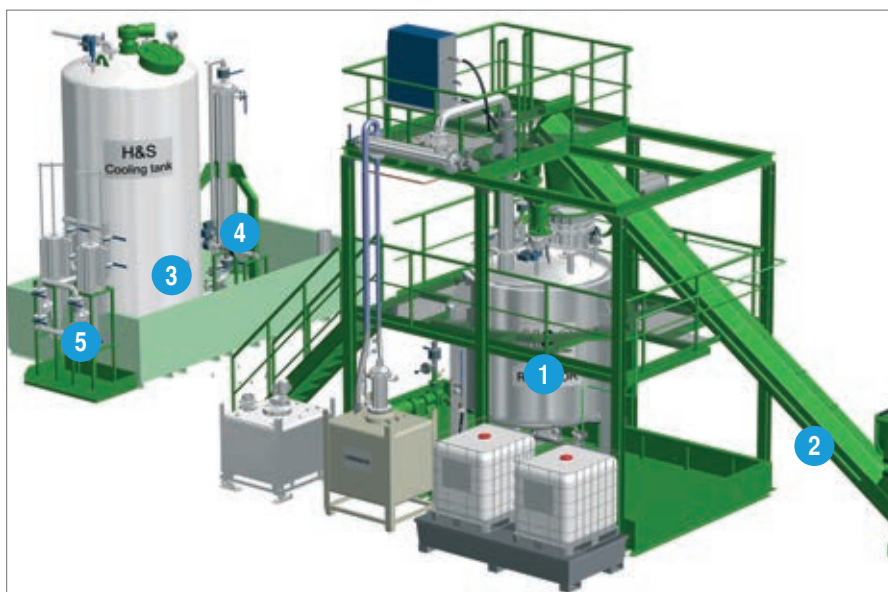
The physical and mechanical properties of the PU/PIR foam produced with recovered polyol are comparable with reference samples manufactured without recycled polyol.

Physical and mechanical properties of the rigid PU foam in comparison to original foam produced on a continuous lamination line (example)

	Master sample (original PU foam)	PU foam with recycled polyol
Percentage of the recycled polyol used (%)	0	20
Density (kg/m <sup>3</sup> )	29	29
Compression (%)	250	246
Counter rise strength (kg/m <sup>3</sup> )	90	89
Lambda coefficient	0,0230	0,0225
Isocyanate index	260	230



#### Reactor and peripheral equipment core unit



1. Reactor
2. Feeding system for  
PU residues
3. Cooling tank
4. Heat exchanger
5. Filtration system

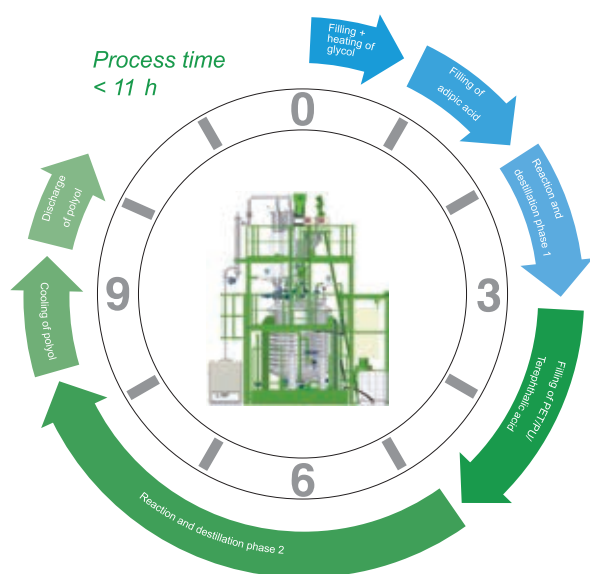
Rigid foam reactors can be supplied with batch capacity from 1t to 5t.

# Polyester polyol reactors (PET/PA)

## Polyol synthesis technology

H&S technology for generating aromatic polyester polyols (APP) from polyethylene terephthalate (PET) as well as phthalic acid anhydride (PA) is based on the glycolysis method.

## Process sequence and duration (polyol generating based on PET)



## Raw materials required for the processes

### • Polyethylene terephthalate (PET)

- flakes from PET bottles
- preforms out of specification
- dust and granulate (preforms production waste)
- fibers

### • Phthalic acid anhydride (PA)

is an organic compound. It is a colorless solid. PA is widely used for the large-scale production of plasticizers for plastics, polyester and alkyd resins.

### • Adipic acid

is the organic compound, dicarboxylic acid. It is used mainly for the production of nylon, plasticizers for PVC as well as polyamide fibres and resins. Significant amount is used in the food industry as a flavorant and gelling acid.

### • Diethylene glycol

is an organic compound. DEG is used in production of unsaturated polyester resins, plasticizers, acrylate and methacrylate resins and urethanes.

### • Monoethylene glycol

is an organic compound. It is widely used for manufacturing of polyester resins (PET) as well as automotive antifreezes and coolants.

### • Glycerol

belongs to the alcohol family of organic compounds. It is widely used in manufacturing of coating resins, softening agents and plasticizers as well as in pharmaceutical formulations.

### • Catalysts



## PET and PA polyols properties

**PET based polyols** are aromatic polyester polyol for application in rigid PU foam.

Hydroxyl number	150 - 550 mg KOH/g
Acid number	<1,0 mg KOH/g
Aromatic content	25 - 42%
Viscosity (25 °C)	1.500 – 20.000 mPas
Appearance	viscous transparent liquid from colorless to light-brown color.

### Example recipe for generating PET polyol

Raw Materials	%
PET	40
DEG	40
Adipic acid	15
3 functional glycol	5
Catalysts	in ppm range

**PA based polyols** are aromatic polyester polyol for application in rigid PU foam.

Hydroxyl number	150 - 500 mg KOH/g
Acid number	0 - 2,5 mg KOH/g
Aromatic content	25 - 45%
Viscosity (25 °C)	1.500 – 12.000 mPas
Appearance	viscous transparent liquid from colorless to light-brown color.

### Example recipe for generating PA polyol

Raw Materials	%
PA	44
DEG	56
There can be used 3 functional glycols, natural oils and high-molecular acids.	

## Adipatic polyols

H&S also has developed a technology of generating adipates. Adipates are polyols based on adipic acid used for CASE applications (elastomers, shoe soles and coatings).

## Product applications

Polyols based on PET and PA are high-quality polyester polyols, which fit perfectly into the formulations for insulation foams, cast resins, sealants or adhesives.

## Reactor and peripheral equipment core unit



1. Reactor
2. Feeding system for PET or PA
3. Feeding system for adipic acid
4. Filtration system

H&S reactors for generating polyols based on PET and PA can be supplied with batch capacity from 1t to 40t.





## Prepolymer reactors

Generating prepolymers is a complex task which requires very precise control of the process conditions and parameters like temperature, pressure, agitation etc. Most of the raw materials which are necessary for producing prepolymers are sensitive and need special pre-treatment before being processed like melting, heating, cold storing, special way of dosing etc. H&S offers comprehensive reactor systems including all necessary equipment for storage and pre-treatment of the raw materials, controlling devices and filling stations for packaging of the ready prepolymers in tanks, drums, buckets or containers.

Basic and optional equipment for H&S prepolymer reactors includes:

- reactor vessel from 1 m<sup>3</sup> to 40 m<sup>3</sup> with half-pipe jacket
- safety trough for protection in case of leakages
- insulation with mineral wool and aluminium cladding
- specially designed agitator for optimal homogenizing the material
- pumps (with magnetic coupling for isocyanate)
- vacuum pump (if required)
- distillation column (if required)
- heating unit: electrical or gas, heating medium: oil or hot water (depending on the process temperature)
- cooling unit (air cooler or chiller)
- filling lines for raw materials incl. pumps and valves (heated if required)
- mass flow meters
- rupture disc or safety valves for protection the reactor vessel against overpressure and negative pressure
- automatic valves
- shut-off valves
- weighing cells
- overfilling protection device
- temperature sensors at all relevant points
- pressure sensors at all relevant points
- pipeline system, insulated and heated
- wiring of the complete module
- control cabinet with modern and high-performance PLC and PC, with operator friendly controlling functions and recipe management

## Blending stations

H&S blending stations enable the fully automated mixing of components according to available own recipes. Our highly reliable systems use continuous and discontinuous procedures to formulate polyol blends. This facilitates the easy processing of various additives, catalysts, blowing agents and solids. Accurate weighing cells on the blending tanks used for discontinuous operations and the flow meters on the continuous mixing stations guarantee the production of high-quality polyol blends for both large and small batches.



### Benefits

Our mixing and metering equipment operates on a continuous and batch basis and provides the perfect complement to our storage tank systems. This guarantees the cost-effective and environmentally friendly handling of raw materials from delivery to the end product. In-house blending provides you with the following technical benefits:

- The greatest possible metering accuracy and intensive mixing of raw materials
- Automated processes deliver the highest level of process reliability
- Consistent quality
- Precise temperature control of the raw materials
- Enhanced process reliability via visualisation of the processes
- Intelligent recipe management
- Modular method of construction

### Monitoring and control

All process parameters are fully monitored via an electronic PLC control system and a proprietary process management system. The precise regulation of pressure, temperature, flow and stirrer settings guarantees high metering accuracy and outstanding mixing intensity. The detailed recording of all process parameters facilitates the manufacture of polyol blends of consistently high quality. The whole process can also be visualised via an equipment flow diagram which displays all parameter and valve settings.

### Flexibility and security

New opportunities for the in-house formulation of high-quality polyol blends mean that our customers enjoy greater independence from fluctuations on the raw material markets. This allows them to react much more quickly and flexibly to the various requirements of their own customers and enables them to raise their production performance. In addition to this, in-house formulation of polyol blends makes it possible to achieve savings of up to 20% on raw materials procurement. This represents a real economic benefit for our customers.

H&S mixing and metering modules can be easily integrated into existing plants. This facilitates risk-free processing of the raw materials within a closed system.

## Blending stations for polyol and additives

Polyol formulating is a sensitive process which requires approved input materials, high-qualified personnel and reliable blending equipment. The quality of the PU systems is very important either for system houses or for end users which are consuming ready system polyols for internal application.



H&S blending stations designed for batch method are mostly used for formulating the components for all kinds of PU applications where it is necessary to mix polyol with liquid additives (catalysts, stabilizers etc.). H&S blending installations enable high dosing accuracy of the components due to optimal design of the units consisting out of preblender for the small amount of additives and main blender for the basic polyols. The precise weight control is being executed due to load cells installed for both of the blending tanks.

H&S blending stations are easy to operate due to high level of automation of all relevant processes like filling of the raw materials into blending tanks, metering, agitating, protection against overfilling, temperature controlling, discharge etc. Ready polyol blend can be transferred either to the intermediate storage tank, tank truck or into drums and containers by means of specially designed H&S filling station.







## Blending stations for polyol and solids

The technology of mixing polyol with fillers like calcium carbonate or melamine is mostly used for flexible PU foam application. The purpose of using fillers is on one side to reduce the manufacturing costs on the other side to improve such properties of the end product as flame resistance.

H&S offers online mixing as well as batch processing solutions. The technology of mixing polyol with solids demands a proper homogenization as well as process temperature control due to medium warming during the agitation. Besides standard equipment for blending stations H&S supplies complete solutions for dosing of solids as big-bag or silo truck handling including dosing screws, vacuum or compressed air feeding systems.



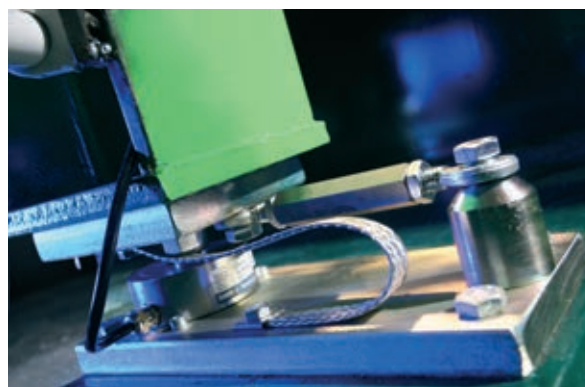


## Blending stations for polyol and blowing agents

Blending stations for polyol and blowing agents are being used for the technologies where it is necessary to integrate the blowing agent into polyol mixture not on the mixing head of a production line but already in the blending vessel. Typical application for such technology is for example PU spray foam.

H&S offers blending stations for polyol and blowing agents based on batch process which are consisting out of mixing tank and a buffer tank for storing the blend. Batch technology gives a number of advantages over the online mixing units, it provides more flexibility due to possibility to mix and store at the same time, it also prevents interruptions in the production process as for example in case of possible breaks a stock of blend will be always available. Another advantage is that buffer tank can be used for supplying all production lines and not only one.

While handling blowing agents especially flammable ones it is important to consider production safety like ex-proof design of all electrical parts and special mixing technology. H&S has a long experience and guarantees high level of processing safety and quality.







## Tank farms

H&S Anlagentechnik supplies turnkey storage tanks for polyols, isocyanates, resins and pentane. We provide customer support which extends from the planning stage to the final commissioning of the new equipment. We also offer regular maintenance of the systems and training for staff.

### Cost efficiency

Our storage tank systems help our customers to facilitate a good-value procurement of raw materials whilst also reducing the costly material losses occasioned by unused residual materials and removing the expensive necessity of disposing of empty drums and containers. This provides an effective way for our customers to cut costs and enjoy greater independence from the fluctuations on the raw material markets. The avoidance of disruptions to the work process caused by reloading or exchanging drums also increases the efficiency of the production process.

### Storage stability

The quality of the raw materials used is a particularly important factor in the manufacture of polyurethane products. H&S storage tank systems provide opportunities for the stable storage of polyurethane components within closed systems. Raw materials stored in this way are afforded effective protection against external influences in the form of temperature fluctuations or humidity and are monitored on an ongoing basis to check key factors such as temperature and pressure. Integrated trace heating, insulation or heat exchanger systems guarantee the compliance with the prescribed storage conditions at all times.

### Safety

Handling raw materials in a clean and safe manner is of high importance for a company's staff as well as for the external image it portrays. H&S develops sophisticated safety concepts for its equipment which it implements in accordance with the relevant statutory provisions. We take care of any water licences required in our capacity as a registered specialist company pursuant to §19 of the German Water Resources Act (WHG).

Our engineers have undergone specialist training in fire and explosion protection at the German Technical Inspection Agency (TÜV). In addition to this, the H&S manufacturing plant is also in possession of higher level proof of suitability pursuant to German Standard DIN 18800 and is registered in accordance with German Standard DIN 8563. A monitoring agreement with the TÜV is also in place. We are adjusting our safety precautions internationally according to the local standards (e.g. ASME).

### Electronic control systems

Our electronic control units enable our customers to retain full control over raw materials stored at all times. All processes are automatically protocolled and escalated to superordinate management systems as required. Processes may also be visualised and evaluated over longer periods of time.

### Delivery and assembly

H&S storage tank systems are supplied in the form of pre-fabricated modules. This ensures simple and rapid installation on site, whether above or below ground or whether free-standing or as an integrated part of a complete solution. All storage tank modules are installed in a tested safety trough which fulfils the most stringent safety regulations.





## Tank farms for polyol / isocyanate

H&S manufactures ideal solutions for you - tank storage systems for polyol and isocyanate in modern design and high level of technical performance as perfect alternative to costly and inefficient storage in drums or containers.

### Your advantages:

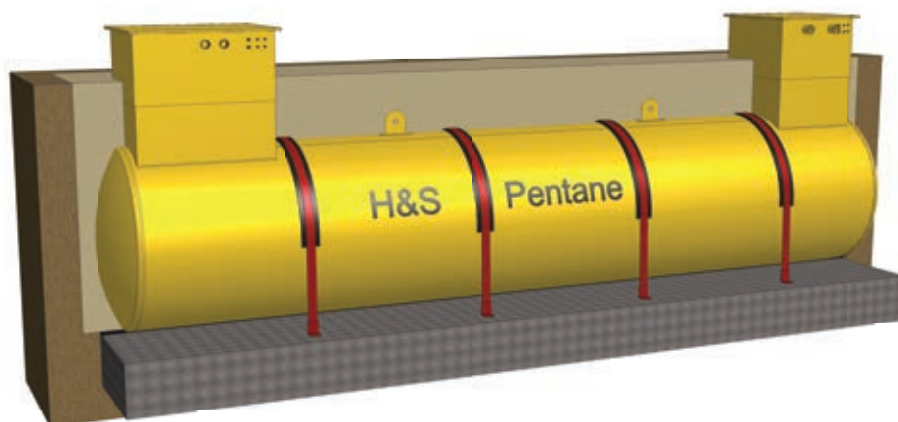
- reasonable discount from raw material suppliers when ordering in bulk in comparison to purchasing in drums
- no interruption or troubles of the production process caused by refilling or changing of drums
- escaping of permanent uncovered costs for drums residues
- controlled stable storage temperature of the raw materials
- avoidance of external negative influences such as humidity
- safe and environmental friendly handling of the raw materials
- perfect control of pressure and temperature in pipelines and tanks
- safety trough for protection against leakage
- modular design, which enables precise adaptation to customer requirements and further extension



## Tank farms for pentane



Storing of such blowing agents as pentane and other flammable and explosively dangerous liquids represents a particular challenge. The difficulty of handling blowing agents requires particular solutions which must be individually aligned to the parameters of the liquids to be stored. H&S offers individually designed solutions for underground and aboveground storage systems for pentane which enable safe and reliable storage of blowing agents.









# R&D

Being an innovative and competent company in the field of chemical recycling of the PU waste as well as generating polyester polyols based on PET, PA and natural oils H&S owns a Research & Development Center which is located in the city of Wildau (near Berlin).

The main activities of H&S R&D department are dedicated to the development of the technological processes and recipes of the recovered polyols, virgin polyester polyols as well as PU foam formulations for all kinds of the PU applications. The R&D center is equipped with pilot reactors with capacities of 90L, 320L and 700L where all developed processes can be simulated offering a perfect upscaling possibility when adjusting the industrial scale processes. The reactors are also being used for generating polyol samples for H&S customers when it is necessary to test the material on the production line. The laboratory is fitted out with all necessary labware for analysing the parameters of the polyols as well as modern and precise devices for testing the physical and mechanical properties of the PU foams.



H&S service and support in the field of chemical developments for its customers include:

- testing of the customers PU foam residues samples
- producing of the polyol samples from flask up to industrial scale in the pilot reactors
- foaming tests and analysing the foam physical and mechanical properties
- adjusting the parameters of the polyol according to customers' requirements and specifications
- developing and adjusting of the formulations for PU foam based on polyester polyols and recovered polyols
- comprehensive consultations in all PU issues
- training of the customers personnel by H&S chemists within the framework of common projects
- long-term customer support during presale, start-up and production period and after sale

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