

Technical handout

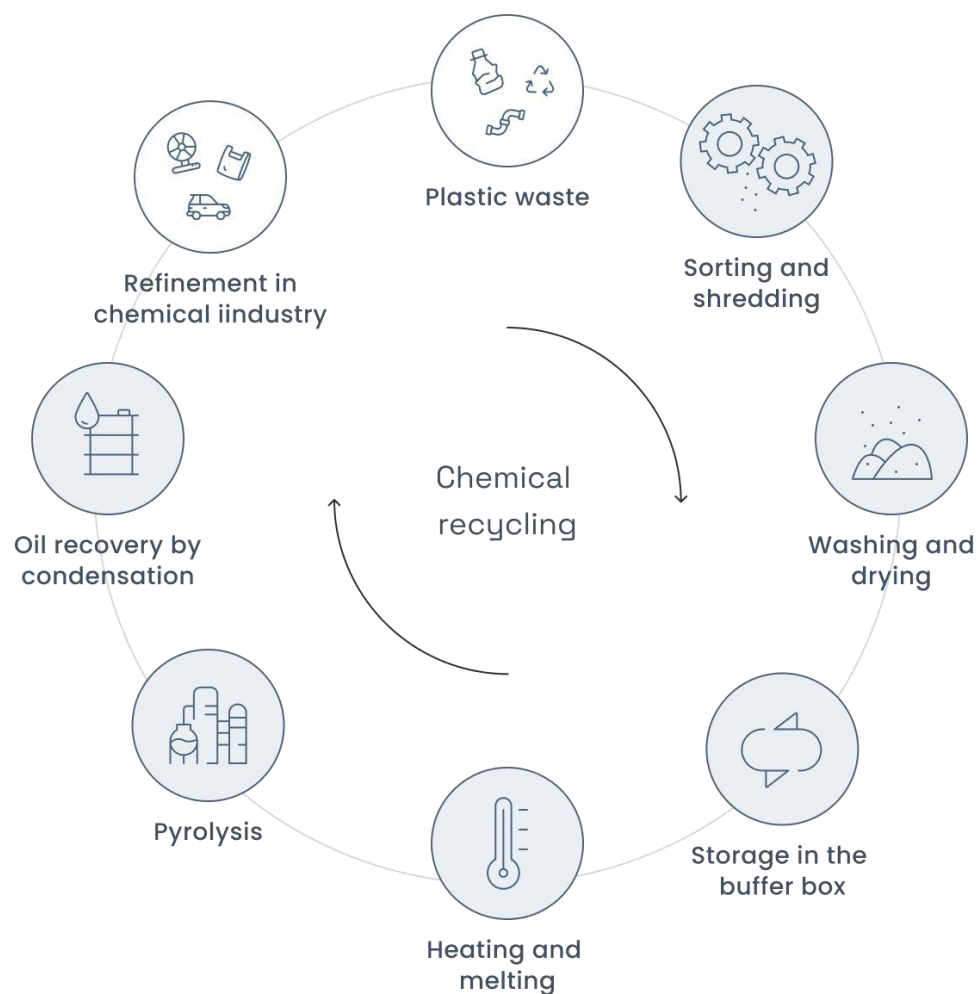
Plastic to Oil Pyrolysis System

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CIRCULAR

04/2025-2

Chemical recycling - closing the plastic cycle

Chemical recycling closes the gap between mechanical recycling processes and energy recovery. This is the only way to recover contaminated or mixed plastic waste that is too valuable to dispose of. However, circular value creation is only possible if the circle is closed. This – and not technical feasibility – is our greatest challenge.



A turnkey project requires expertise in various disciplines

With chemical recycling, polyolefin based plastic waste can be recycled into high value chemicals (HVC) which are used in the petrochemical industry to manufacture plastic products with a wide range of applications. This closes the circular economy for products (e.g. plastic bags) that would otherwise not be reused and would end up as waste products.

Currently, not all plastics can be effectively recycled using this process. Its development is still evolving. Chemical recycling needs to be further developed and established as a key technology. At enespa, we are pioneers in this field. For a long time, chemical recycling was considered inefficient and uneconomical. This is no longer the case with one of enespa's modern plants.

The NeoOil P5 - Technical Data

General information

System type	Pyrolysis system
Manufacturer	Enespa
Dimensions (LxWxH)	12 x 10 x 3.4 m
Total weight	12.7 t
Approval	CE marking

Consumables

Nitrogen	4 l/min
Compressed air	min. 6 bar
Cooling water (60 °C)	4 m3/h
Cooling water (6 °C)	4 m3/h

Operating conditions

Operating mode	continuous
Operating temperature	400 - 500 ° C
Max. Operating pressure	0.5 bar
Installation	at ground level
Sound immission	< 75 dB (A)

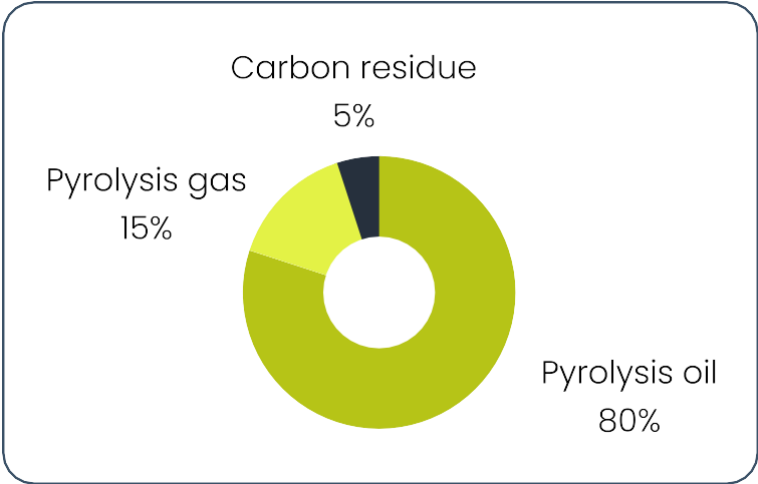
Operating conditions

Installed power	500 kW
Voltage	400 V, 50 Hz
Amperage	500 A
Earthing system	TNC-S

Performance data

Max. Raw material throughput	5 tons/day
Pyrolysis oil*	80%
Pyrolysis gas*	15%
Ash*	5%

Mass balance*

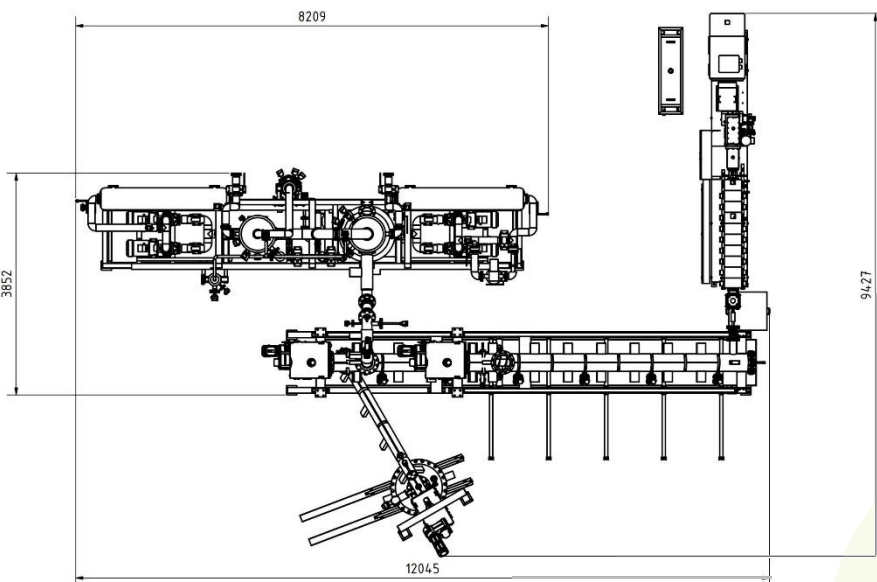


*depending on the operating parameters and the quality of the feedstock

Operating control

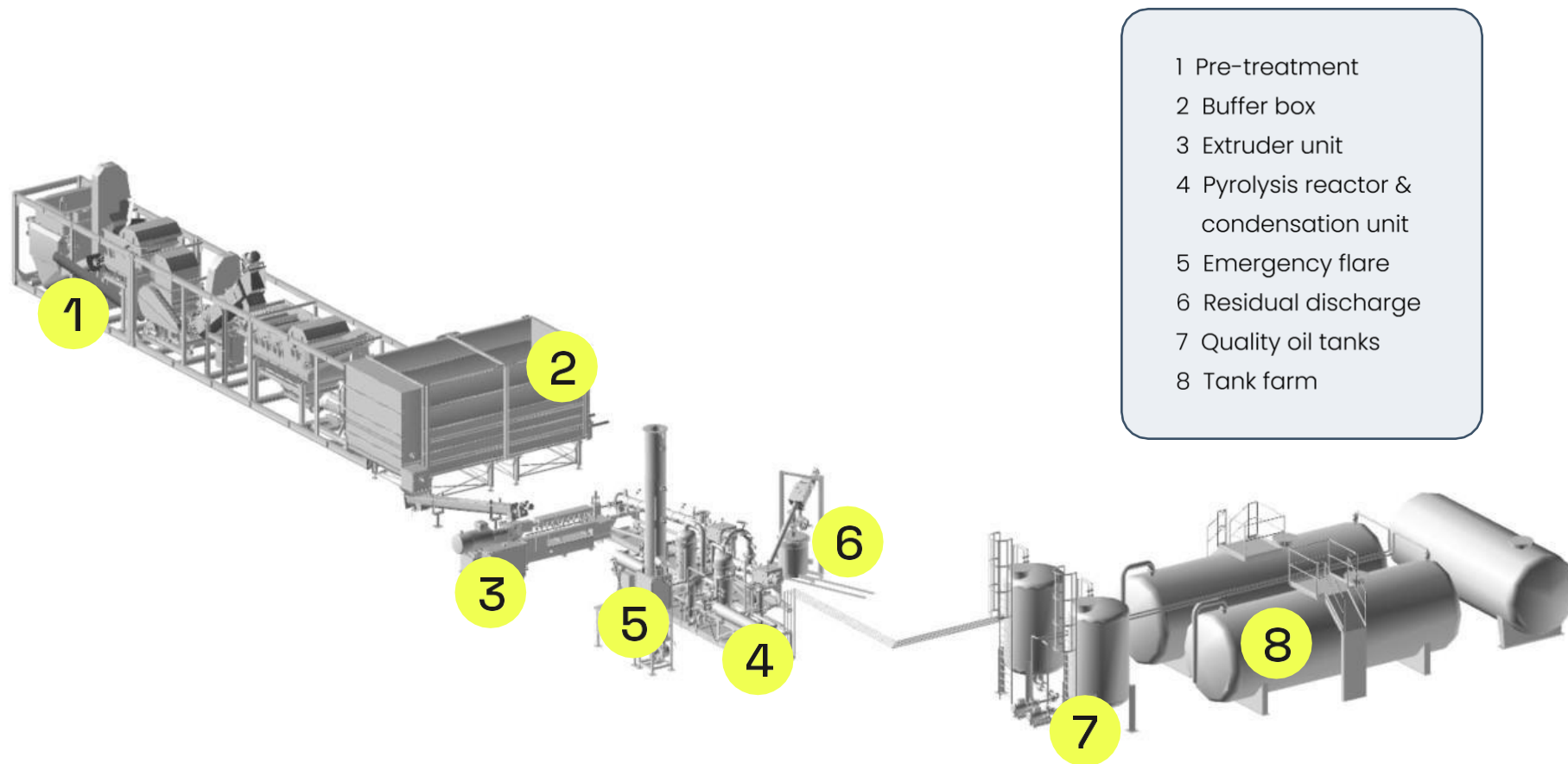
Control system	Siemens S7
Operating device	22" touch panel
Operating mode	fully automated

Layout



The NeoOil P5

NeoOil P5 is the result of years of research and learning. To achieve a continuous process, all parts of the system must be optimally coordinated: pre-treatment system, pyrolysis module and tank farm. This is why we offer turnkey projects, designed by us from the purchase of the plastic waste to the collection of the oil by an offtake partner.



For your turnkey project, we offer expertise in several disciplines

Pre-treatment

- Shredding:** by primary shredder and granulator
- Cleaning:** by one or two step friction washers and washing tanks
- Separation:** of non-pyrolyzable plastic by floatation-separation tank
- Drying:** by mechanical dryer
- Buffering:** to ensure continuous pyrolysis operation

Trusted equipment partner

Pyrolysis module

- Extruder:** liquefies the plastic for airtight entry
- Pyrolysis reactor:** gasifies plastic
- Condensation:** of pyrolysis vapour and discharge to intermediate storage
- Residual discharge:** of non-pyrolyzable components as solid residues
- Gas utilization:** emission controlled thermal oxidation by flaring system or optional use for power generation.



Tank Farm

- Quality tanks:** Intermediate storage of product oil and quality check before final storage
- Product tanks:** Tank logistics are dependent on the offtake partner. Redundancy ensures continuous operation even during collection.
- Quality assurance logistics:** contractual and analytical measures to ensure acceptability.



Turning waste into Plastic Pyrolysis Oil (PPO)

Market Potential: Why PPO is the Raw Material of the Future

Rapid Market Growth: Global PPO market grows >20% p.a., reaching \$351B by 2035

Circular Economy & Climate Targets

By 2050, >50% of plastics could come from recycled raw materials, reducing fossil dependency.

Proven Refinery Applications: Refineries already integrate PPO to replace fossil oil in plastics and chemicals production.



Technological Advantages & Applications: Where is PPO Being Used?

Use as a crude oil substitute: PPO serves as a certified raw material in plastics manufacturing (e.g., BASF ChemCycling).

Versatile uses: Fuels, chemical feedstocks, specialty chemicals, hydrogen, and more.

High quality and adaptability: After technical upgrading, PPO is nearly identical to fossil crude oil, making it easily integrable into existing infrastructure.

Drivers & Regulatory Environment: What is Accelerating the Market?

Global political backing – EU Green Deal:

Recognizes chemical recycling as key to a climate-neutral economy. **USA:** More than 20 states promote chemical recycling as a technology of the future. **Asia/Australia:** National recycling roadmaps drive large-scale investments in pyrolysis plants.

Sustainability pressures:

Globally, only about 10% of plastic waste is currently recycled, highlighting huge growth potential for pyrolysis technologies. Without chemical recycling, global recycling and climate targets will be challenging to achieve.

Confidence through Market Expertise: Why Now is the Perfect Time

Independent market studies (e.g., McKinsey, OECD, Global Market Insights) forecast **exponential market growth**.

Major chemical companies are already investing heavily in pyrolysis technology, indicating high industry acceptance.

International certifications (e.g., ISCC Plus) ensure transparency, sustainability, and measurable circular economy results.

Guideline for your pyrolysis project

The following key points should be observed for every Pyrolysis project. During the project planning process, these are worked out together with your Enespa contact person.

Feedstock supply



Plastic waste will be your raw material. For the project you need long-term security of supply. In addition, all properties of the waste are required: from the daily quantity to be processed, water content and impurities to the chemical composition of the plastic.

① Enespa helps you to scientifically analyze your feedstock and evaluate its pyrolyzability. We have an in-house petrochemical laboratory for this purpose.

Oil offtake



Different feedstock plastics produce different oil qualities, which requires different treatments on the off-taker side. Offtake negotiations, oil quality management, collection logistics and certifications like REACH or ISCC PLUS require specialized know how.

① Thanks to our global Offtake partners, we are able to support PPO Offtake for many regions around the world and even guarantee it if the project parameters are suitable.

Project location



Site conditions can be your best friend or your worst enemy. A pyrolysis plant requires special building and emission control permits. Location in an industrial area can help. It is also advisable to be close to feedstock supply and offtake partners to optimise logistics costs.

① With years of experience in approval processes, operating concepts and logistical challenges, we can help with site selection.

Project financing



Chemical recycling projects are complex and involve many stakeholders, making the business plan challenging. Sustainability programs provide funding for project financing.

① No two projects are the same. We understand complex financing structures and have built up the expertise and partners to help you with your project.

Why enespa?

Enespa combines technological innovation with years of hands-on experience developing and operating chemical recycling plants in Aalen, Hamburg, and Bulgaria. Our expertise extends to manufacturing and operating various petrochemical facilities, positioning us as a reliable partner offering integrated solutions—from planning to successful commissioning.

Strong management team in Appenzell, Switzerland

At the end of the day, it all comes down to business. With an experienced management team with expertise in managing international projects and financing, we are well equipped to help you build a strong business case for your pyrolysis project.



Serial manufacturing in Hamburg, Germany

At our Hamburg facility, we engineer and produce highly efficient, modular chemical recycling plants, tailored for global deployment. Our expert team ensures fast installation, optimized energy usage, and guarantees plant throughput—significantly reducing risks and accelerating your project's profitability.



State-of-the art laboratory in Hamburg, Germany

Our in-house petrochemical laboratory provides precise analyses of pyrolysis oils and gases, enhancing the safety, feasibility, and regulatory compliance of your plastic pyrolysis project. This ensures credible data and informed decision-making.

Expert partnerships all over the globe

We provide a complete ecosystem of partners across the chemical recycling sector. From universities to large refineries to equipment manufacturers and engineers. This means we have everything needed to run a profitable business model in any country in the world.

References (excerpt)

Enespa projects can be found around the world. This selection offers a brief overview — for more details on selected projects, visit enespa.com.

Project in development

- USA:** 40 t/d sorted plastic waste from economic concept phase
- Canada:** waste oil recycling technical concept phase
- Denmark:** 5 t/d dirty plastic waste economic and technical concept phase
- Morocco:** 5 t/d of untreated mixed plastics technical concept phase



Texas, USA

Projects in progress

- Texas, USA:** 10 t/d of pre-sorted polyolefin waste plant construction phase
- Rio de Janeiro, BRA:** 1 t/d R&D unit for research purposes shipping phase
- Melbourne, AUS:** 10 t/d of pre-sorted soft plastics construction phase on site
- Lahti, FIN:** 5 t/d of untreated mixed plastics commissioning phase

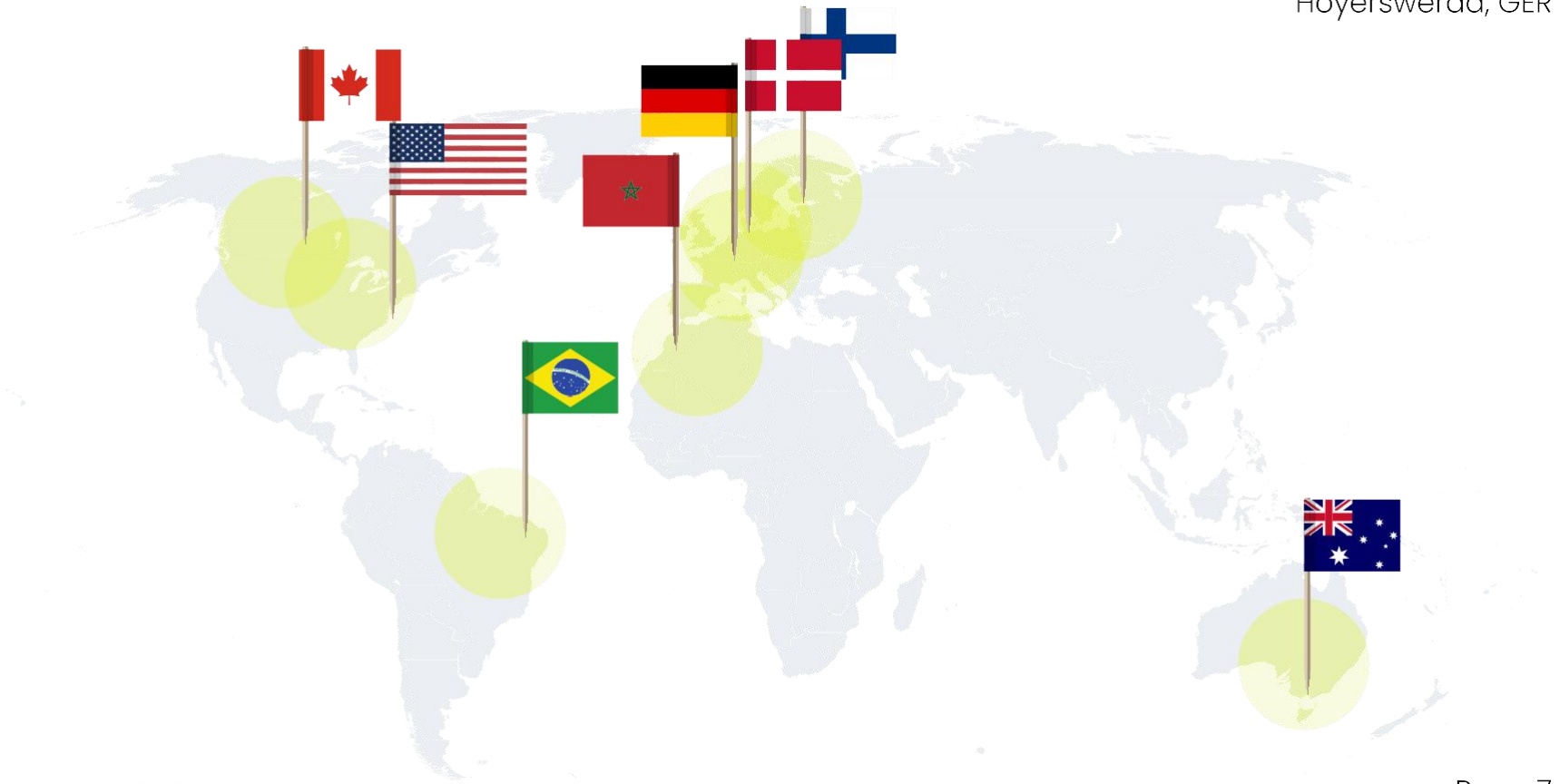


Lahti, FIN

Projects in operation

- Hoyerswerda, GER:** <5 t/d waste oil recycling operational since 2022
- Bernsdorf, GER:** Own AdBlue® production operational since 2024





Feedstock requirements

The aim of pyrolysis is to obtain pyrolysis oil from the thermal decomposition of plastic. The quality of the raw material is crucial for the overall process. The ideal raw material compositions and the process-critical impurities are described below. Impurities must be eliminated during raw material preparation in order to rule out health and environmental hazards.

Project in development

The Enespa pyrolysis systems are designed for processing polyolefins. The ideal feedstock is packaging film (no multilayer systems) up to 2 mm thick, consisting of the following materials.

Abbreviation	Designation
HDPE	High Density Polyethylene
LLDPE	Linear Low Density Polyethylene
PP	Polypropylene
PP + C	Polypropylene w. C adhesions
PE	Polyethylene film

Impurities

More problematic, however, are foreign plastics such as PVC, PA or PET, which cannot be separated via the sorting process. These leads, for example, to increased chlorine, nitrogen or oxygen-saturated compounds in the resulting pyrolysis oils and can cause serious process problems such as corrosion and treatment costs. The following structural elements are particularly critical:

- Plasticizers: aromatics, chlorine
- Fillers: silicates, carbonates, carbon black, silicones
- Flame retardants: bromine, chlorine, antimony, aromatics, organic phosphorus compounds
- Ageing protection: tin, aromatics, sulphur
- Hardener: Aromatics
- Colorants: chromium, chlorine, cobalt, copper, strontium
- Lubricant: Tin
- PVDC and PA barrier coatings
- Residual products and adhesions

We are happy to provide a full list of limits on request. However, we always recommend that a full laboratory analysis is carried out for final implementation. Experience has shown that a lot can be solved with complete data on pre-treatment systems and peripheral elements.