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Automotive Recycling

Engineering Workshop at the
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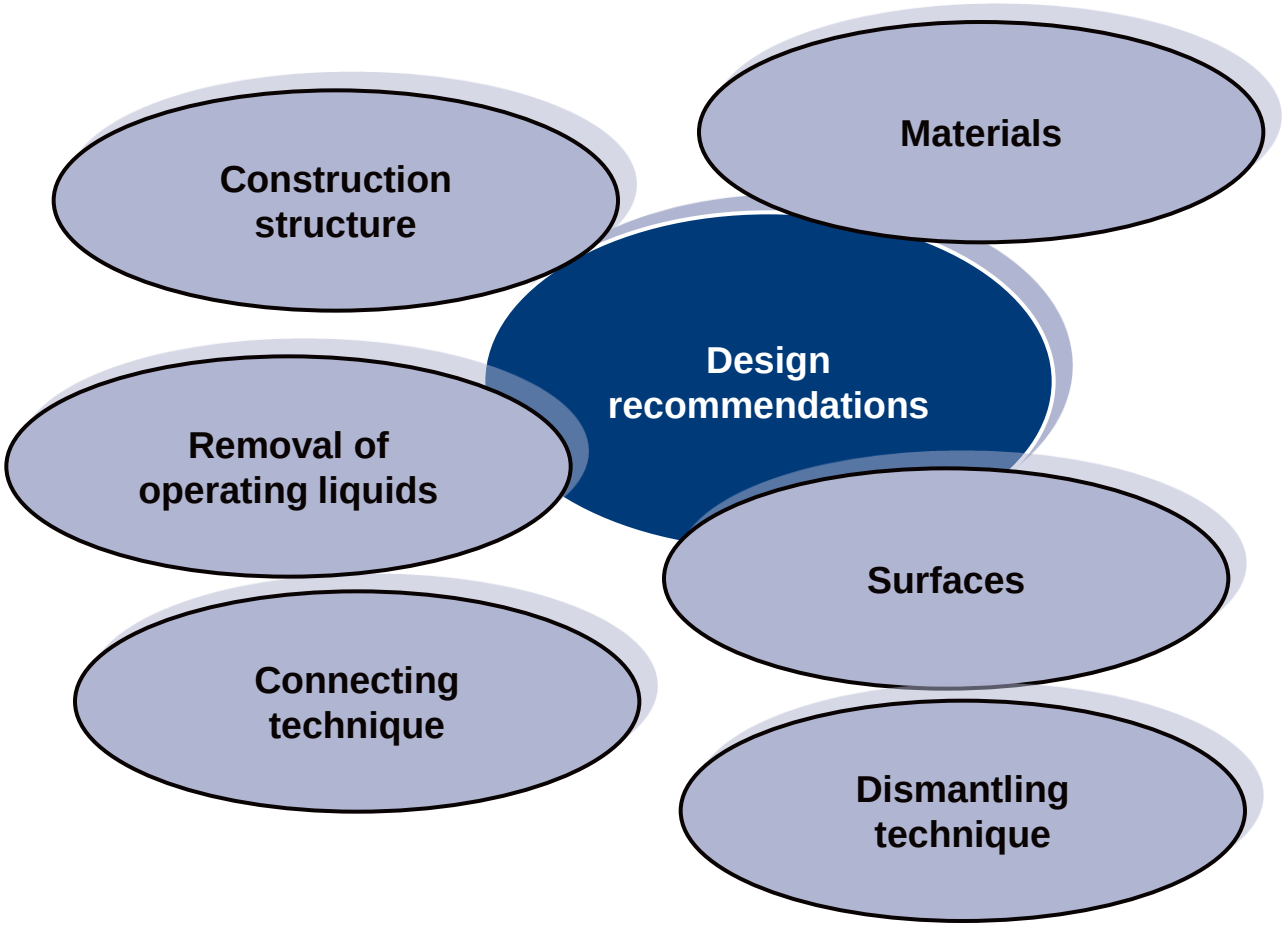
Port Elizabeth
South Africa 2011

6 Environment and recycling oriented design

Salzgitter
Suderburg
Wolfenbüttel & Braunschweig
Wolfsburg

6 Environment and recycling oriented design



Design recommendations - practical hints

For recycling-friendly construction there are three points in the spot light: building structure, materials and connection types.

In general, there should be a recycling concept for the building structure, the materials should be recycled and the connections should be solvable.

The design recommendations can be structured into the following groups:

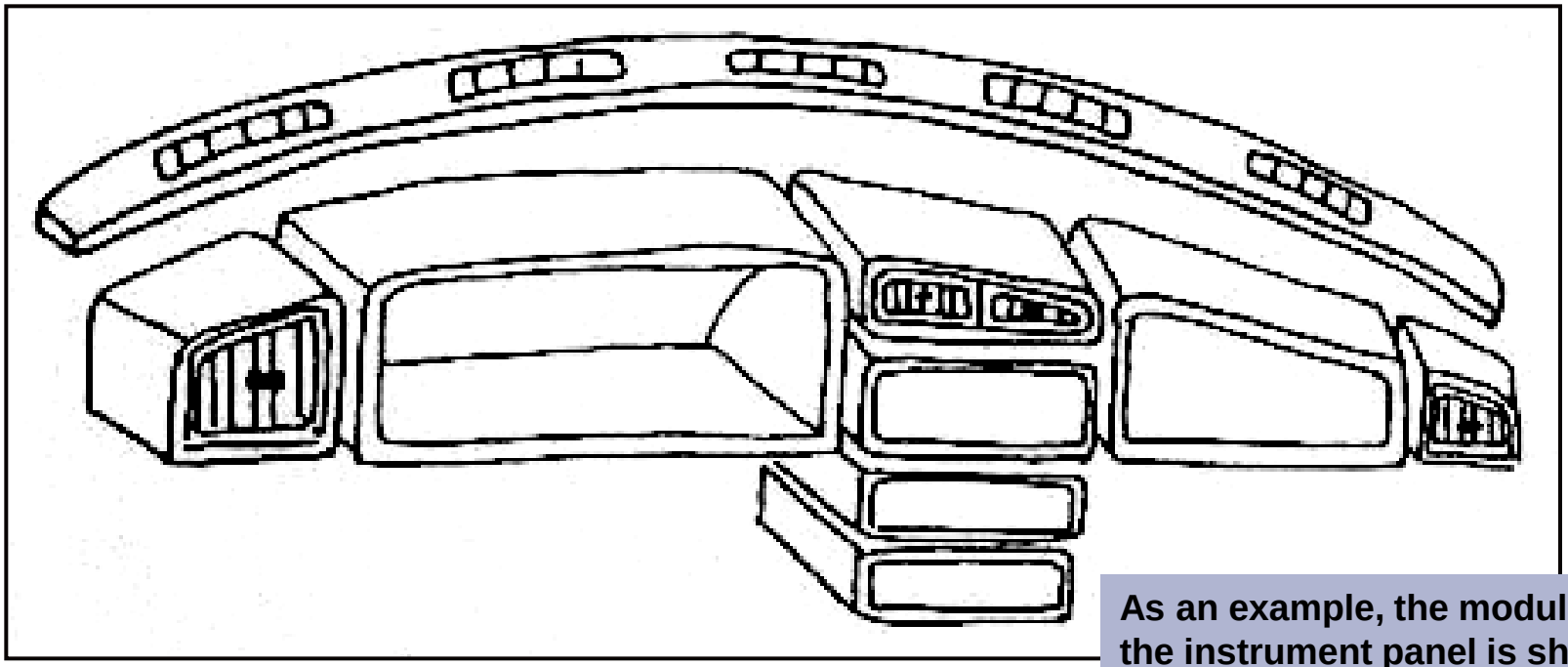
Construction structure
Materials and surfaces
Dismantling- and connecting technique
Removal of operating liquids.

Different examples shall be looked at in the following.

Design recommendations for the construction structure

Recommendation: Provide a functional, modular construction

Advantage: simple dismantling, lower dismantling costs



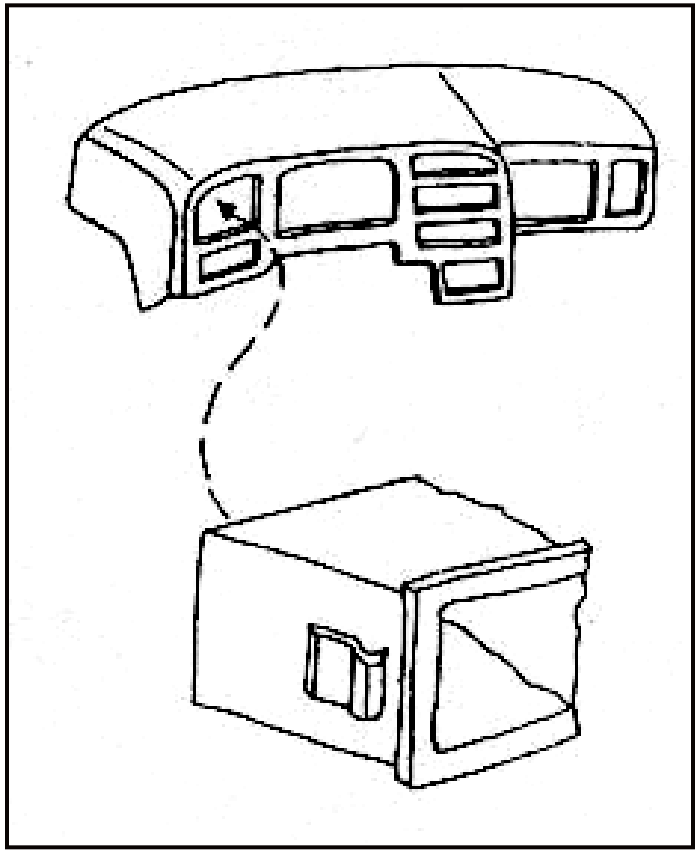
As an example, the modular structure of the instrument panel is shown.

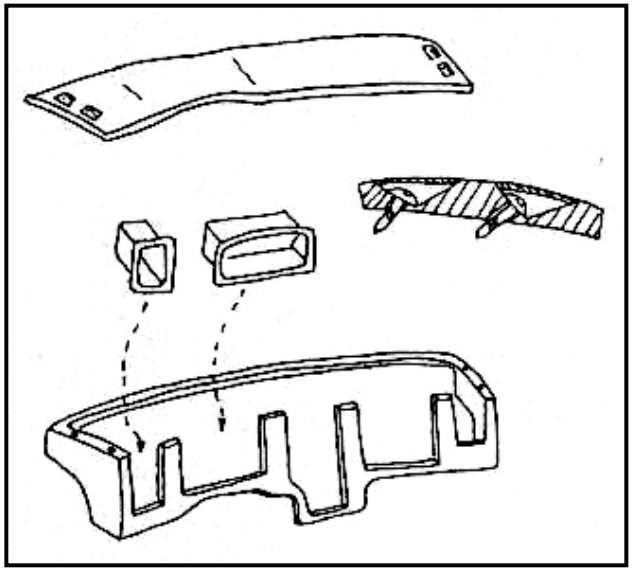
You can find this building structure on many vehicles.

Design recommendations – Practical hints for the construction structure

Recommendation: Prefer horizontal structures

Advantage: simple dismantling, lower dismantling costs





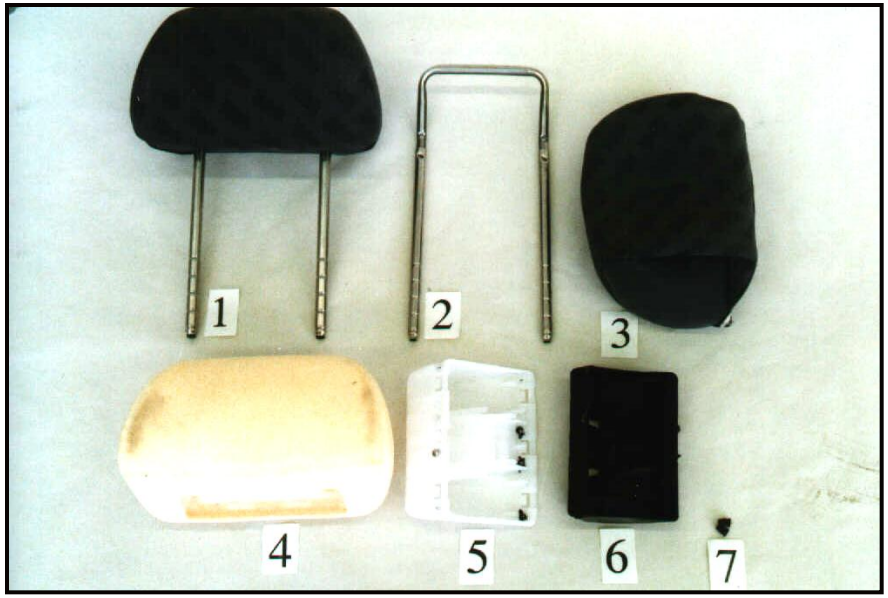
As an example, the horizontal and vertical structure of the instrument panel is shown.

Electrical components can thus be removed in one direction easily and quickly.

Design recommendations – Practical hints for the construction structure

Recommendation: Arrange recycle-suitable components or/and materials in such a way that they are accessible and can be dismantled easily

Advantage: Allows non-destructive dismantling. Defective parts can be replaced more easily (easily serviceable)



Easy dismantling of all components

As an example, here are different head restraint shown.

The shown headrest can be completely dismantled.

We first solve the fabric cover, remove the polyurethane foam and dissolve the supporting body. The support body is fastened with simple Clip-connectors to the steel bracket.

Design recommendations – Practical hints for the construction structure

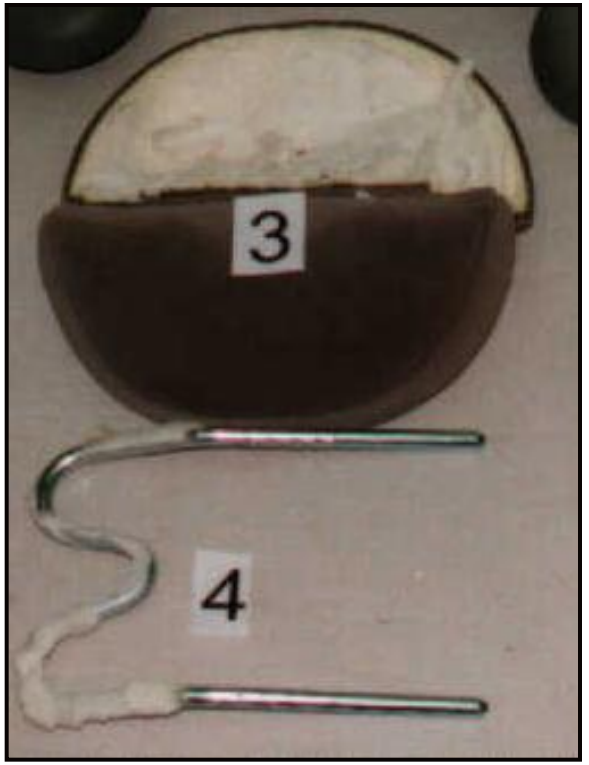
Recommendation: Arrange recycle-suitable components or/and materials in such a way that they are accessible and can be dismantled easily

The picture shown in the middle head restraint is in principle also recyclable.

However, the core material is thermal welded, and therefore, the materials must be procedurally separated.

The right image shows a non detachable head rest. The materials are foamed with each other and not separable.

Body head-rest thermal welded,

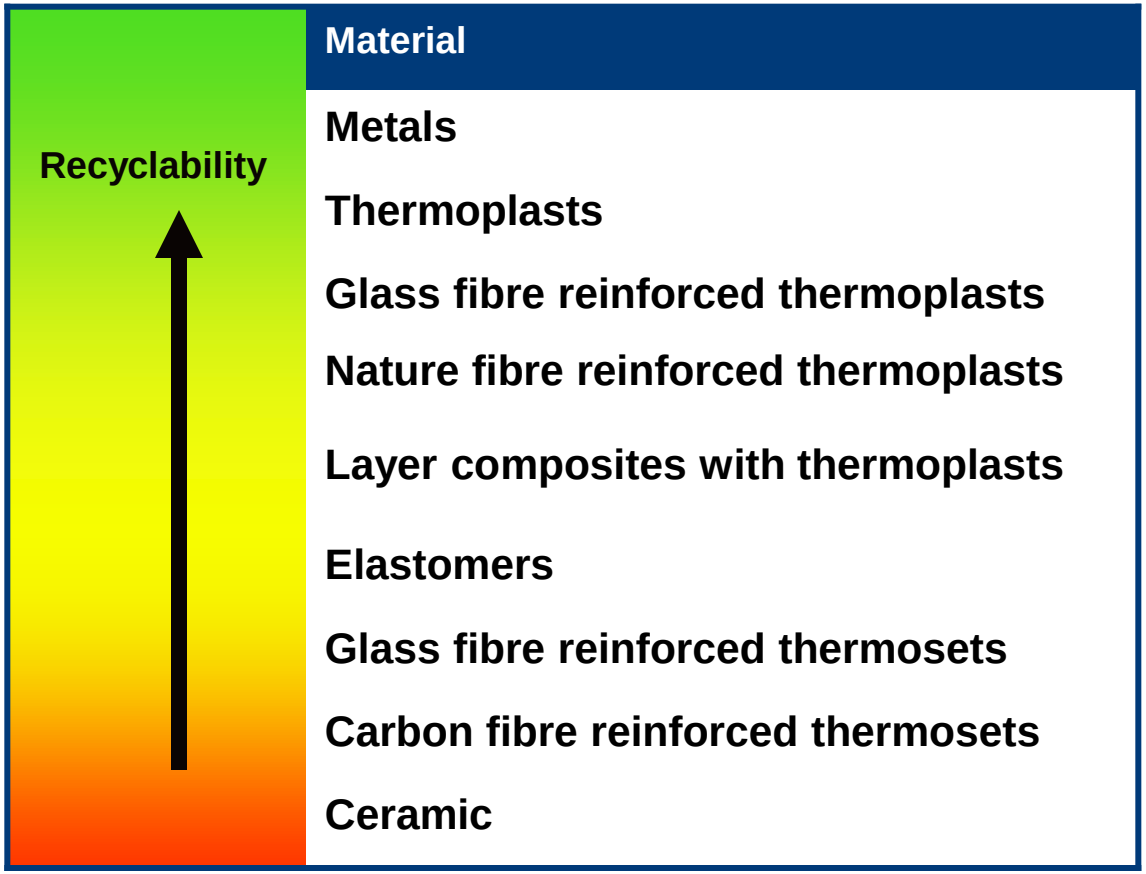


Body head-rest foamed, not detachable

Design recommendations for materials and surfaces

Recommendation: Usage of recyclable materials in product

Advantage: saves resources, reduces pollutants



In the picture is shown a ranking of the various materials in relation to their recyclability.

Thereafter, it should preferably be used in products metals and thermoplastics, followed by glass- and natural fibre reinforced thermoplastics.

Recycling methods for carbon fiber reinforced materials just are in the development.

Ceramic materials are sintered. It is practically only a particle recycling possible.

Design recommendations – Practical hints for materials and surfaces

Recommendation: Usage of recyclable materials in product

Recyclability	Polymer material
↑	PE, PP, EPDM (Polyolefine)
	PS, SAN, ABS, ASA (Styrolpolymeren)
	SMA (Styrolmaleinsäureanhydrid)
	PA6, PA66, PA12 (Polyamide)
	PPE/PS, PPE/PA (Polyphenylenetherblends)
	PMMA (Polymethylmethacrylat)
	PET, PBT, PC (Polyester)
	PBT/PC, PET/PC
	POM (Polyoxymethylen)
	PVC (Polyvinylchlorid)
	PU (Polyurethan)
	PF, UP, Epoxid, Silikon (Thermosets)
	Composites

Thermoplastic materials behave very differently in the recycling process.

For example, PE, PP, PA and PMMA feeding a relatively uncomplicated recovery.

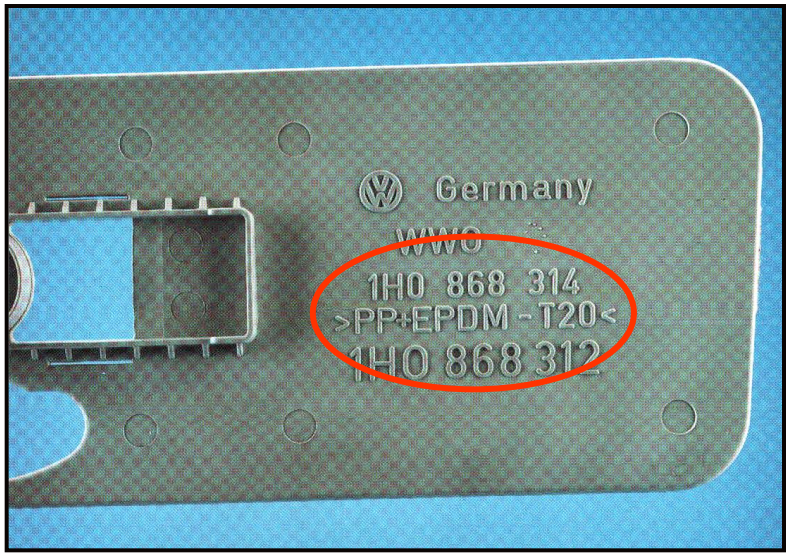
In materials such as POM, it can occur even in the extrusion process to a decomposition of polymer chains.

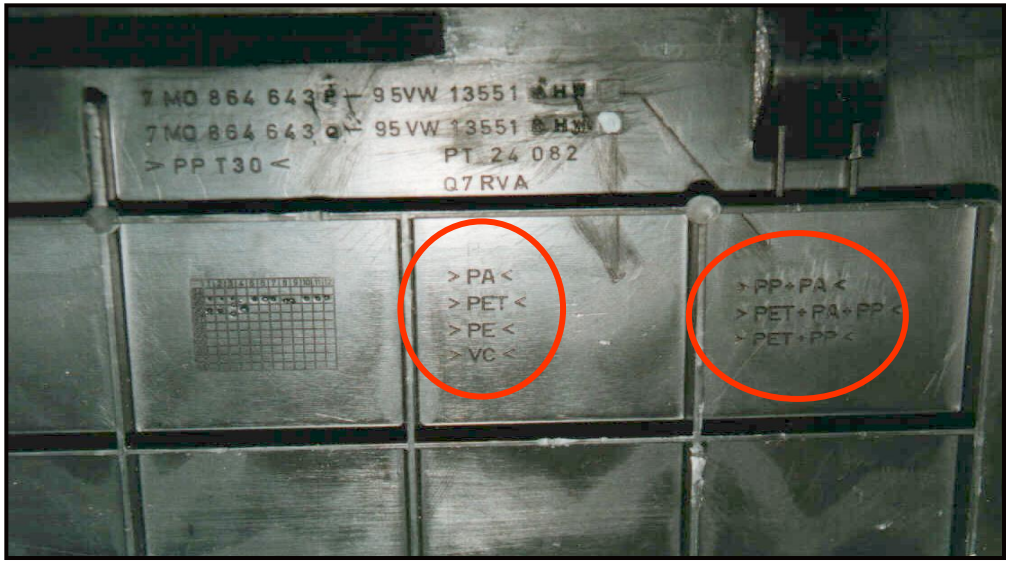
In PVC can at higher temperatures chlorinate be flagged. together with water forms hydrochloric acid, and thus of machines and plant components due to corrosion.

Design recommendations – Practical hints for materials and surfaces

Recommendation: Identification of materials in accordance with relevant standards and regulations. Identifications must be easily visible and easily legible after the use phase

Advantage: manual fractionation possible, avoidance of complicated subsequent process steps

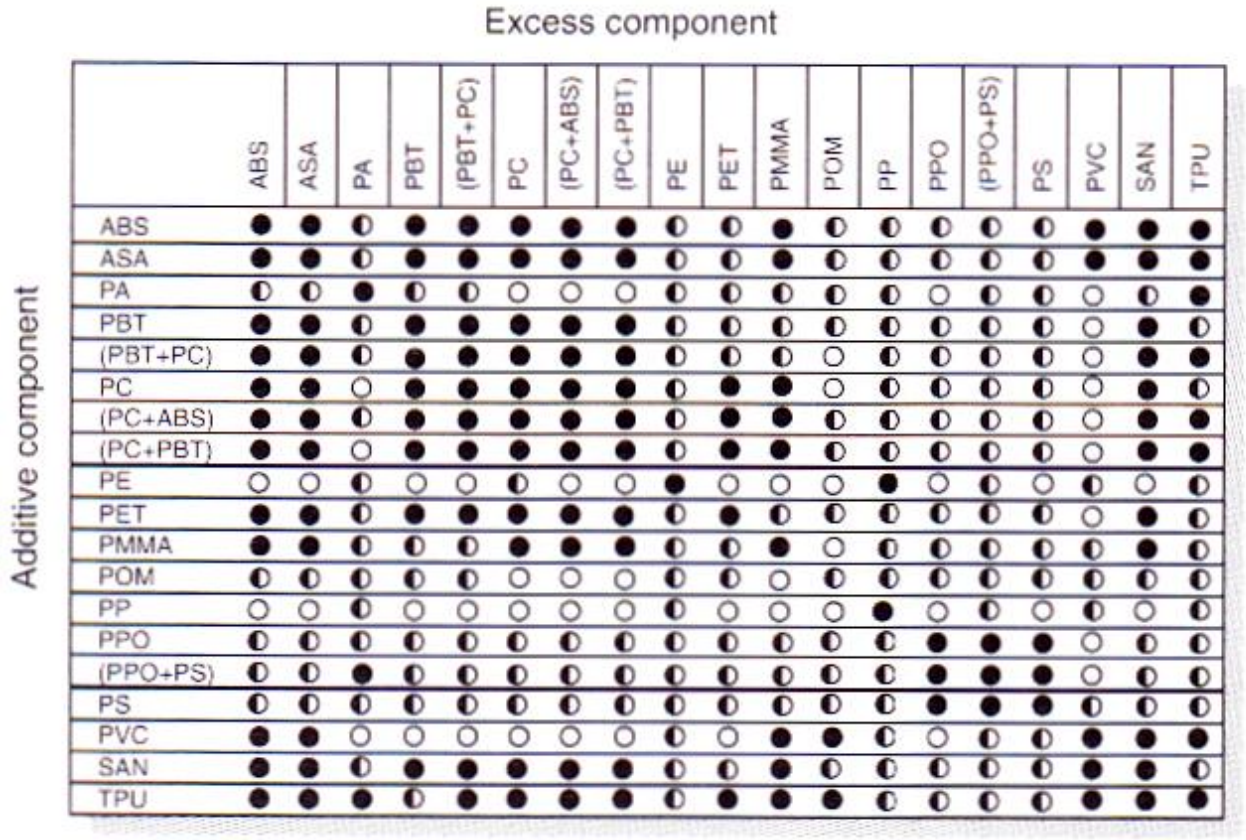




The component on the left side is clearly labelled polymer blend (PP + EPDM-T20).
On the right side, there are several marks within to cover all equipment variants. This information is useless for a recycling process, the material cannot be clearly assigned.

Design recommendations – Practical hints for materials and surfaces

Table for the compatibility of thermoplastic materials

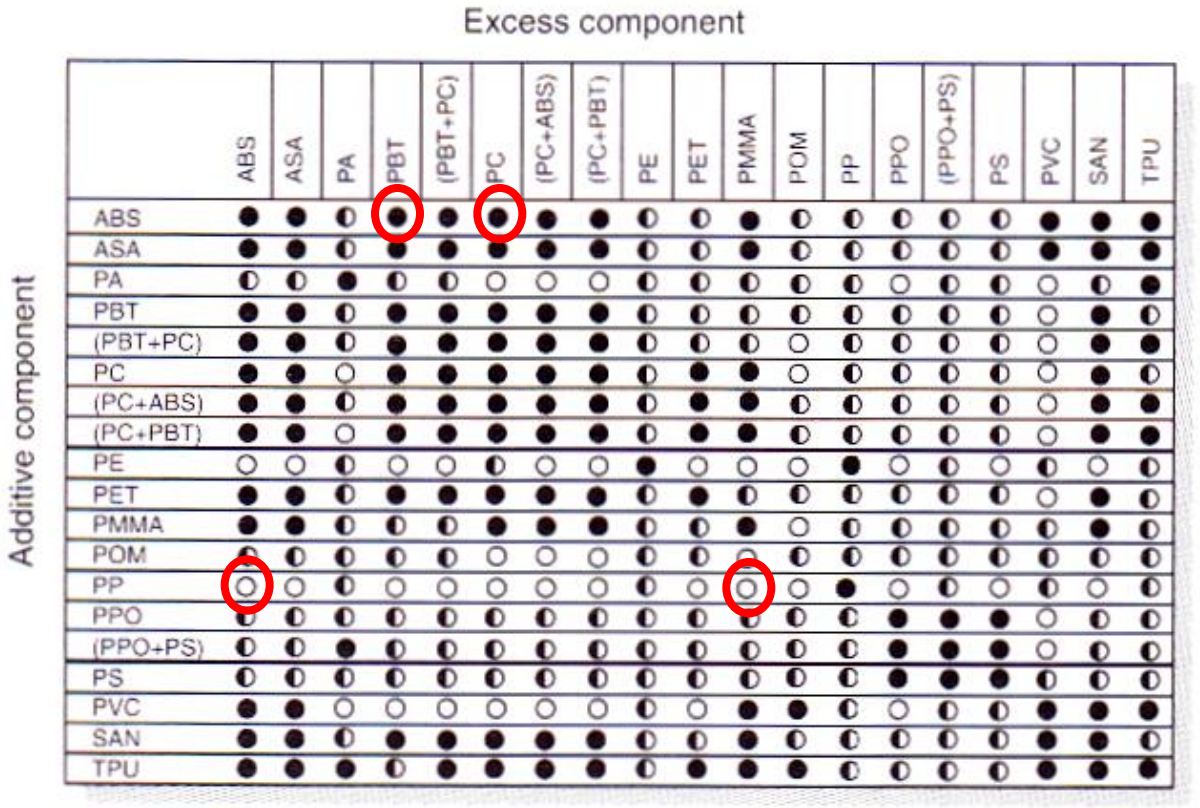


In the picture, the table for the compatibility of thermoplastic materials is presented.

Compatible here means that the materials have each received a chemical compound and defined material properties.

Design recommendations – Practical hints for materials and surfaces

Table for the compatibility of thermoplastic materials



- ● Good compatibility over a wide blending range
- ◐ Limited compatibility with low volumes
- ○ Incompatibility

For example, ABS is very compatible with PC, as well as ABS with PBT.

A combination of materials PP-ABS or PMMA should be avoided. In many cases, however, we could find these material combinations.

Design recommendations – Practical hints for materials and surfaces

Recommendation: The use of recycling-compatible materials in modules/sub-assemblies, in particular in composite materials

Advantage: compatible materials permit cost-effective recycling of materials without separation

Display unit

Materials used today in display unit

View plate: PMMA
Case: ABS
Lid: PP

Car interior concept optimised for recycling

View plate: PC
Case: ABS
Lid: ABS

Design recommendations – Practical hints for materials and surfaces

Recommendation: The use of recycling-compatible materials

Headlamp reflector

Materials used today

PP
PMMA
SMC/BMC
ABS
PC

Car interior concept optimised for recycling

PC
PC-HT
PC+PBT
PC+ABS

Design recommendations – Practical hints for materials and surfaces

Recommendation: The use of recycling-compatible materials

Instrument panel, door panel, ...

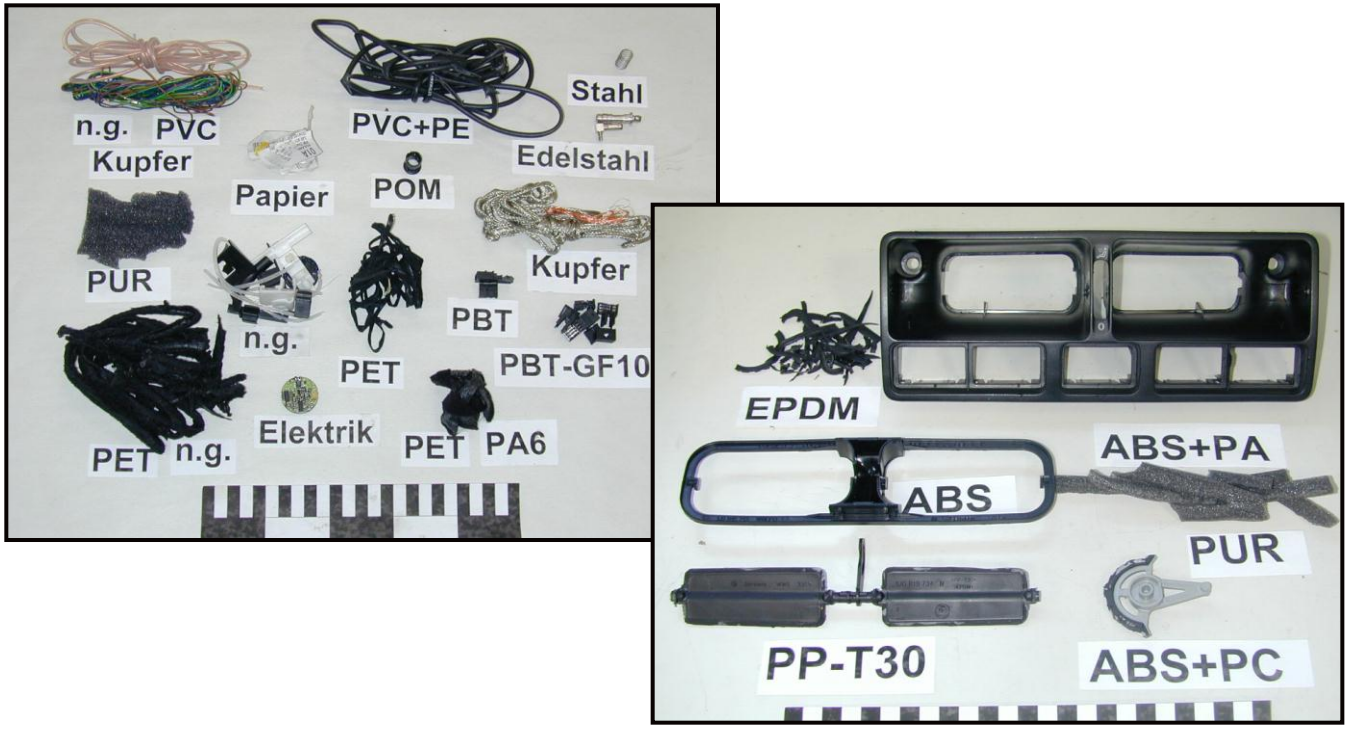
Materials used today
PP
PVC
ABS
PA
PMMA
SMC/GMC

Car interior concept optimised for recycling
ABS
PC+ABS
PBT
PET
ASA film
Compatible paints

Design recommendations – Practical hints for materials and surfaces

Recommendation: Reduction in the diversity of materials, and standardization of materials

Advantage: more cost-effective material recycling



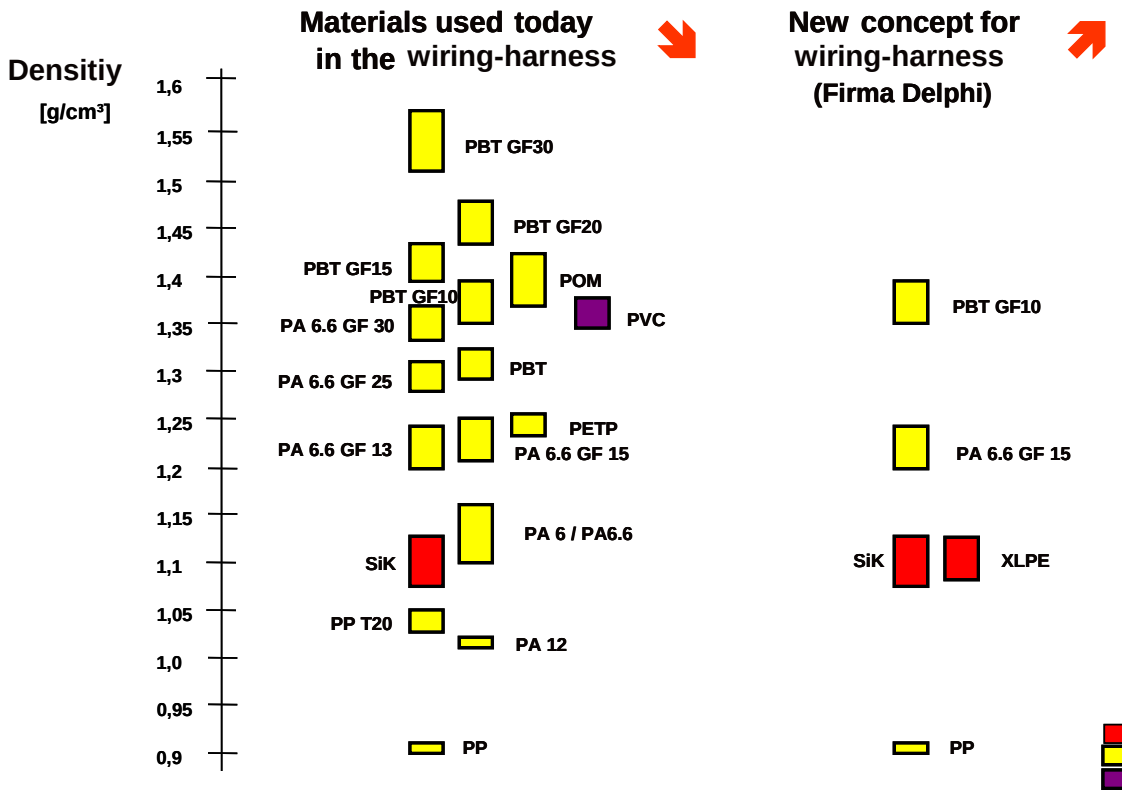
As an example shown in the illustration, there are materials presented in a wiring- harness and an air nozzle.

There is a diversity of materials. An economic separation of the materials is not possible.

We should reduce the variety of materials to a minimum.

Design recommendations – Practical hints for materials and surfaces

Recommendation: Reduction in the diversity of materials, and standardization of materials



As an example of the reduction in the diversity of materials in the illustration is shown the concept of Delphi for a wiring-harness.

The whole wiring-harness consists of five materials that can be clearly differ in their density and thus, well separated.

In the present approach, overlap the densities of the materials and thus, a separation is not possible.

Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Standardise connecting elements

Advantage: no tool changing reduces dismantling and dissasembly times which mean lower costs

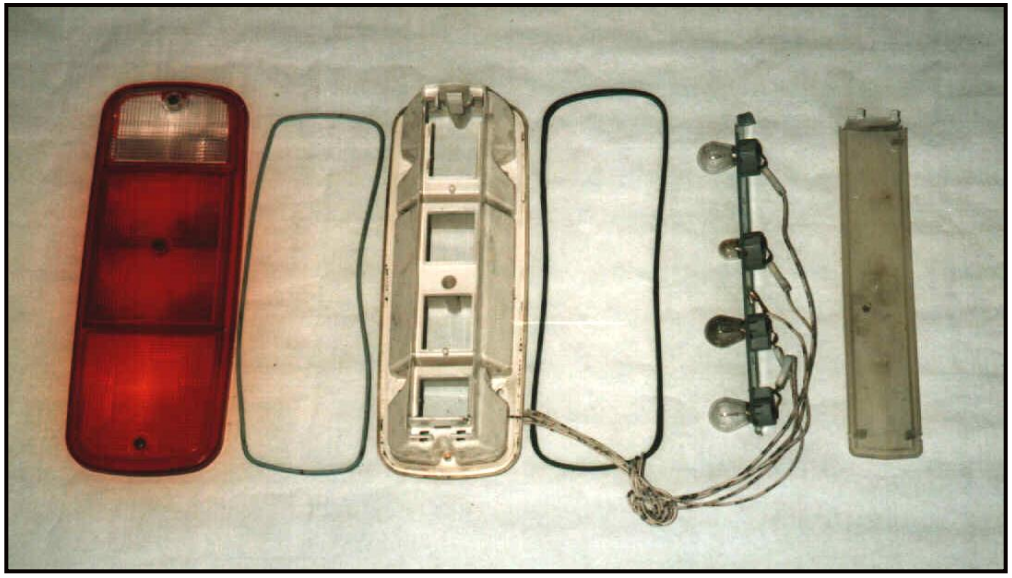
The example shows the steering column cover of a vehicle.

It is fastened with two different screws, a torx-screw and a cross-screw, so as for a tool exchange to be necessary and the dismantling costs increase.

Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Minimize non-detachable types of connection and as far as possible only recycling-compatible materials

Advantage: reduces isolating and separation processes for material recycling, lower process cost



The left figure shows the simple decomposition of a rear light.

By loosening two screws, the materials can be completely separated.

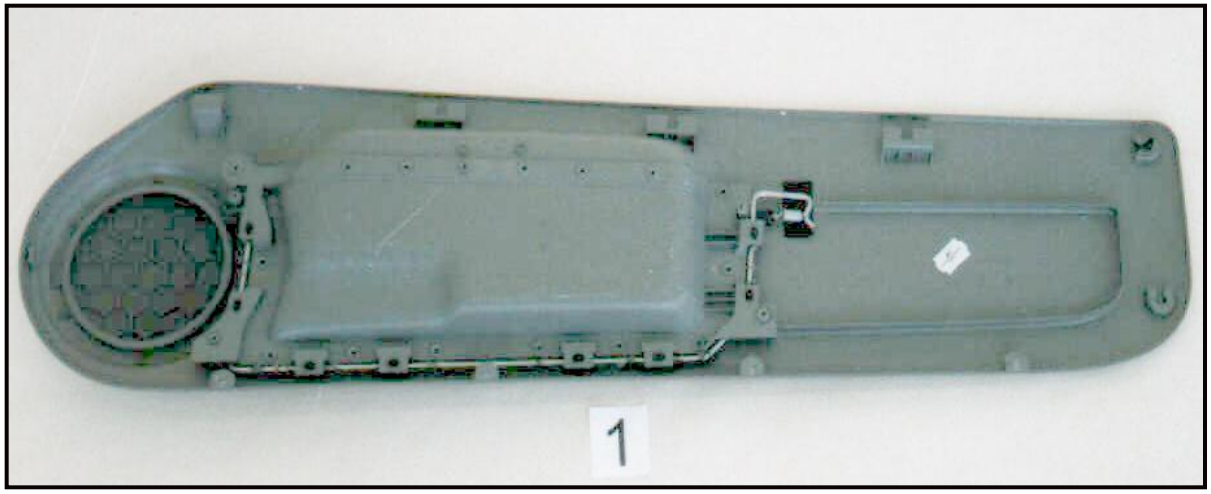
Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Minimize non-detachable types of connection

In the right example is a door-panel representing.

A thermo-welded metal bracket holds the map pocket on the front of the panel. During the shredding, the knives of the cutting mill would be destroyed immediately.

A better solution would be to attach the bracket, so that it will have screws or snap fits wich are easily separable.



Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Minimize non-detachable types of connection

In the illustration, two constructions of seats are shown.

In the left image is felt firmly glued to the polyurethane foam. A separation is not possible and so the material can only be supplied to an energy-recovery.

In the right example, rubber-hair-cushion, felt and polyurethane foam can easily be separated from each other.

For all three materials have recycling processes availably.

Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Minimize non-detachable types of connection

The left side shows an impact cushion door panel, which is a large scale gluing.

The separation is not economically feasible and must be fed as part of an energy recovery.

The image on the right also shows an impact cushion door panel. In this case, the component between the door outer panel and door panel was jammed. It is easy to disassemble and recycle them as one part material too.

Design recommendations – Practical hints for dismantling and connecting technique

Recommendation: Minimize non-detachable types of connection

The material consists of high-grade polycarbonate that is contaminated by the large-scale adhesion.

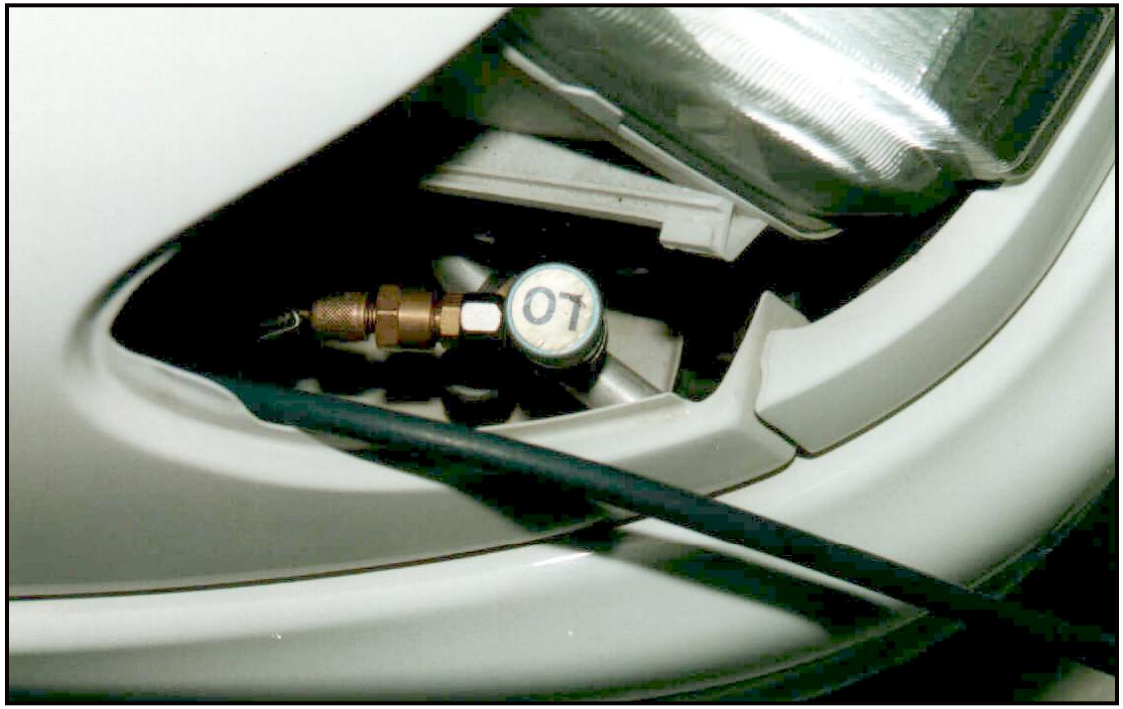
Material recycling for PC is practically possible, but not in this case.

Here, it should be examined whether a snap connection or a power-strip-connection would be beneficial.

Design recommendations for removal of operating material

Recommendation: Ensure that operating liquids can be removed independently from one another - simply, quickly and completely

Advantage: no environmental pollution results from uncontrolled liquids in subsequent recycling processes



Draining of the vehicles is to ensure that the components are not contaminated with fluids.

Therefore, the drainage must be done at an early stage of the dismantling process. It should not be necessary, if possible pre-disassembly.

In this example, the flashing light must be dismantled, because a removal of the refrigerant is otherwise not possible.

Design recommendations – Practical hints for the removal of operating material

Recommendation: Design drainage features and ensure that they can be detected and accessed easily

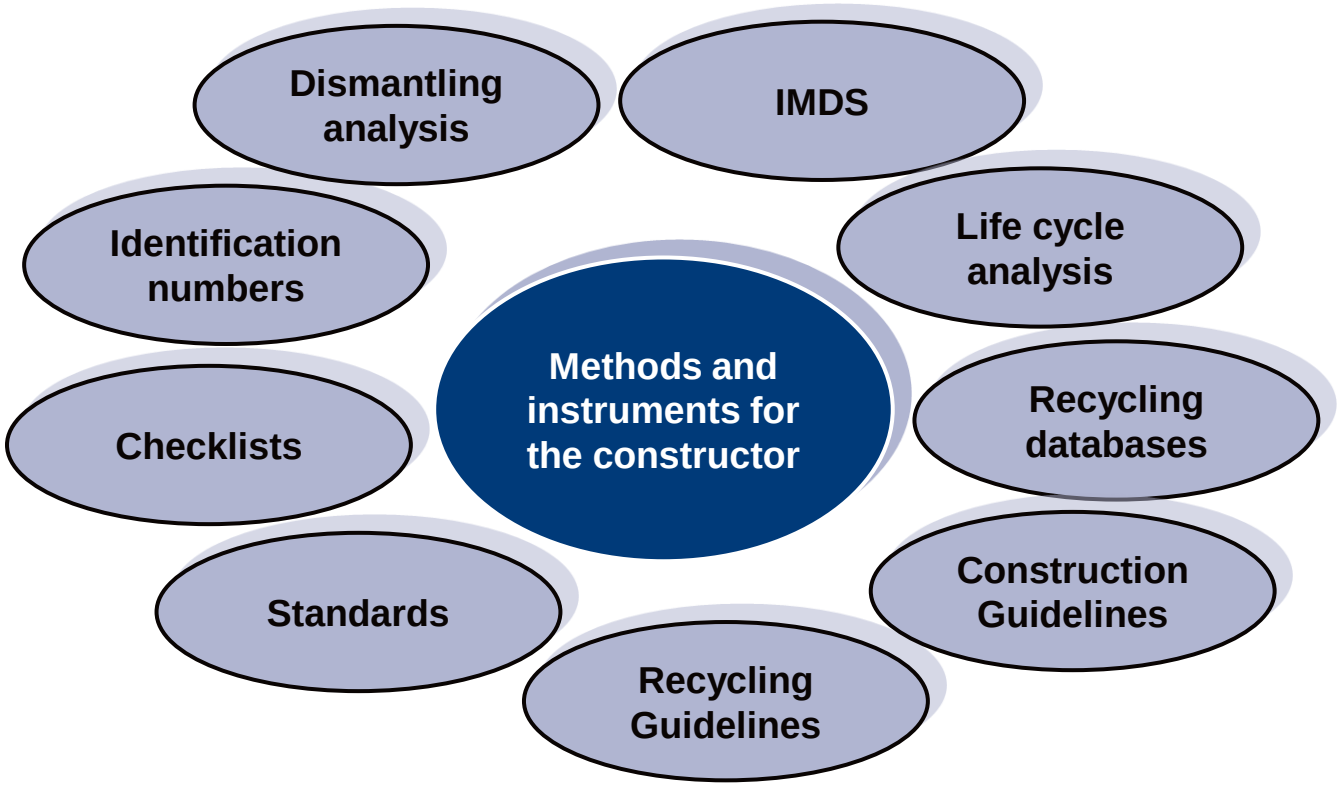
Advantage: specific and rapid removal means lower costs

The picture shows an engine mount from which the suspension fluid is drained.

The engine mounts have no possibility to drain the fluid and must, therefore, be destructively dismantled.

Liquid contained components should always be drained through a drain plug or a breaking point.

Methods of and instruments for the Constructor



For recycling-oriented design various tools and methods are available for engineers.

The designer considers in the design process, the recyclable suitability of the product. Here are various methods and instruments available.

At the end of the process is a design solution that must be reviewed and assessed. Therefor methods and instruments for the assessment of the solution are also available.

In the figure, the most important methods and tools are shown.

Dismantling analysis

Dismantling studies are an important tool for the assessment of products and components.

With them one can expose weaknesses in products and introduce improvements for future products.

Knowledge (selection):

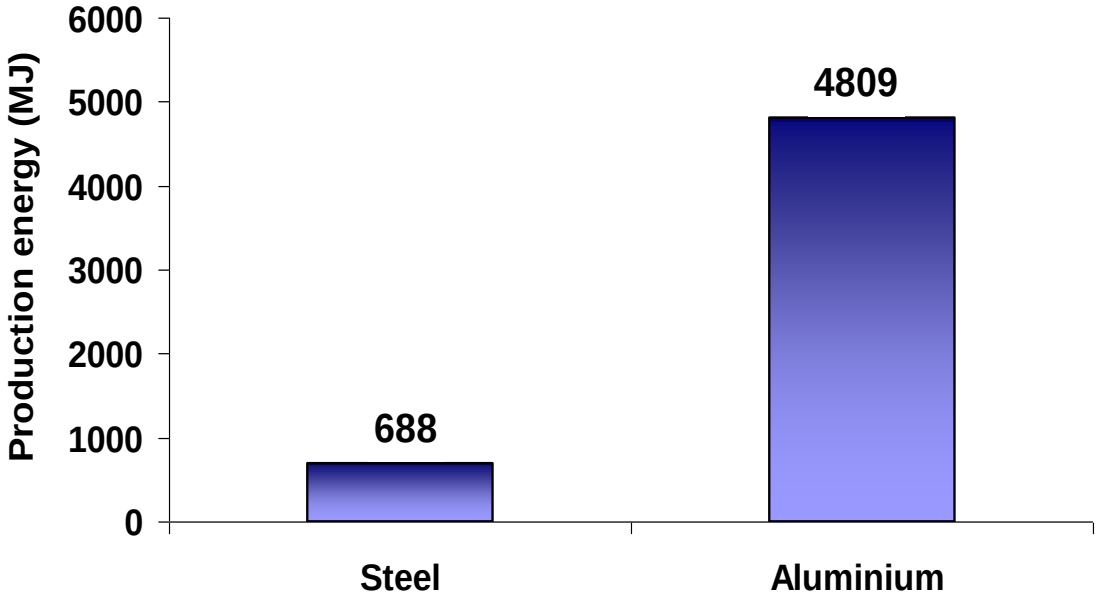
- Recycling quotas and drain off quotas
- Optimization potentials
  - Building structure
  - Material use
  - Material compatibility
  - Material identification
  - Connection technology
- Pollutant potential
- Processing and utilization concept
- Dismantling information IDIS

Example of a component-related energy balance (Source: BMW)

Accumulated consumption of energy for production

Weight of the steel intensive axis: approx. 50 kg

Weight of the aluminium intensive axis: approx. 30 kg



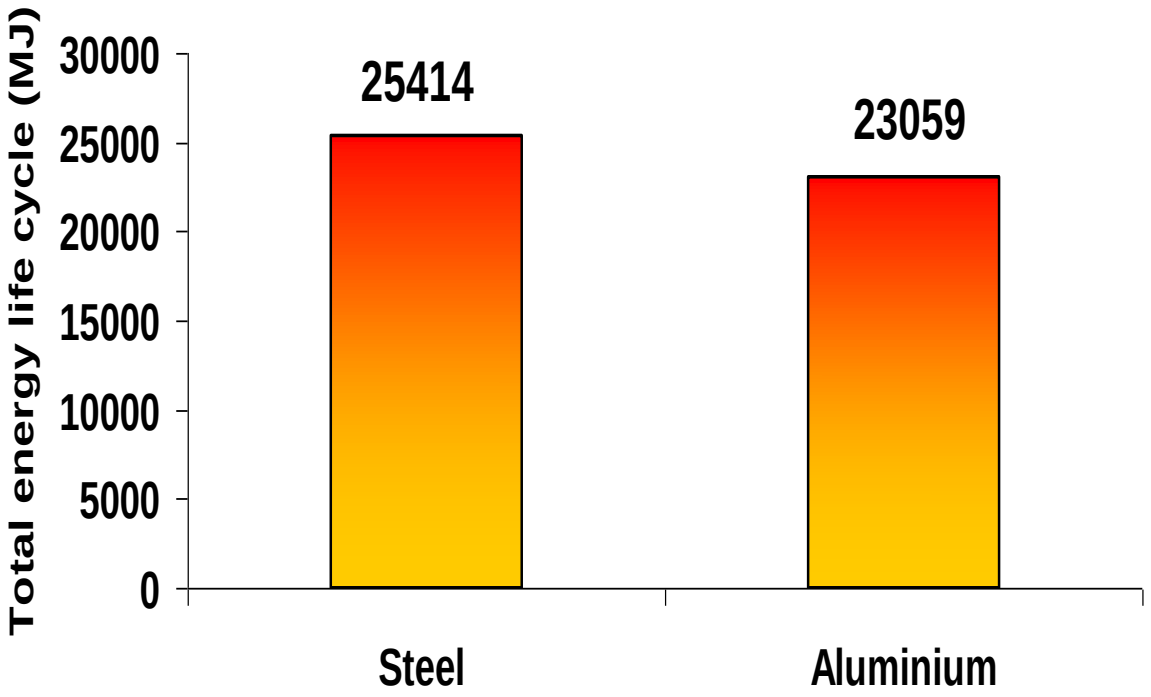
For the designer component balances are particularly interesting.

On the left side of the picture the energy consumption for an steel- and an aluminum axis is shown for comparison.

The aluminum axis requires in the production about 7 times more energy than the steel axis.

Example of a component-related energy balance (Source: BMW)

Accumulated consumption of energy for production, use and recycling of a steel intensive and an aluminium intensive rear axle, driven distance 200.000 km



In operation, the aluminum axis saves back the energy with increasing driven distance, because it is 20 kg lighter, and thus less energy consuming.

With approximately 160,000 km the break even point is reached and the aluminum axis then evaluate energetically favorable.

Assessment of the construction solution - suitability for recycling (materials recycleability KE_M)

Equation:

$$KE_M = \frac{\text{Costs of new products + disposal costs in €/kg}}{\text{Recycling costs secondary material in €/kg}} \quad (1)$$

Explanation: *Recycling costs of secondary material = costs (dismantling + preparation + logistics)*
Secondary material is comparable with the characteristics profile of the new products!

The material is (component-based) suitable for recycling, that is to say its material can be reused economically, if $KE_M > 1$.

The identification number for recycling suitability KE was defined to evaluate the economic viability of a recycling process.

The value compares the cost of new production with the cost of recycling.

If the value is greater than 1, the cost of the new production is higher and hence recycling is economically.

Assessment of the construction solution - suitability for recycling (materials recycleability KE_M)

Example:

Component made of ABS, weight 1 kg: (*values used subject to market fluctuations*)

Dismantling steps:	Loosen 12 screws at 3,0 s = 36,0 s	= –0.37 €
	Remove 3 parts at 4,0 s = 12,0 s	= –0.12 €
Preparation (cleaning, grinding, compounding, etc.) per kg		= –0.72 €
Logistics (registration, transport, acceptance) per kg		= –0.20 €
New products per kg		= –1.53 €
Elimination per kg		= –0.26 €

Calculation:

$$KE_M = \frac{(-1.53) + (-0.26) \text{ in } €/kg}{(-0.37) + (-0.12) + (-0.72) + (-0.20) \text{ in } €/kg} = 1.27$$

Result: **For this example, the recycling of ABS is ecologically and economically more favorable than using new ABS products**

In the figure, the KE-value for a component of ABS is shown. Due to the high price of new material recycling of the old component is recommented.