InCar –
the Modular Automotive Solution Kit

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ThyssenKrupp Steel USA
Introduction
InCar - Modular Solution Kit for the Automotive Industry

- The InCar – solution kit includes over 30 innovative solutions for body-in-white, chassis and powertrain
- Focus on key-requirements for the automotive industry: weight, cost, function and emissions
- In-house development of a validated reference structure as the basis for comparing all solutions
- InCar solutions have a high level of product maturity
InCar - Offers over 30 Innovative Solutions

- Roof
- Hood
- Seat crossmember
- Dash panel
- Valve trains
- Camshaft
- Longitudinal member front
- Integrated steering
- Side panel
- B-pillar
- Door
- Twist beam axle
- DampTronic® select
- Lightweight-chassis-concept II
- ThermoTecSpring®
- McPherson strut

Solutions for body

Solutions for chassis

Solutions for powertrain
Vehicle structure represents state-of-the-art

Full-size station wagon

Validated through extensive calculations and simulations

Basis of solution kit and reference for functional, technical and cost evaluation of all innovations

Customer-independent database will be used for future projects
Highlights
B-Pillar Solution Kit Overview

- **cold-stamped B-pillar**
  - B-pillar
  - hot-stamped B-pillar
- **One-piece**
  - Tailored Blank
  - Hotform Blank
  - Tailored Tempering
  - TPN®-W 900 Monolithic
  - DP-K® 45/78 Monolithic
  - DP-K® 45/78 / DP-K® 45/78 Tailored Blank
  - DP-K® 60/98 / RA-K® 40/70 Tailored Blank
  - MBW® 1500/MHZ 340 Hotformed TB, same gauge
  - MBW® 1500/MHZ 340 Hotformed TB, var. gauge
  - MBW® 1500 with Tailored Tempering
  - MBW® 1900 with Tailored Tempering

Reference:
B-pillar – cold-stamped – Tailored Blank – DP-W® 600 / DP-W® 600
## B-Pillar Solution Kit Overview

<table>
<thead>
<tr>
<th>No.</th>
<th>Solutions</th>
<th>Costs</th>
<th>Weight</th>
<th>CO₂-emissions (g/km)</th>
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<tbody>
<tr>
<td>REF</td>
<td>DP-W® 600 Tailored Blank (TB)</td>
<td></td>
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<td></td>
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<td>_01</td>
<td>TPN®-W 900 Monolithic</td>
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<td>-19%</td>
<td>-0.30</td>
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<td>_02</td>
<td>DP-K® 60/98 / RA-K® 40/70 TB</td>
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<tr>
<td>_03</td>
<td>MBW® 1500/MHZ 340 Hotformed TB Same Thickness</td>
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<td>-15%</td>
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<tr>
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<td>MBW® 1500/MHZ 340 Hotformed TB Variable Thickness</td>
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<tr>
<td>_05</td>
<td>MBW® 1500 with Tailored Tempering</td>
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<td>-17%</td>
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<tr>
<td>_06</td>
<td>MBW® 1900 with Tailored Tempering</td>
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<tr>
<td>_07</td>
<td>DP-K® 45/78 Monolithic</td>
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<tr>
<td>_08</td>
<td>DP-K® 45/78 / DP-K® 45/78 TB</td>
<td>-5%</td>
<td>-5%</td>
<td>-0.08</td>
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</tbody>
</table>

Reference: DP-W® 600 Tailored Blank
MBW 1500 / MHZ 340 Hot-formed Tailored Blank B-Pillar

Highlights

• Cost reduction of $2.50
• Weight reduction of 2.80 kg

Customer Benefits

• Provides good elongation (> 15%) at foot of B-pillar
• Excellent dimensional accuracy
• High volume series production achieved

Sheet thickness: 1.80/1.80 mm

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<td>-15%</td>
<td>-0.24 g</td>
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</table>

Reference: DP-W® 600 TB 2.20/2.00 mm
Hot-forming Simulation

• The B-pillars were validated for production using AutoForm
• Input for simulation: Process parameters, heat transfer coefficients, flow properties, friction, phase transformation, forming limit curve

Temperature distribution:

- min. temp approx. 400°C

Thickness distribution:

- min. sheet thickness: 1.11 mm
  initial sheet thickness: 1.80 mm
### Material Properties and Prototyping

* Depending on process parameters

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Min. yield strength [MPa]</th>
<th>Tensile strength [MPa]</th>
<th>Min. elongation [A$_{80}$ %]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before heat treatment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MHZ 340</td>
<td>340</td>
<td>410</td>
<td>21</td>
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<tr>
<td>MBW 1500</td>
<td>310</td>
<td>480</td>
<td>10</td>
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<tr>
<td><strong>After heat treatment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MHZ 340</td>
<td>450</td>
<td>550</td>
<td>15</td>
</tr>
<tr>
<td>MBW 1500</td>
<td>1,100</td>
<td>1,600</td>
<td>5</td>
</tr>
</tbody>
</table>

* Depending on process parameters

**Die**
- Pre-production prototype die

**Die entry temp**
- approx. 800 °C

**Transfer time**
- approx. 6 sec

**Press holding time**
- 20 sec

**Test material**
- MBW 1500 +AS, MHZ 340 +AS

**Thickness**
- 2.00 mm (test only)

**No. of parts**
- > 30 prototypes

Thermal image of part after forming process
Crash Behavior of Laser Weld

Test setup

- Mass: 130 kg
- Impact velocity: 30 km/h (18.6 mph)
- Impactor positioned on laser weld
- No cracking in laser weld

Energy-distance diagram, MBW1500/MHZ 340
Advanced Door Hot-stamped

Highlight

• Weight reduction of 1.96 kg per door at no additional cost
• Highly integrative Mid Panel design

Customer Benefits

• Most weight savings through use of DP 500 Outer Panel
• Mid Panel provides additional support for Outer Panel improving oil canning performance
• Improved side impact performance using hot-stamped TB Mid Panel

Advanced Door HS

Cost | Weight | CO₂/km

Reference: Conventional Tailored Blank Steel Door
Advanced Door - Design Characteristics

- Modular Design
- Outer Panel: 0.55 mm DP 500
- Inner Panel: 0.75 mm HX160
- Window Frame: 2.30/1.00 mm Tailor Welded Blank with integrated Hinge Rnf Upper
- Total Weight: 15.21 kg
Advanced Door Hot-stamped Forming Simulation

Simulation Temperature

Simulation Thinning
Dent Resistance and Oil Canning Performance

- Improved dent resistance, comparable oil canning
Forces approx. 20% higher than Reference Door
Front Rail Solution Kit Overview

- Front rail
  - Shell design
  - Profile design

One-piece
- Tailored Blank

Tailored Blank
- Monolithic RA-K® 40/70 / MHZ 340
- Monolithic TPN®-W 780 / TPN®-W 780
- DP-K® 45/78 / DP-K® 45/78
- DP-K® 45/78 / CP-W® 800 TPN®-K 60/90
- TPN®-K 60/90 / TPN®-W 900 DP-K® 60/98
- T³-longitudinal member DP-W® 600 / DP-W® 600
- T³-longitudinal member TPN®-W 780 / TPN®-W 780

Reference:
Longitudinal member – cold-stamped – Tailored Blank – DP-W® 600 / DP-W® 600
InForm T³ Longitudinal Member

Highlights
- Cost reduction of $4.51
- Weight reduction of 2.52 kg

Customer Benefits
- Improved material utilization
- InForm T³ technology can be adapted to conventional stamping press
- Spot-weldable subassembly for simple production integration
- Innovative solutions for integration of bulkheads and bushings developed

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<tr>
<td>-11%</td>
<td>-16%</td>
<td>-0.21 g</td>
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* Longitudinal member (not sub-assembly)
Reference: DP-W 600 TB C-section 1.80/2.00
DP-W 600 Side Member 1.80
InForm T³ Process Steps

- Blank is positioned above U-shaped die
- U-forming through vertical movement of punch
- Cam side forming with core inserted
- O-forming by punch with core inserted
- End flange forming, holes punching
- Die opened, core removed, edges welded
InForm T³ Process Video
InForm T³ Pilot Line

- Double-acting servohydraulic press with 5 controlled main axes and several auxiliary axes
- Multifunctional die to test process variants, flanges and piercing
- Close-to-production 3D longitudinal welding through integrated laser optics and sensors
Dimensional Accuracy of Prototypes

- More than 100 parts produced
- Good correlation with simulation
- Repeatability accuracy for prototyping: ± 0.2 mm
- Expected dimensional accuracy for production:
  - General: ± 0.3 mm
  - Ends/flanges: ±0.5 mm

Maximum variances from mean value
Tubular Member Bulkhead and Bushing Integration

- Front bulkhead inserted from the side and attached by MAG welding
- Remote laser welding used to join Bulkheads to Bushings
- Fatigue testing showed comparable performance to reference design
InForm T³ Longitudinal Member Cost Comparison

- European cost analysis based on production volume of 200,000 veh/year for an eight year life cycle
- 11 - 13% cost reduction obtained for tubular longitudinal members
- Most cost savings achieved through improved material utilization
InCar - Summary

- Over 30 innovative solutions to meet current auto industry requirements
- Validated, reliable information on cost, weight and function/performance
- Objective comparability of solutions by benchmarking against reference structure
- Use of innovative and production-ready materials, processes and technologies
- More than 100 dies built, 329 parts in total, 3 complete body-in-whites built
- InCar will be continued beyond 2011, delivering new results permanently