

## Automobile Roof Design

Roof types, components, FMVSS 216a roof crush, oil canning, materials and manufacturing

### Roof Components

| Component               | Function                                                                    |
|-------------------------|-----------------------------------------------------------------------------|
| Roof bow                | Transverse brace; stops flutter, transfers load between headers in rollover |
| Roof rail / roof ditch  | Side channels at the door openings; carry roof side loads                   |
| Front header            | Above windshield; ties roof to A-pillars, keeps windshield interface intact |
| Rear header             | Above rear window; ties roof to C/D-pillars                                 |
| Sunroof module / ring   | Mechanism frame / reinforcement that restores stiffness around the opening  |
| Roof outer / glass roof | Visible skin; carries little load (~12% in side impact)                     |

### Roof Types

|                           |                                                                                         |
|---------------------------|-----------------------------------------------------------------------------------------|
| <b>Hardtop</b>            | Fixed solid roof; most passenger vehicles.                                              |
| <b>Convertible</b>        | Soft-top, retractable hardtop or targa; needs added structure to replace lost rigidity. |
| <b>Sunroof / moonroof</b> | Tilting or sliding panel / larger tinted-glass version.                                 |
| <b>T-top</b>              | Two removable panels either side of a fixed center bar.                                 |
| <b>Panoramic</b>          | Glass from front to rear seats.                                                         |

### Key Numbers

#### 3 × UVW

FMVSS 216a load for vehicles over 6,000 lb, both sides

#### 0.65-0.75 mm

Typical modern roof panel thickness (was < 1.5 mm)

#### < 5 in

Max roof deformation allowed

#### 250-300 mm

Stiffening bead spacing on SUV roofs

#### ~35%

Rollover occupants killed; >7,500 per year

#### ~1/3 · ~1/4

Body structure · BIW share of vehicle mass

### Design Rules

- Roof crush load path: A-pillars, B-pillars, front header and roof rails (platen sits ahead of the C-pillar).
- Headers and rails use high-strength steel such as press-hardened steel.
- Crown peaking near the B-pillar improves aero and channels water down the roof ditch away from doors.
- **Oil canning:** panel snaps through when load exceeds  $P_{cr}$ . Raise  $P_{cr}$  with curvature, support conditions, roof bows and fore-aft stiffening beads.
- Keep airflow attached over the roof; roof racks add frontal area and drag.
- Roof also mounts headliner, harnesses, curtain airbags, grab handles, visors, console and antenna.

### Manufacturing

- Stamped from one blank; sunroof opening cut during stamping.
- Body shop: toy tabs hold the BIW; headers tie the left and right BSOs together.
- Roof is top-loaded near the end and **laser brazed** (bronze filler) for a clean, molding-free joint with a small heat-affected zone.
- History: Cadillac enclosed body 1905; Peugeot 402 folding hardtop 1935; sunroof 1937; moonroof 1973.