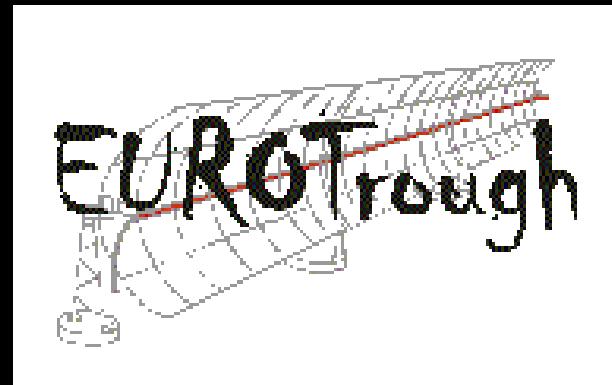


SOLAR INTERNATIONAL



□ Objective

Design and prototyping of an advanced cost effective Parabolic Trough Collector

Partners

- Instalaciones Abengoa SA, División Taller (“INABENSA”) / Spain
- Schlaich Bergermann und Partner (“SBP”) / Germany
- FICHTNER GmbH & Co KG (“FICHTNER”) / Germany
- Pilkington Solar International (“PILKSOL”) / Germany
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (“DLR”) / Germany
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (“CIEMAT”) / Spain
- Centre for Renewable Energy Sources, (“CRES”) / Greece

Budget

- 2,402,514 € (1,199,899 € funded by the European Commission)
-

Conceptual Design

- Collector Specifications, Load and Design Assumptions**
- Wind Tunnel Test**
- Recalculation of Existing Space Frame Structure**
- Design and Evaluation of Torque Tube Design**
- Design and Evaluation of Torque Box Design**

Design Goals

- Dimensions: *LS-3 type Reflectors and Absorbers Tubes should be used*
- Weight of the Support Structure: *Less than LS-3*
- Overall allowed deformation in operation (due to the most severe combination of design loads): *Smaller than 14 mrad*

Wind Load Assumptions

- Operation Wind: 0 m/s – 14.3 m/s

Deformations within tolerances in any position

- Transient Wind: 21 m/s

Maximum tolerable wind speed experienced by the SCA in operation or while moving to stow in response to wind alarm. Stress within tolerances + sufficient drive power in any position

- Survival Wind: 31.3 m/s

Stress within tolerances in stow position

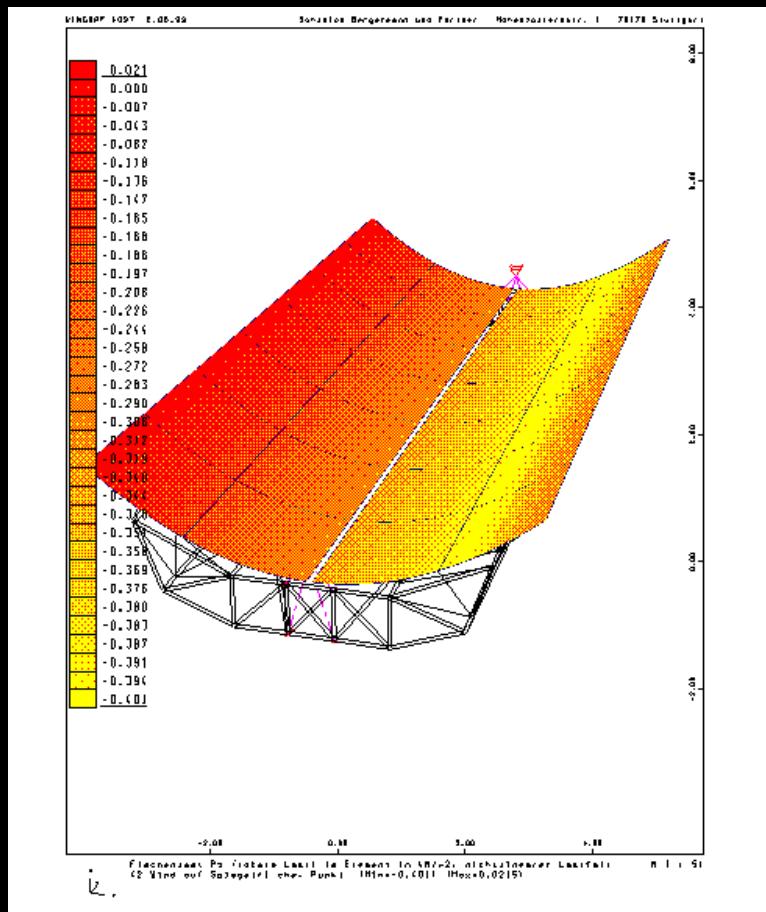
Determination of the C_p values

- for different wind speeds, wind directions, and different collector angles
 - at different positions along a row and at different row locations in the solar field

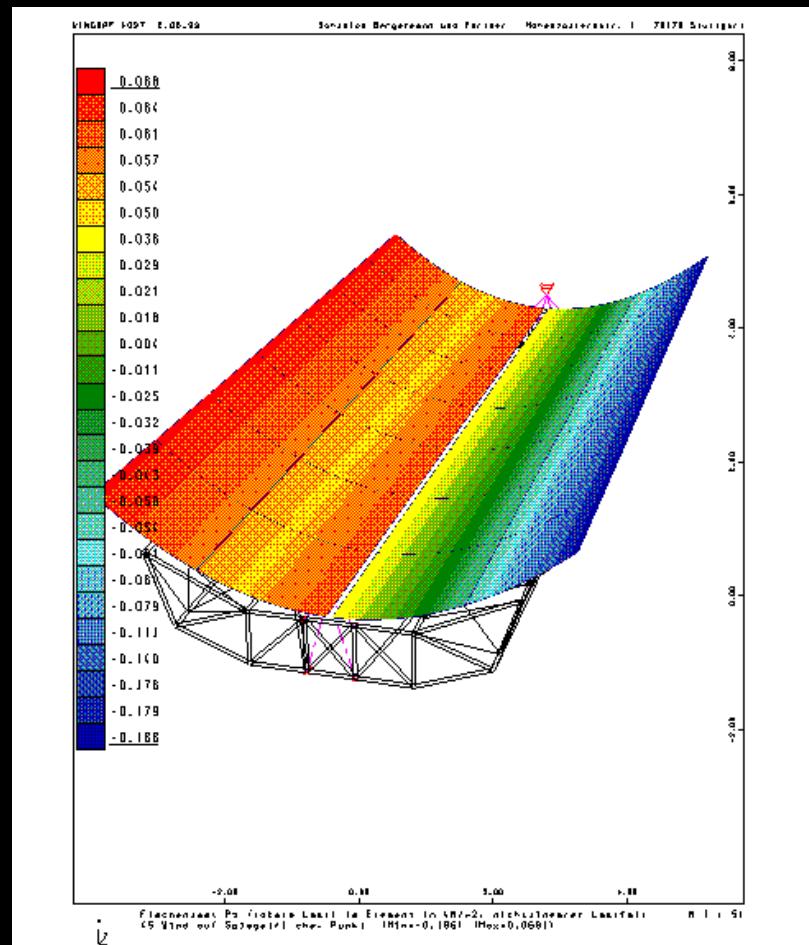
The matrix below summarizes the measured average c_p values for different wind zones in the collector field for Stow Position.



Forces [kN/m²] for a maximum bending wind load case

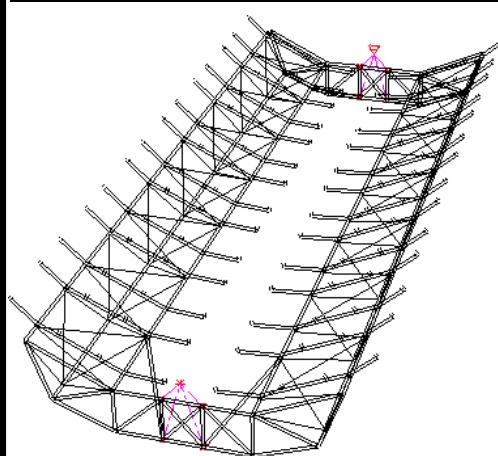


Forces [kN/m²] for a maximum twisting wind load case

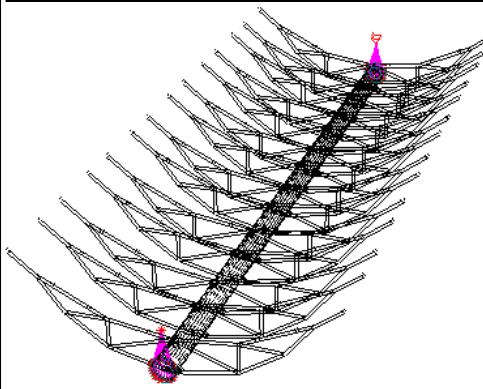


-
- Space Frame Design (LS3) as Reference
 - Torque Tube Design
 - Torque Box Design
-

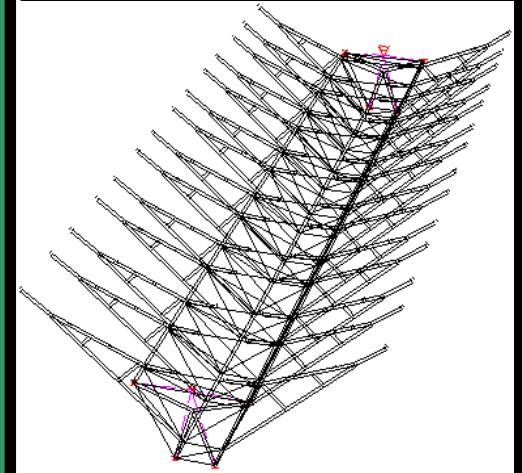
*Space Frame Design
(LS-3)*



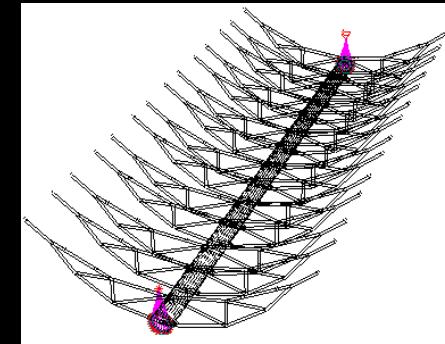
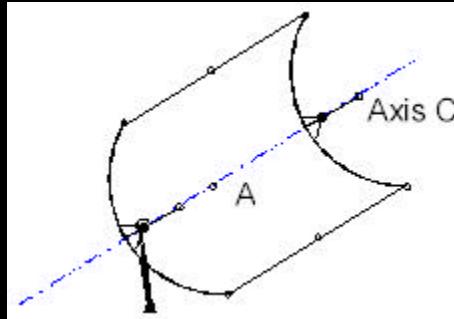
Torque Tube Design



Torque Box Design



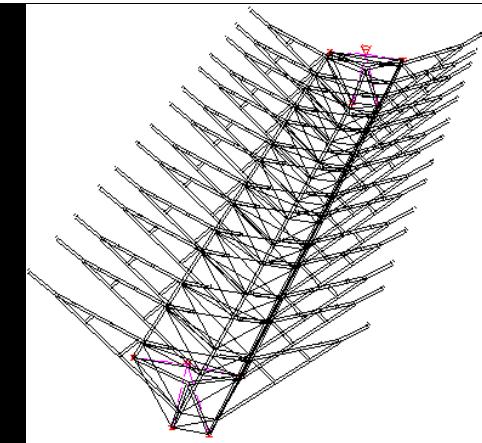
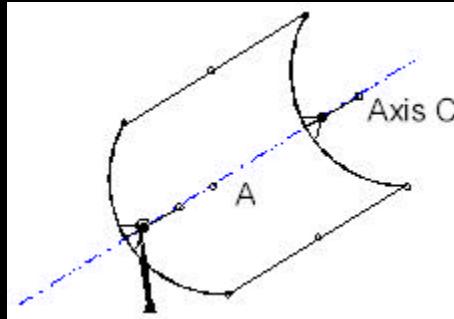
Torque Tube Design B - Zone B, Operation



FEM - Deformation Analysis during Operation:

Load Case	Displacement Point A (lateral) [mm]	Distortion Surface φ_z (average) [mrad]	Torsion Axis C (one CE) [mrad]	m/A	m/ φ_z	m/C

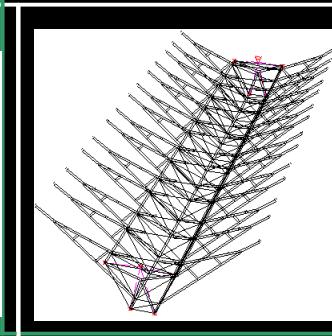
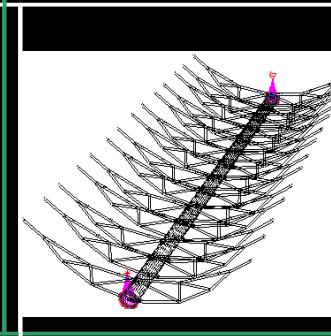
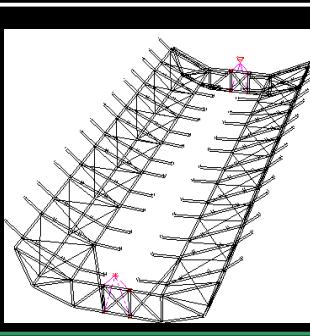
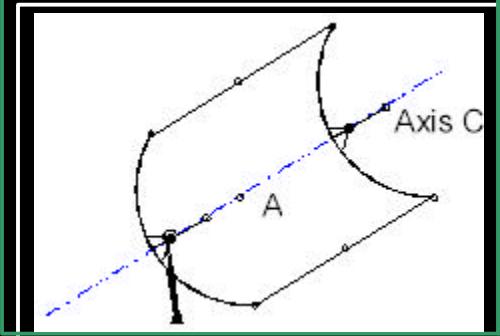
Torque Box Design C - Zone C, Operation



FEM - Deformation Analysis during Operation:

Load Case	Displacement Point A (lateral) [mm]	Distortion Surface φ_z (average) [mrad]	Torsion Axis C (one CE) [mrad]	m/A	m/ φ_z	m/C
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Summary of Results - Zone A



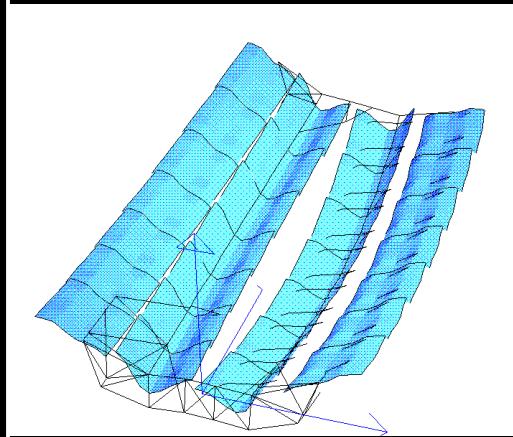
A

A

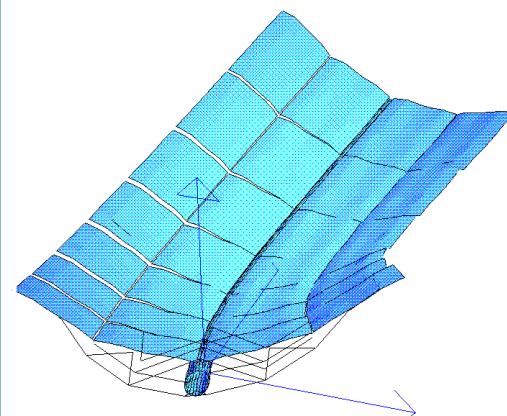
Summary of Results - Zone A, Operation

- Distortion of collector surface [mm x 60] for Maximum Wind Bending

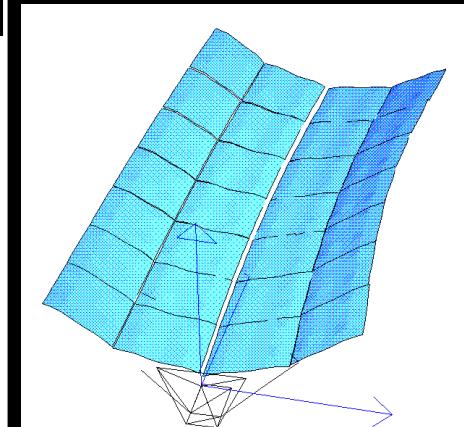
Existing Regular Version



Torque Tube Design



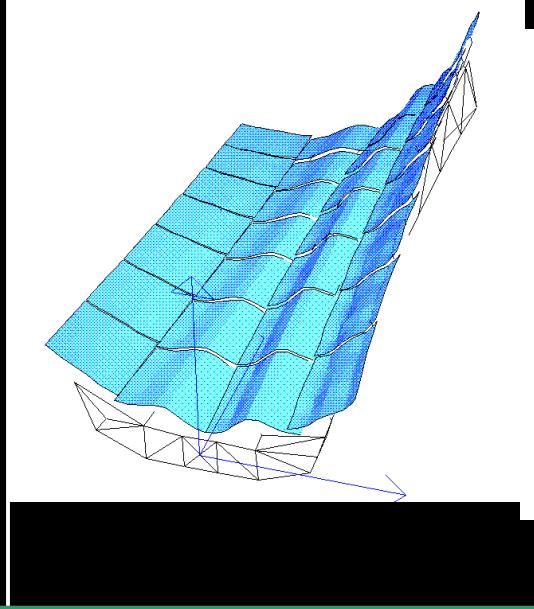
Torque Box Design



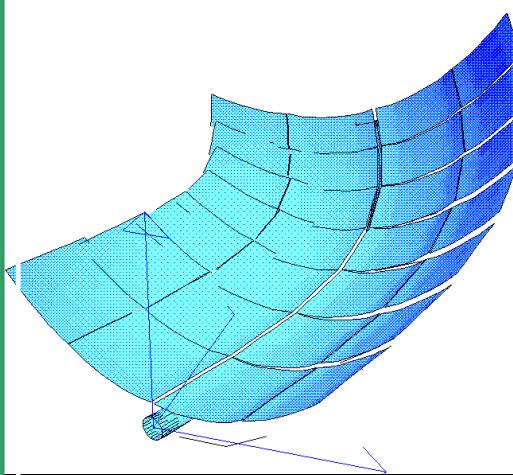
Summary of Results - Zone A, Operation

- Distortion of collector surface [mm x 60] for Maximum Wind Torsion

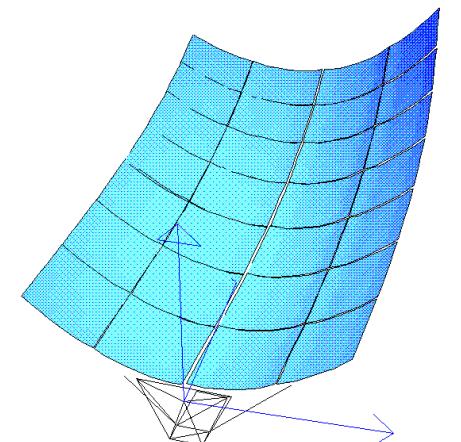
Existing Regular Version



Torque Tube Design



Torque Box Design



Reflector Improvement

First Results

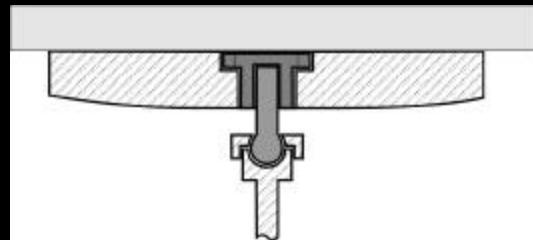
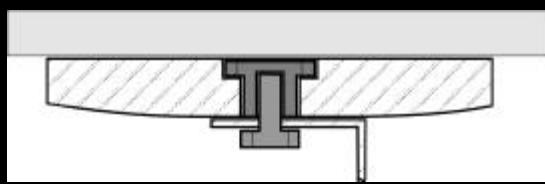
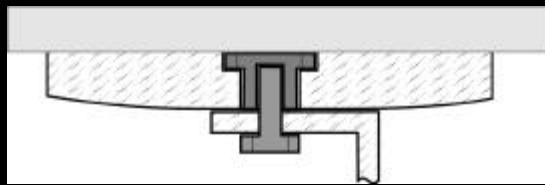


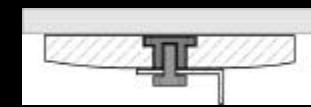
Objective

Improvement of Trough Reflectors

Analyzed Options

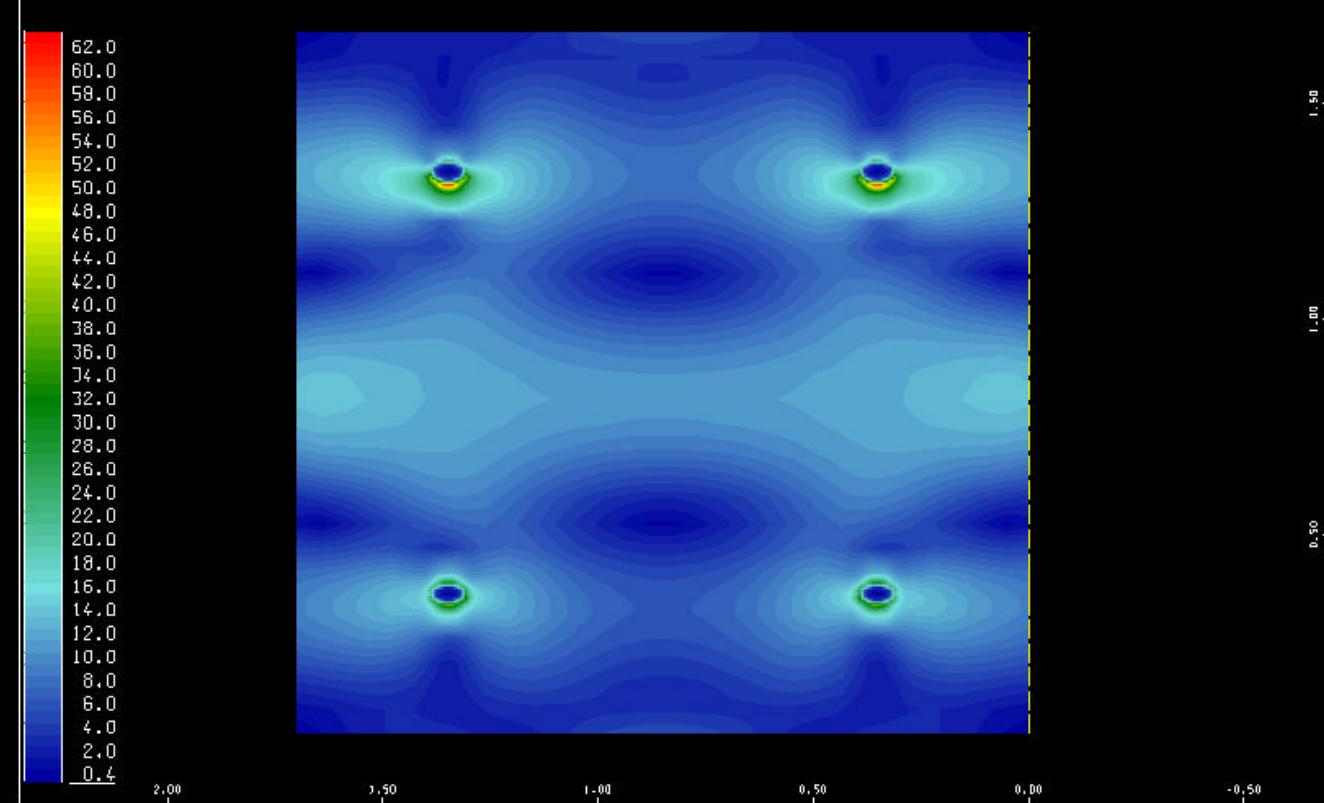
- Different Pad Attachments
 - Thicker Glass
 - Larger Pads
 - Thicker Silicon Layer
 - Different Pad Locations
-





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z Spiegel unten

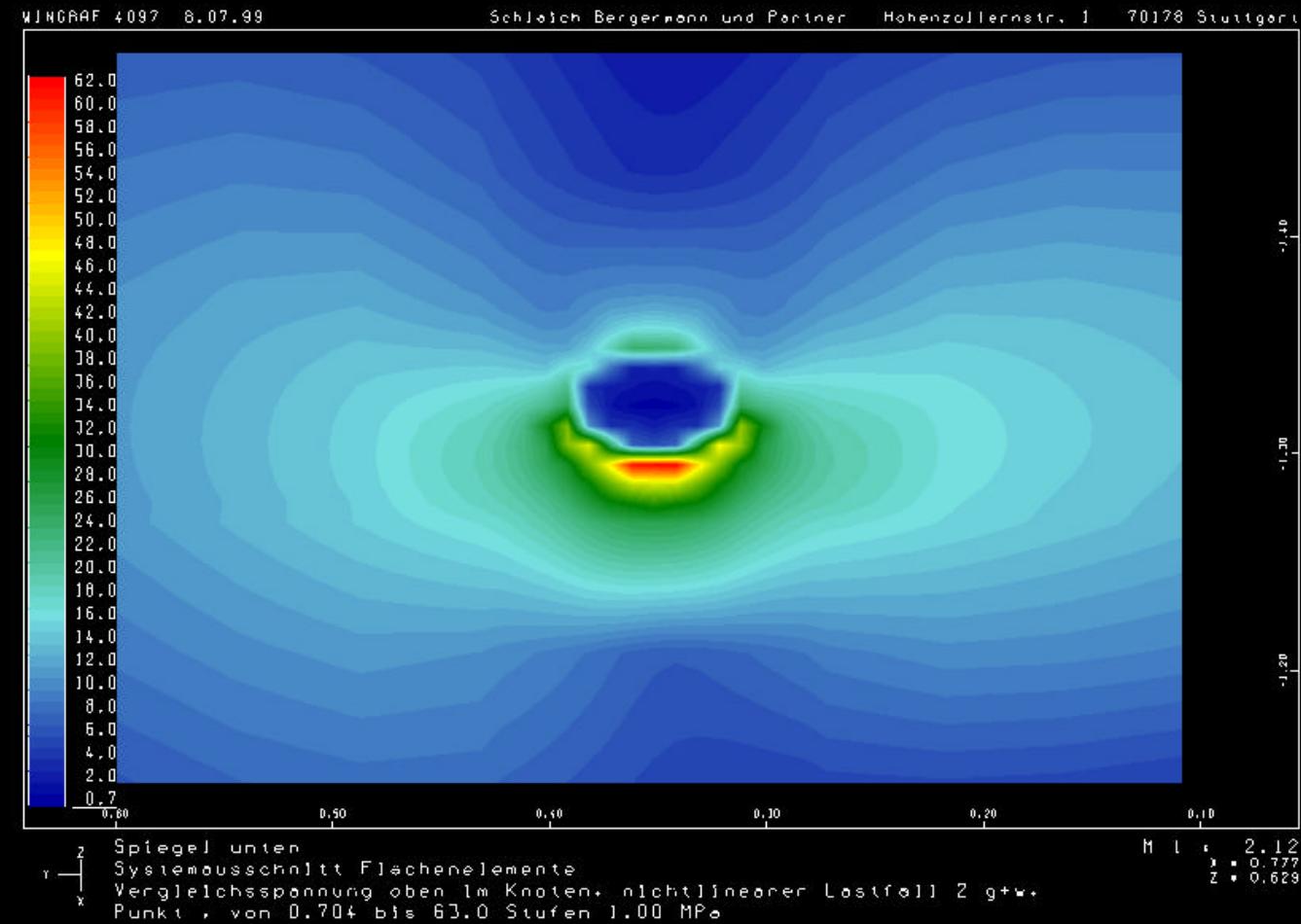
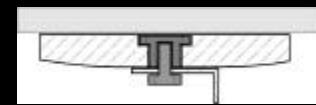
y Systemausschnitt Flächenelemente

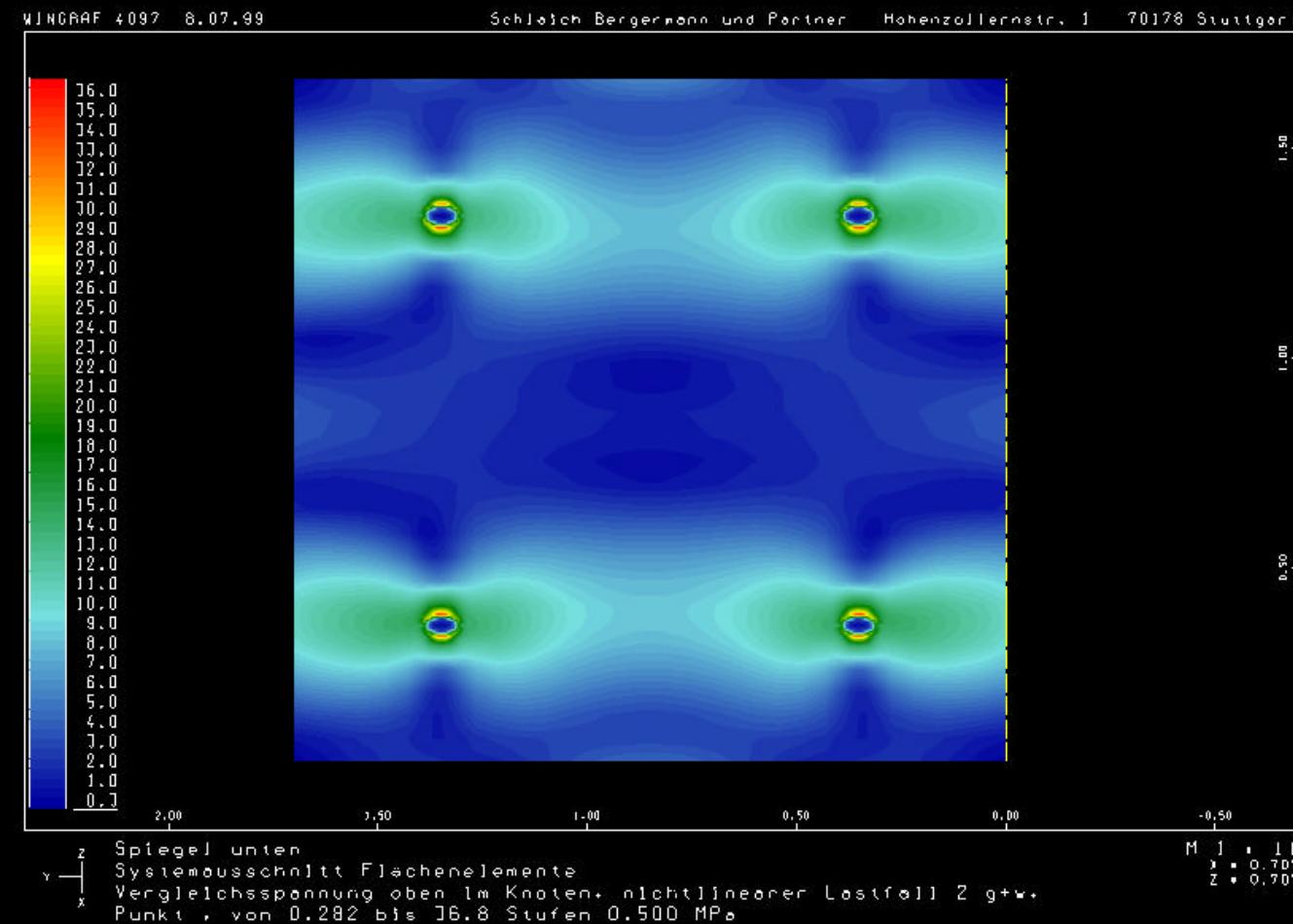
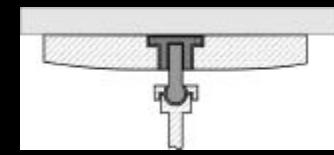
x Vergleichsspannung oben im Knoten, nichtlinearer Lastfall 2 g++
Punkt , von 0.399 bis 63.3 Stufen 1.00 MPa

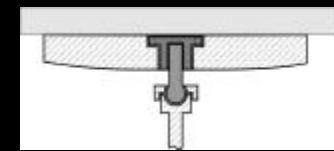
M 1 : 11

x : 0.707

z : 0.707

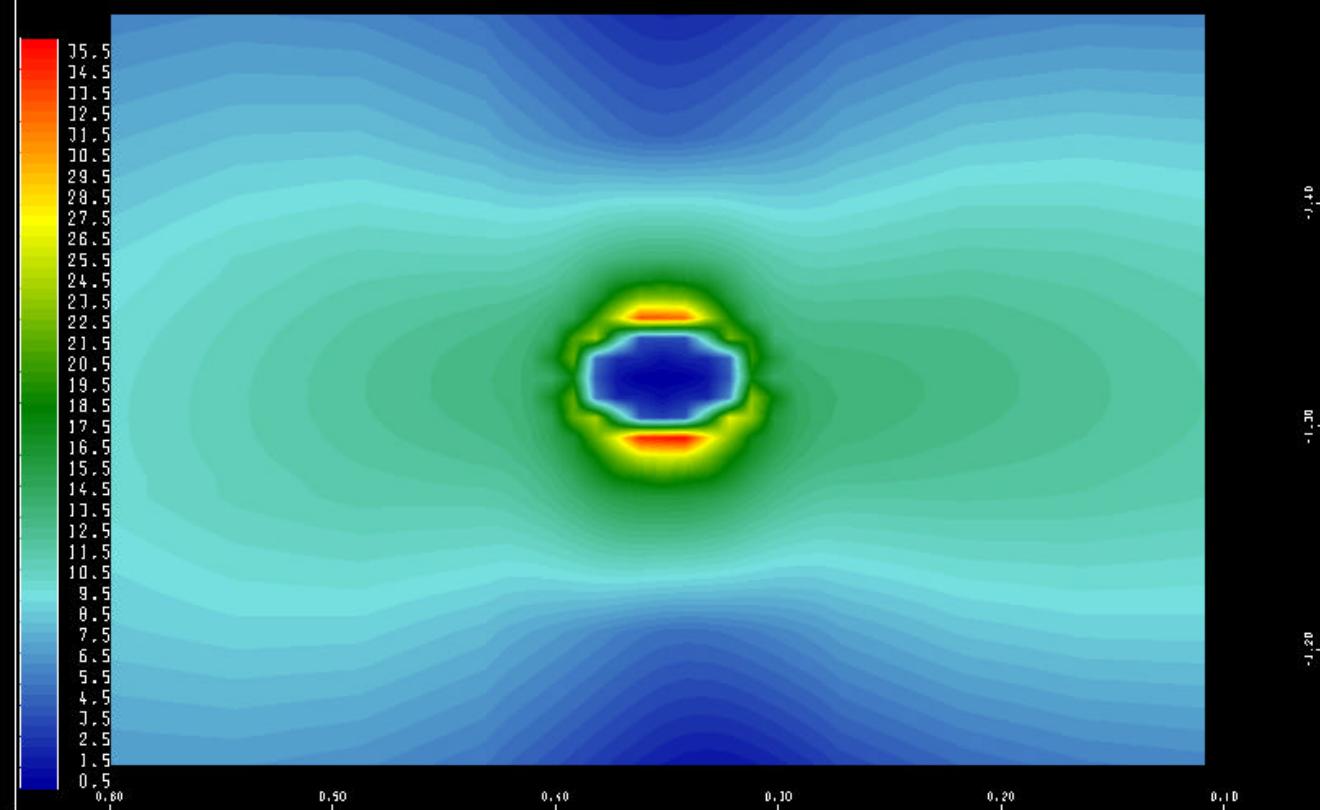






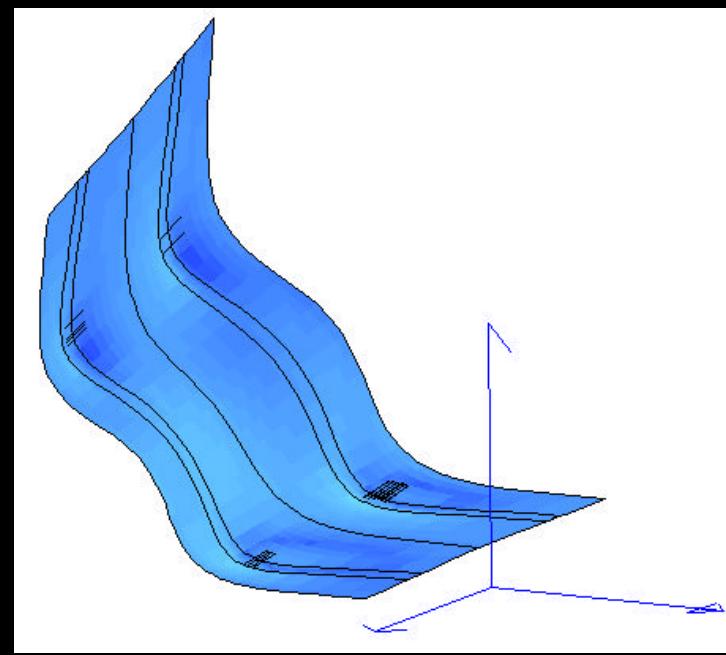
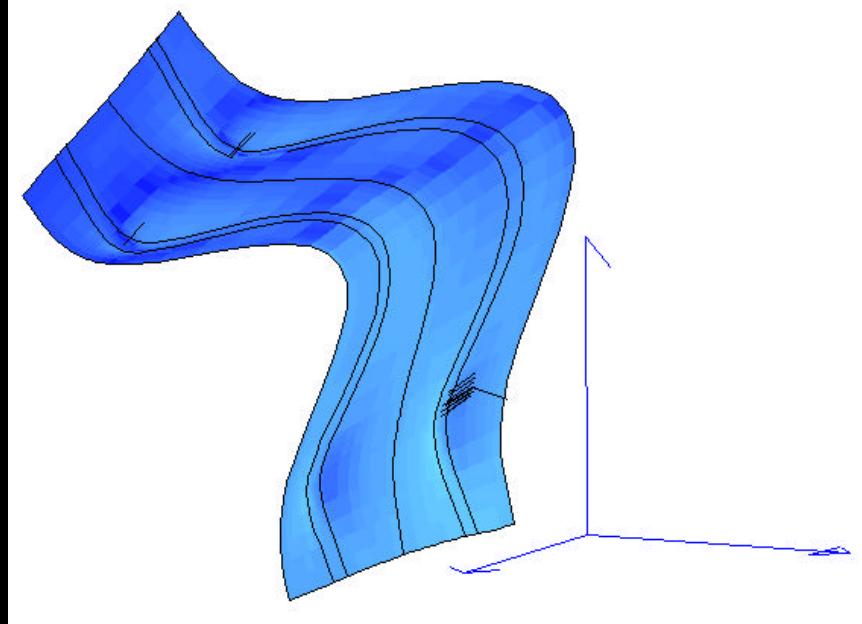
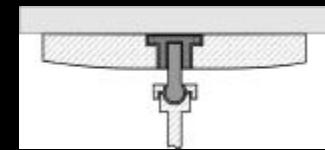
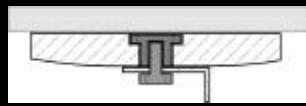
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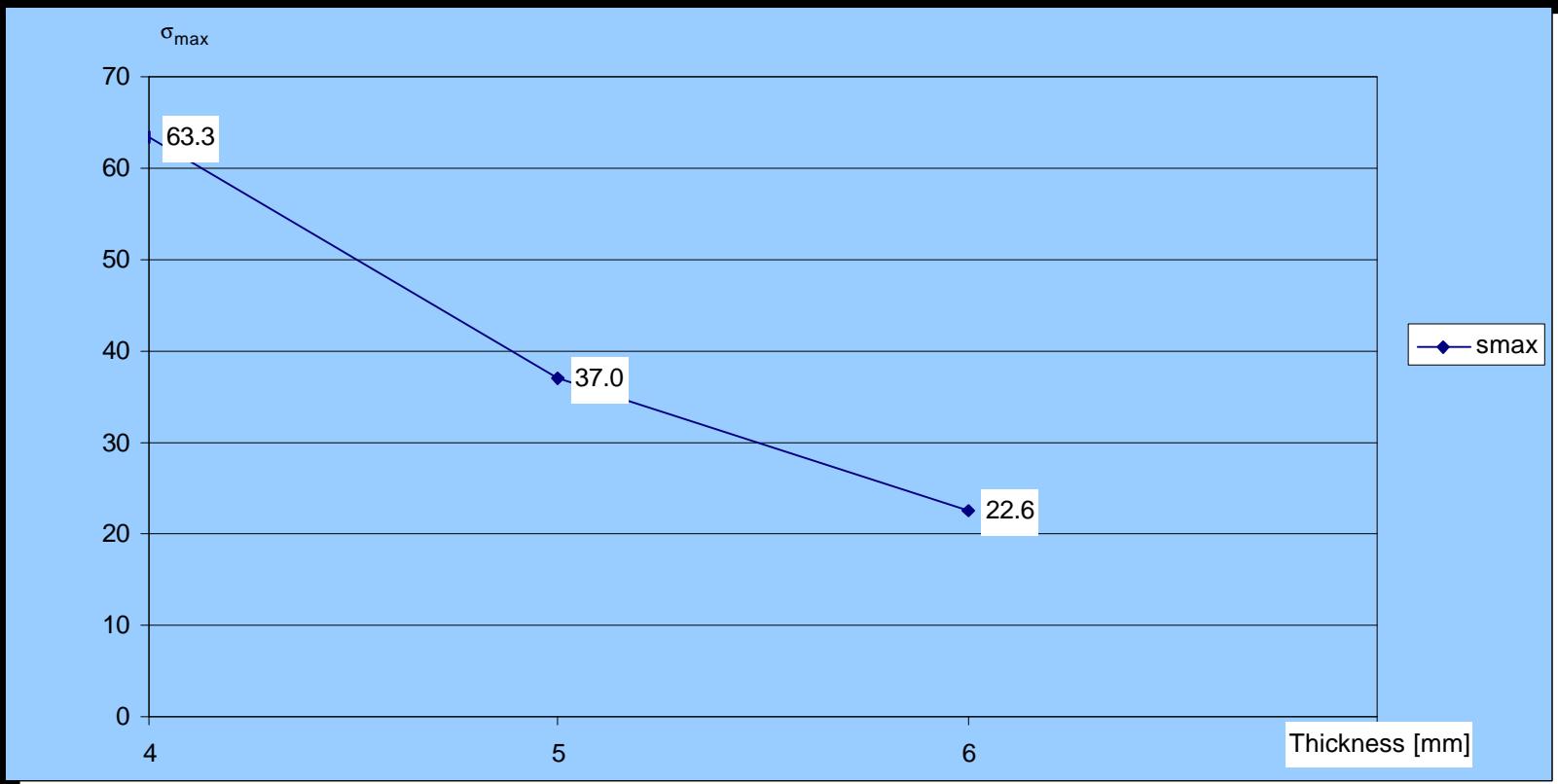
z Spiegel unten
Systemausschnitt Flächenelemente
Vergleichsspannung oben im Knoten+ nichtlinearer Lastfall Z g+w,
Punkte von 0.522 bis 36.3 Stufen 0.500 MPa

M 1 : 2.12
x = 0.777
z = 0.629





Glass thickness [mm]	4	5	6
σ_{\max}	63.3	37.0	22.6



Change	Type of Attachment											
	Flexible (LS-3)				Fixed (LS-2)				Ball (Eurothrough)			
	σ_{\max}	Factor	σ_{avg}	Factor	σ_{\max}	Factor	σ_{avg}	Factor	σ_{\max}	Factor		
Base case	63.3	1.0	12.0	1.0	53.2	1.2	2.0	6.0	36.8	1.7	3.2	3.8
Larger pads (4x)	43.8	1.4	11.4	1.1	32.3	2.0	1.8	6.7	27.9	2.3	2.7	4.4
Thicker silicon layer (5mm)	44.8	1.4	12.3	1.0	37.8	1.7	2.0	6.0	24.1	2.6	3.2	3.8
Thicker glass (5mm)	37.0	1.7	7.7	1.6	32.8	1.9	1.6	7.5	22.9	2.8	2.5	4.8
Different pad location (15cm)	worse		worse		18.3	3.5	2.1	5.7	14.7	4.3	3.4	3.5