

Bulging Resistance of Coke Drums using Staggered Seam Design

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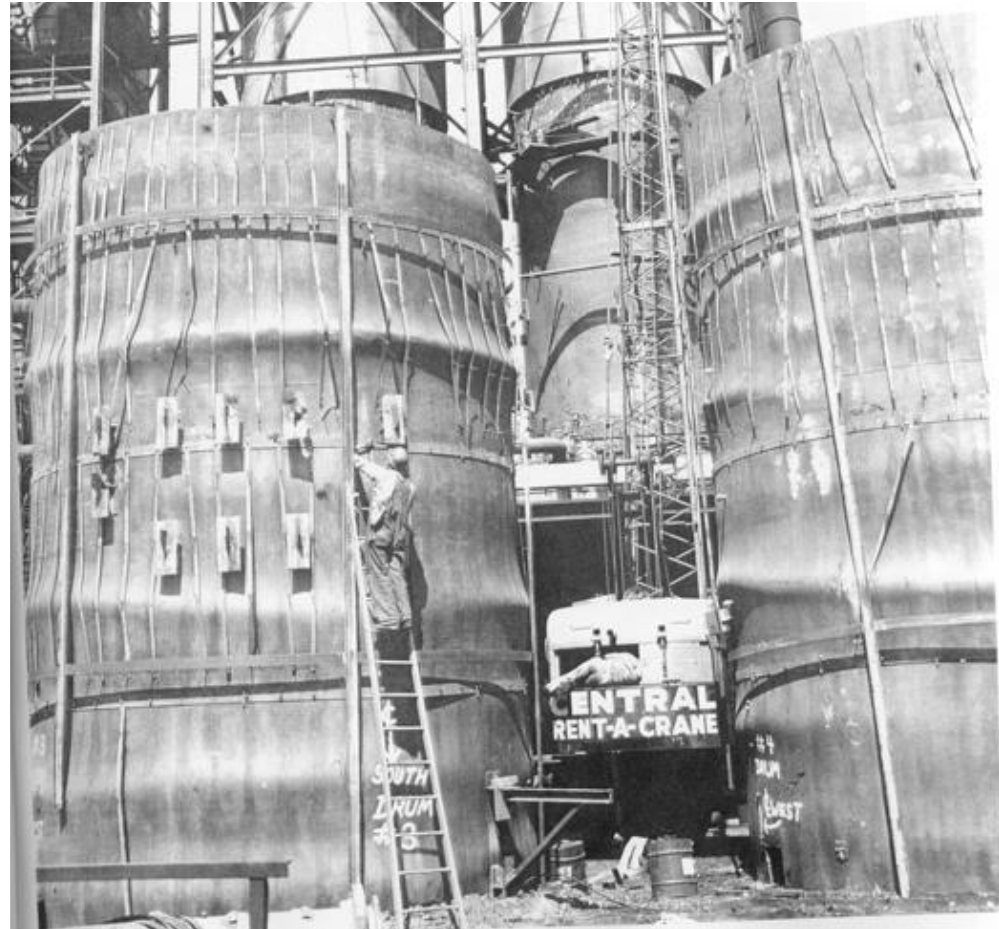
RefComm Global 2020
November 2020

Overview

- Shell bulging
- Types of bulges
- Vertical plate design
- Staggered seam design
- Analysis of staggered seam design
- Recent development

Shell Bulging

- Major problem for decades.
- Despite design improvements, still a problem- perhaps more severe today.

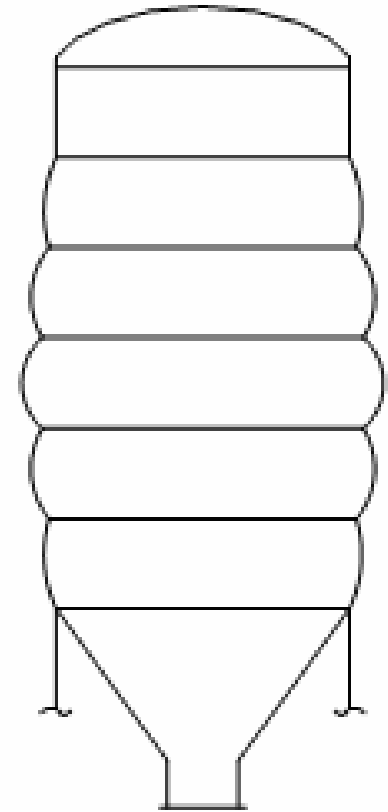


Courtesy of CB&I

Bulging Types

Samman (2016) “Bulging Patterns of Coke Drums.” ASME, PVP2016-63812.

- Uniform
 - Seam Bulging
 - Bottom Growth
 - Tapered Growth
 - Outage Growth
 - Mid-height Growth
 - Band Bulging
 - Helical Bulging
 - Accordion Bulging
- Local



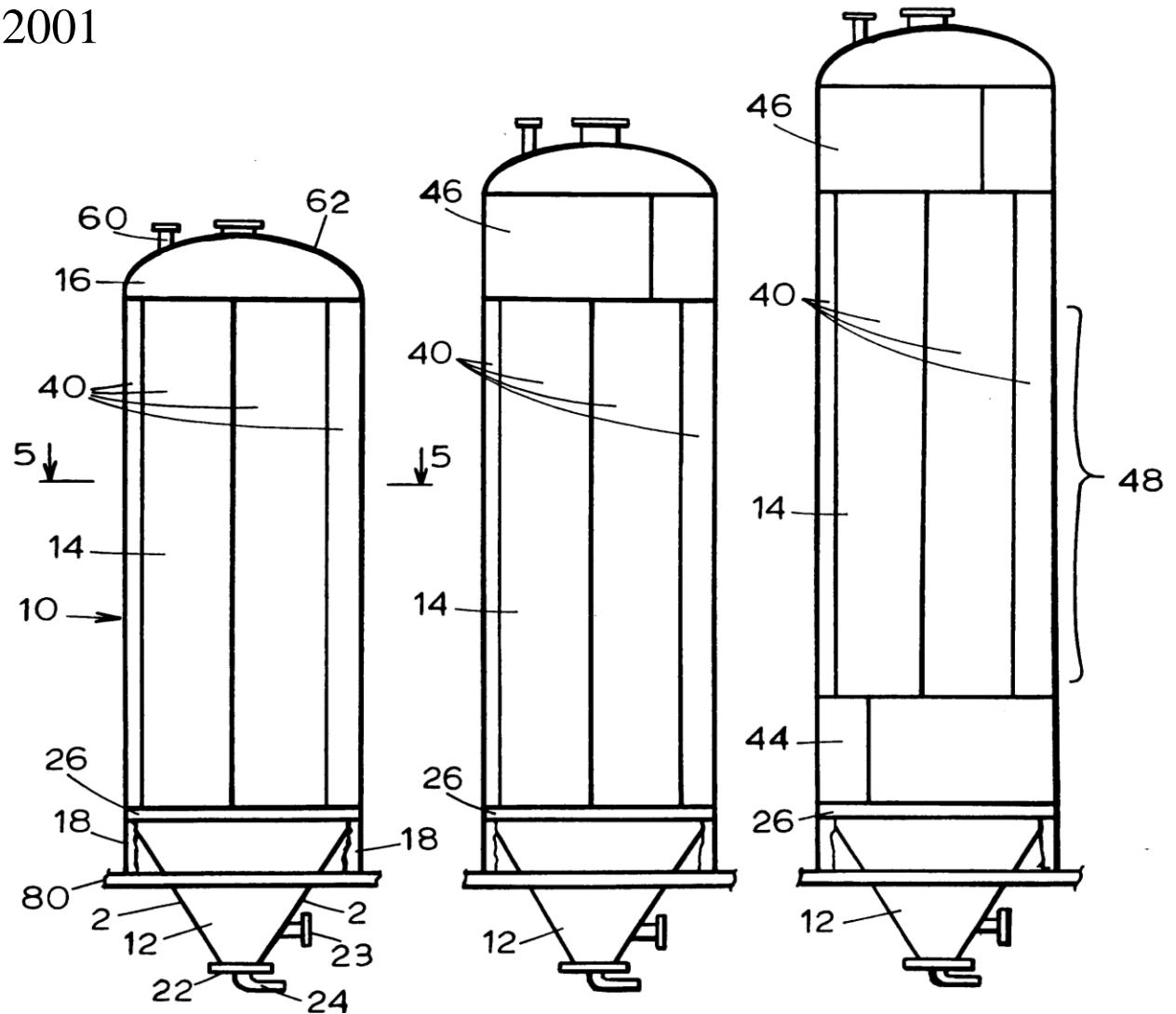
Weil and Rapasky (1958)
The constrained balloon

Unconventional Shell Designs

- Vertical plate
- Staggered seam

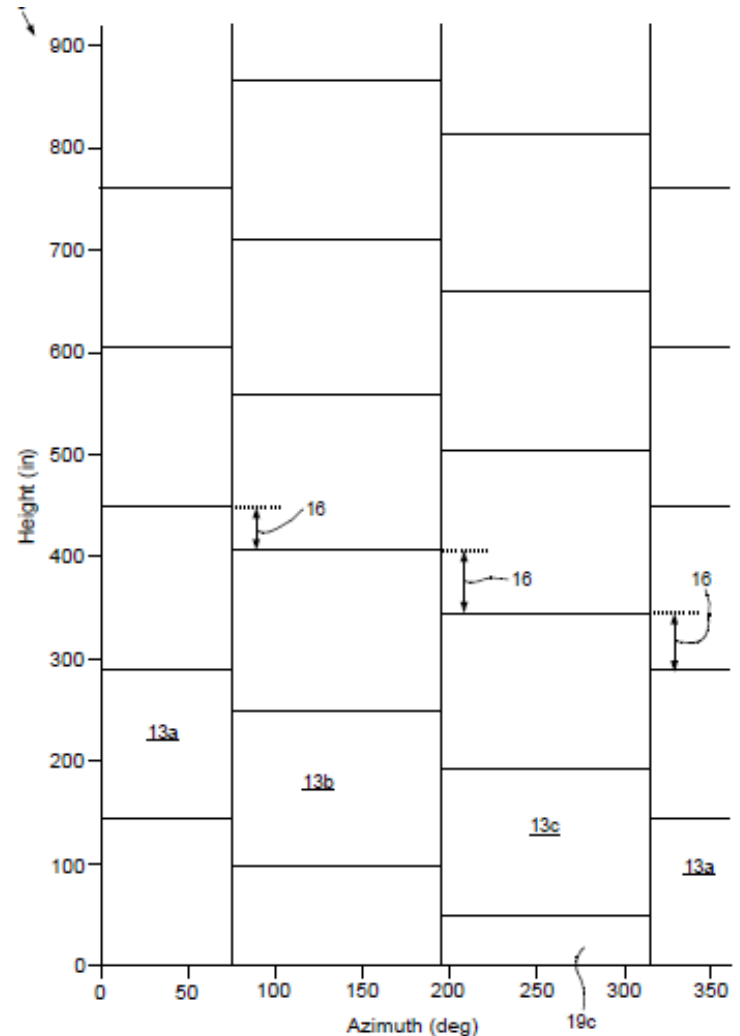
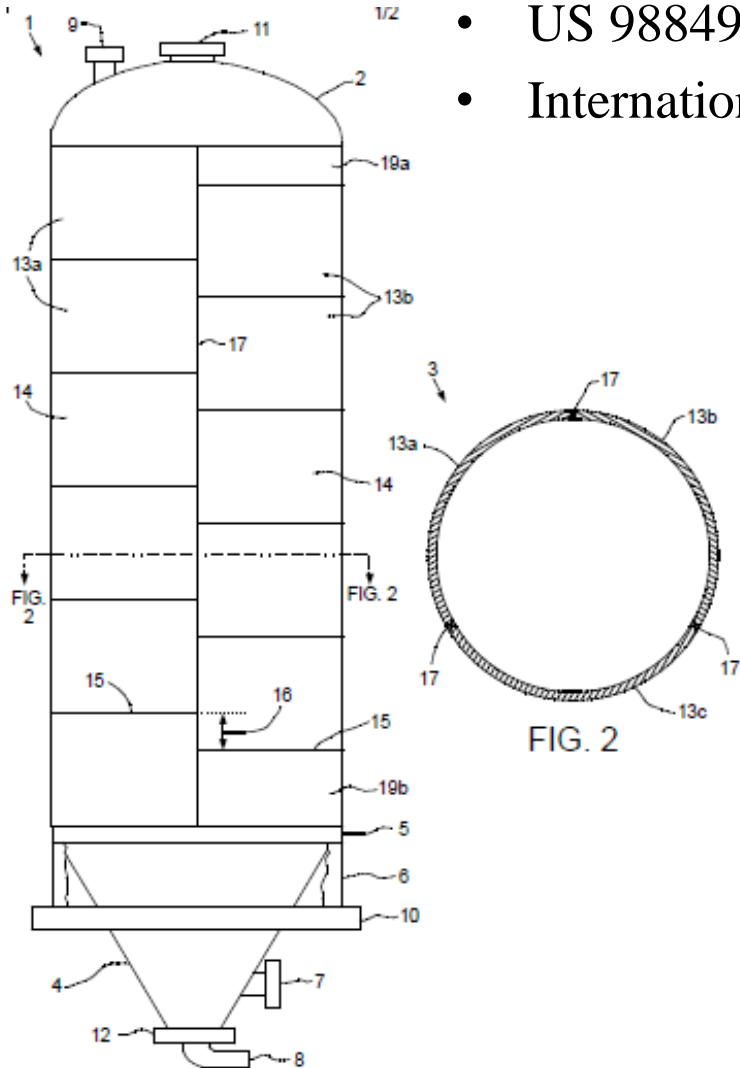
Vertical Plate

- Publication: Feb 27, 2001
- US 6193848 B1
- CBI



Staggered Seam

- US 9884996
- International patents



Analysis of Staggered Seam Design

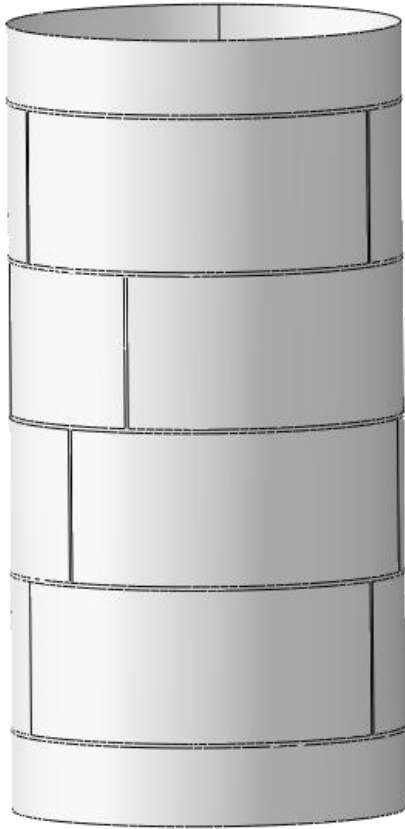
Cause of non-uniform growth:

- Weld-base strength ratio (10% and 50% used)
- Weld reinforcement (10% used)

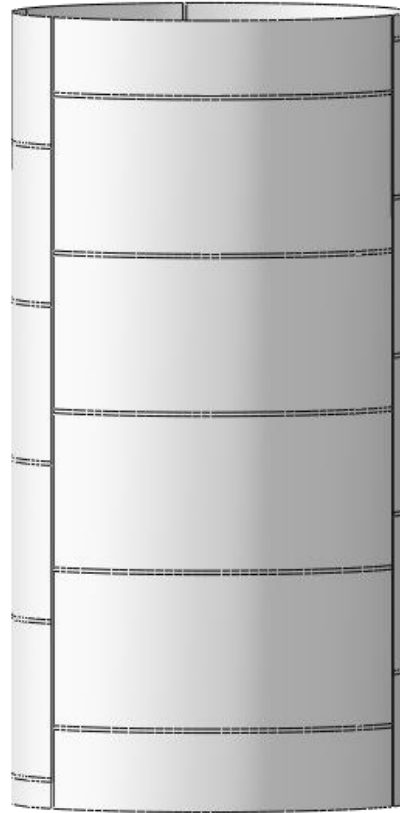
Bulging simulation:

- Pressure (used in this analysis)
- Coke resistance (future)

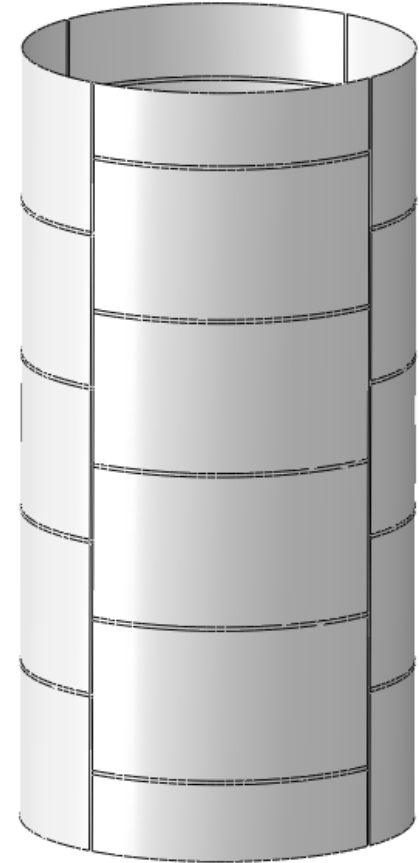
Scope



Conventional



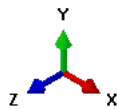
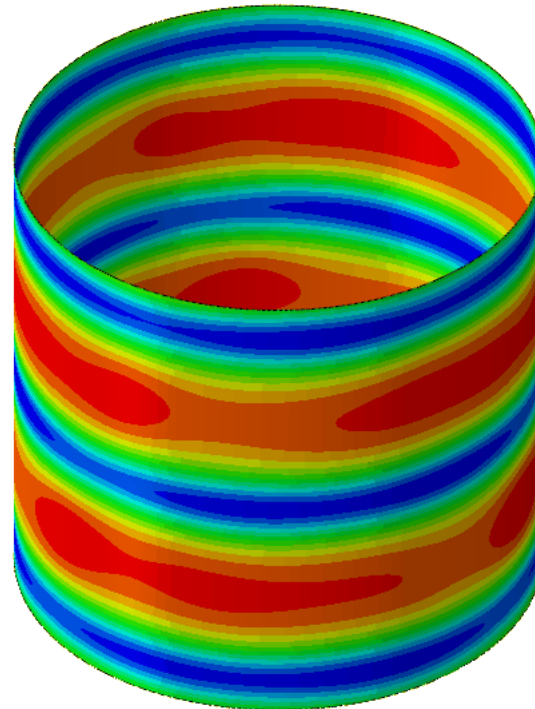
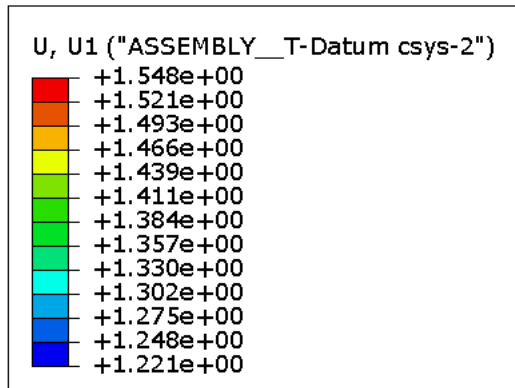
3-leaf



4-leaf

Conventional Design

Radial Displacement

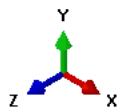
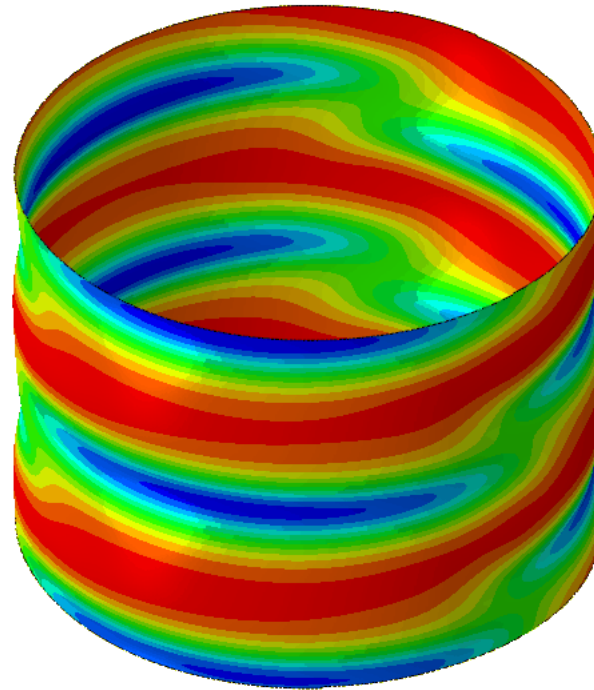
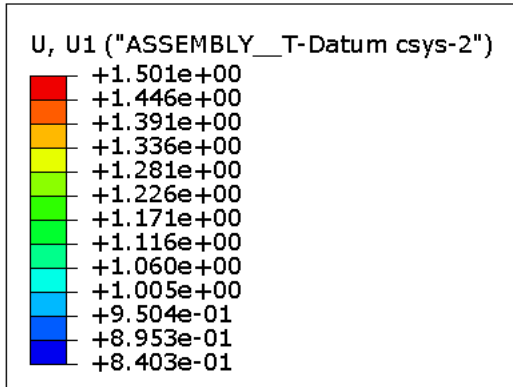


ODB: conv-weld10stiff10reinf-mesh1.odb Abaqus/Standard 3DEXPERIENCE R2017x Thu Oct 22 13:21:59 Central Daylight Time 2020

Step: unload
Increment 1: Step Time = 1.000
Primary Var: U, U1 ("ASSEMBLY__T-Datum csys-2")
Deformed Var: U Deformation Scale Factor: +1.000e+00

3-Leaf Staggered Seam Design

Radial Displacement

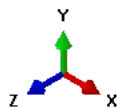
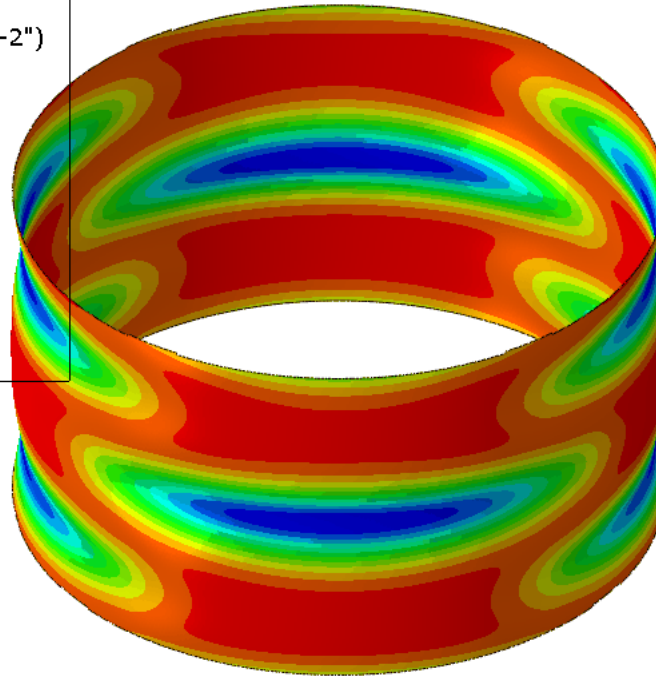
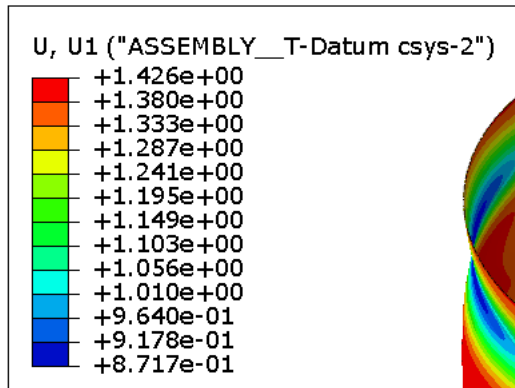


ODB: stagg3-weld50stiff10reinforce-mesh1.odb Abaqus/Standard 3DEXPERIENCE R2017x Thu May 07 14:23:29 Central Daylight Time 2020

Step: unload
Increment 1: Step Time = 1.000
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Deformed Var: U Deformation Scale Factor: +1.000e+01

4-Leaf Staggered Seam Design

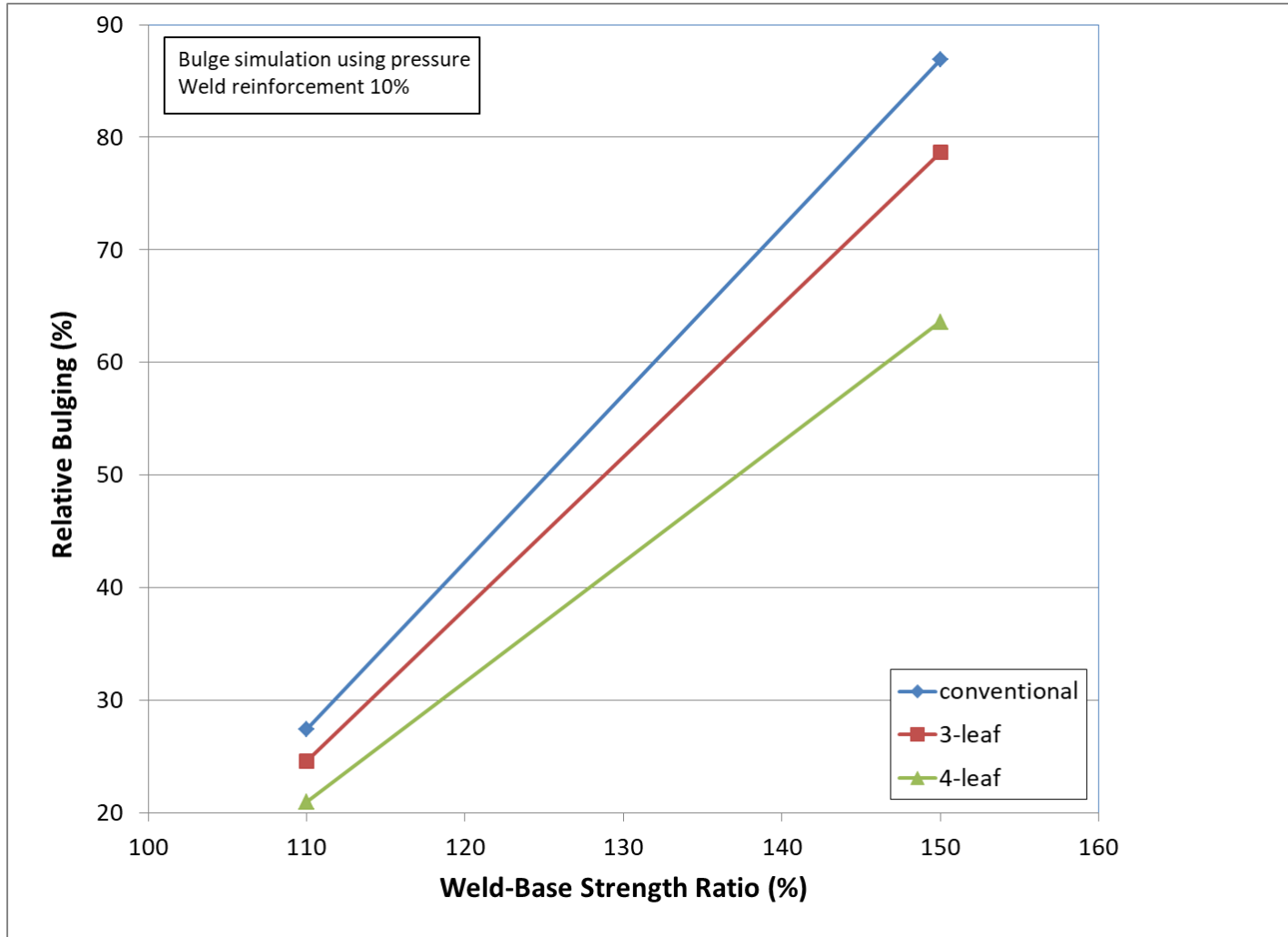
Radial Displacement



ODB: stagg4-weld50stiff10rein-mesh1.odb Abaqus/Standard 3DEXPERIENCE R2017x Thu May 07 21:06:18 Central Daylight Time 2020

Step: unload
Increment 1: Step Time = 1.000
Primary Var: U, U1 ("ASSEMBLY__T-Datum csys-2")
Deformed Var: U Deformation Scale Factor: +1.000e+01

Results



Conclusions

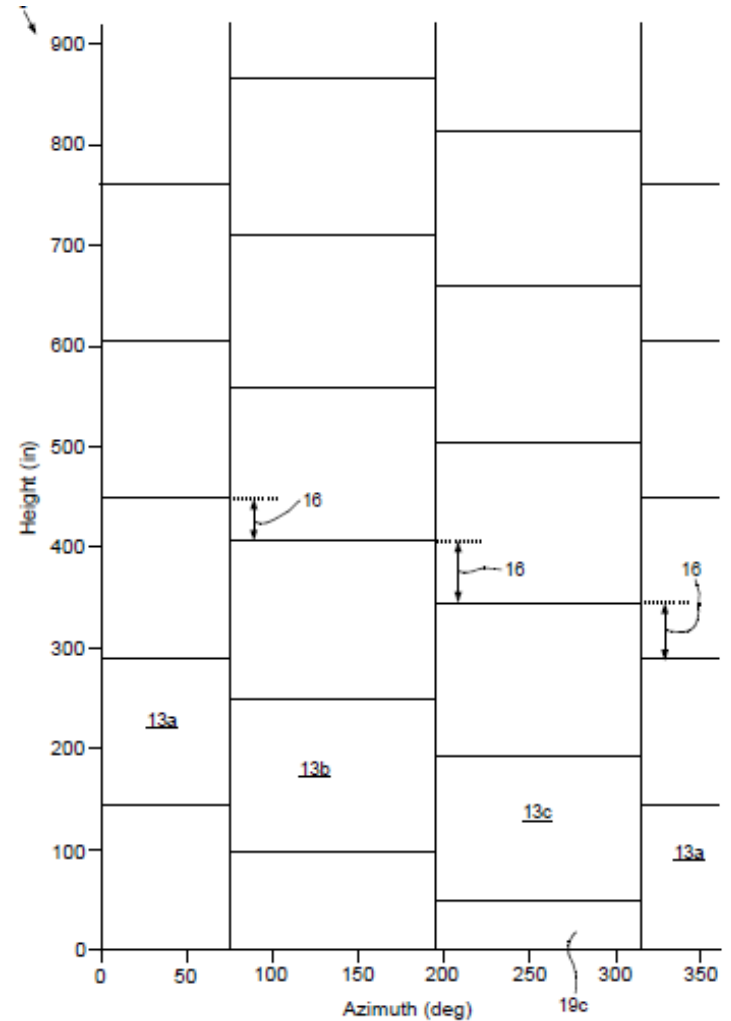
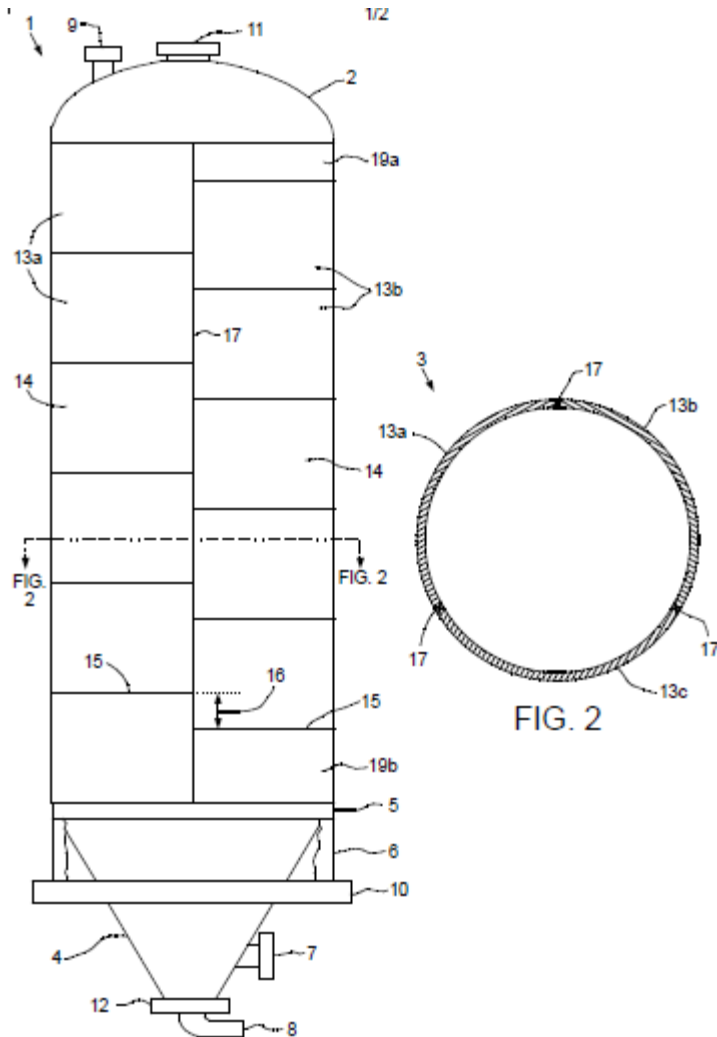
- Analysis confirmed that staggered seam design reduces bulging compared to conventional shell design.
- Using pressure loading, up to 27% bulging reduction is predicted.
- The four-leaf design results in a more significant bulging reduction than the three-leaf design.

design type	weld 10%				weld 50%			
	min	max	Diff (%)	reduc (%)	min	max	Diff (%)	reduc (%)
conventional	1.221	1.556	27.44	0.00	0.8486	1.586	86.90	0.00
3-leaf	1.211	1.509	24.61	10.31	0.8403	1.501	78.63	9.52
4-leaf	1.229	1.487	20.99	23.49	0.8717	1.426	63.59	26.82

Recent Development

Licensed to Sumitomo Heavy Industries, Japan

Oct. 2020



Recap

- Shell bulging
- Types of bulges
- Vertical plate design
- Staggered seam design
- Analysis of staggered seam design
- Recent development: HES-Sumitomo agreement