

# Evaluation of API TR 934 G Skirt-to-Coke Drum Joint Alternatives; An Estimate of Joint Reliability

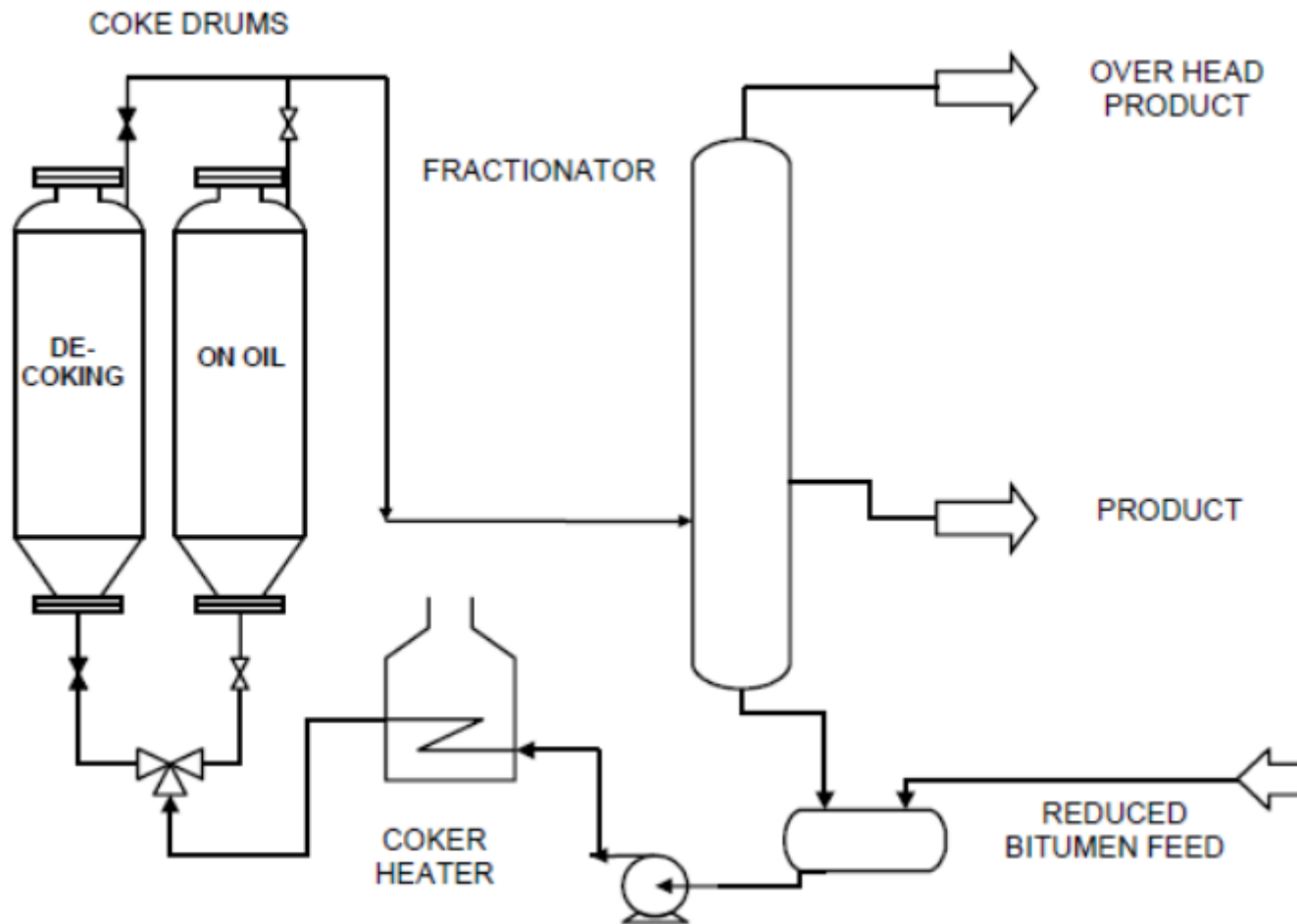
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Note: This presentation is based on a 20 pp paper of the same title.

# Purpose & Objectives

- coke drums are
  - large, high temperature pressure vessels used in oil sands & refineries
  - costly in capital & operating cost
  - a technology developed in 1930's but catastrophic failures continue to occur
- review some common coke drum skirt-to-cone joints
- use FEA and validate / verify against industry experience
- suggest upgrades to the industry API Coke Drum Survey
- suggest upgrades to industry API TR 934-G

# Introduction



- coke drums are;
- equipment technology used in oil sands plants & refineries to recover refined product
- developed in 1930's
- 9,200  $\varnothing$  x 27,400 ht / 30 ft  $\varnothing$  x 90 ft ht
- operate to 345 kPag, 510 °C / 50 psig, 950 °F; cyclic, 24 hr



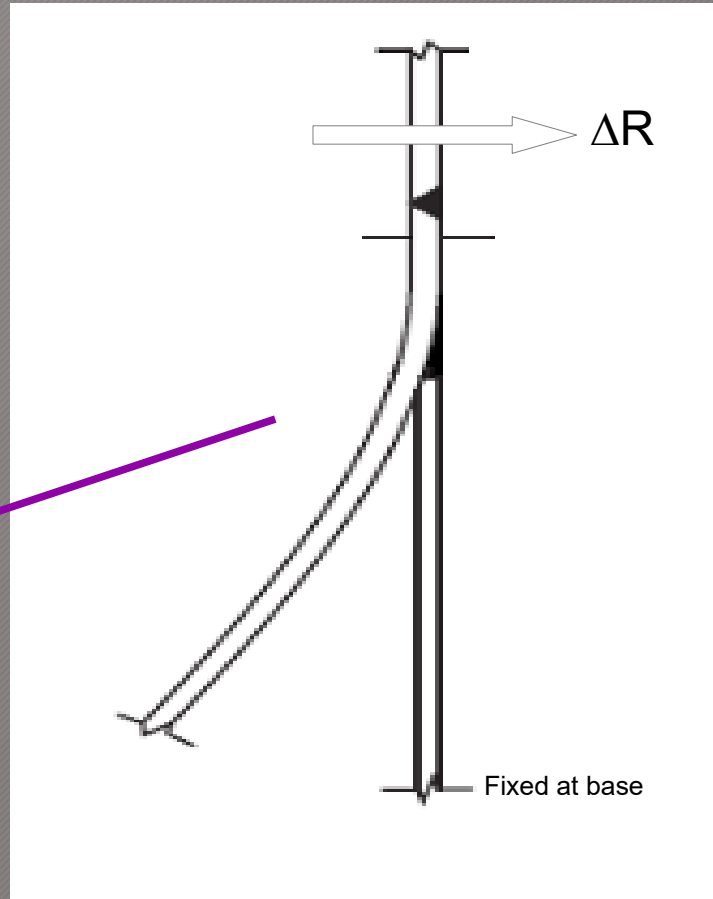
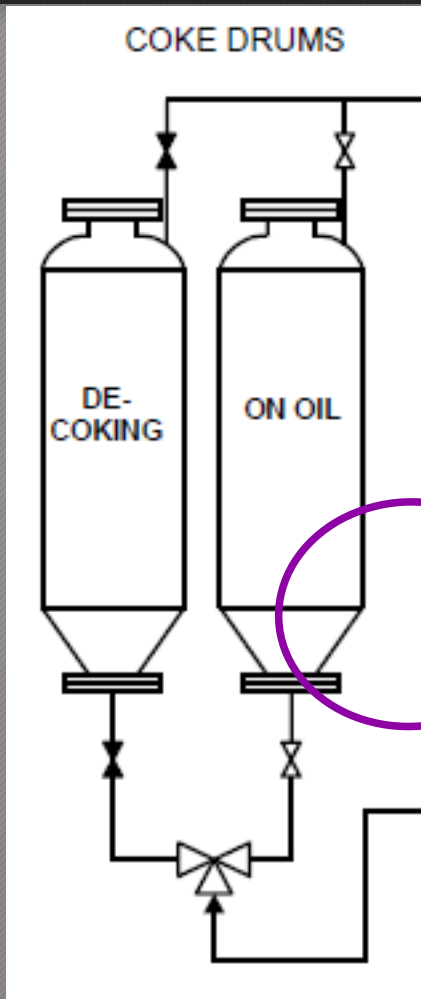
# Introduction



coke drums are a significant economic investment; some factors are:

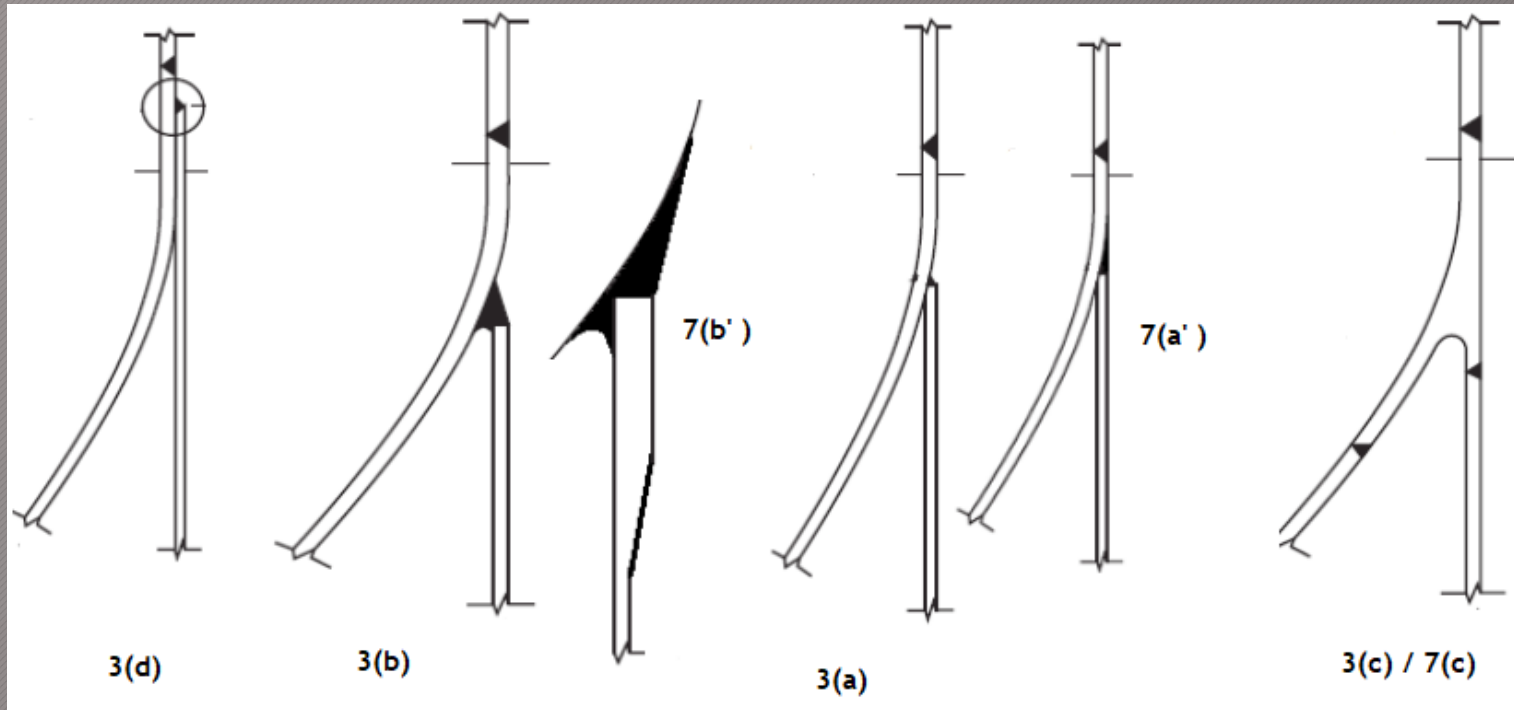
- size, complexity, materials of construction
- C - ½ Mo [SA 204 C]
- 1Cr - ½ Mo [SA 387 12]
- 1¼ Cr - ½ Mo [SA 387 11]
- 2¼ Cr - 1 Mo [SA 387 22]
- 3 Cr - 1 Mo [SA 387 21]
- TP 405 / 410S / N06625 cladding

# Reliability Issue



- on heat-up, vessel radial growth causes differential displacement in skirt
- high bending stresses / strains in joint connection
- low cycle thermo-mechanical fatigue, failure rate; ~1,000 to > 10,000 cycles
- operational, design & fabrication influences

# Analysis of Common Joint Designs



- recommended designs by industry standard API TR 934-G or specific designers / fabricators
- not all designs can be considered nor experienced to be reliable



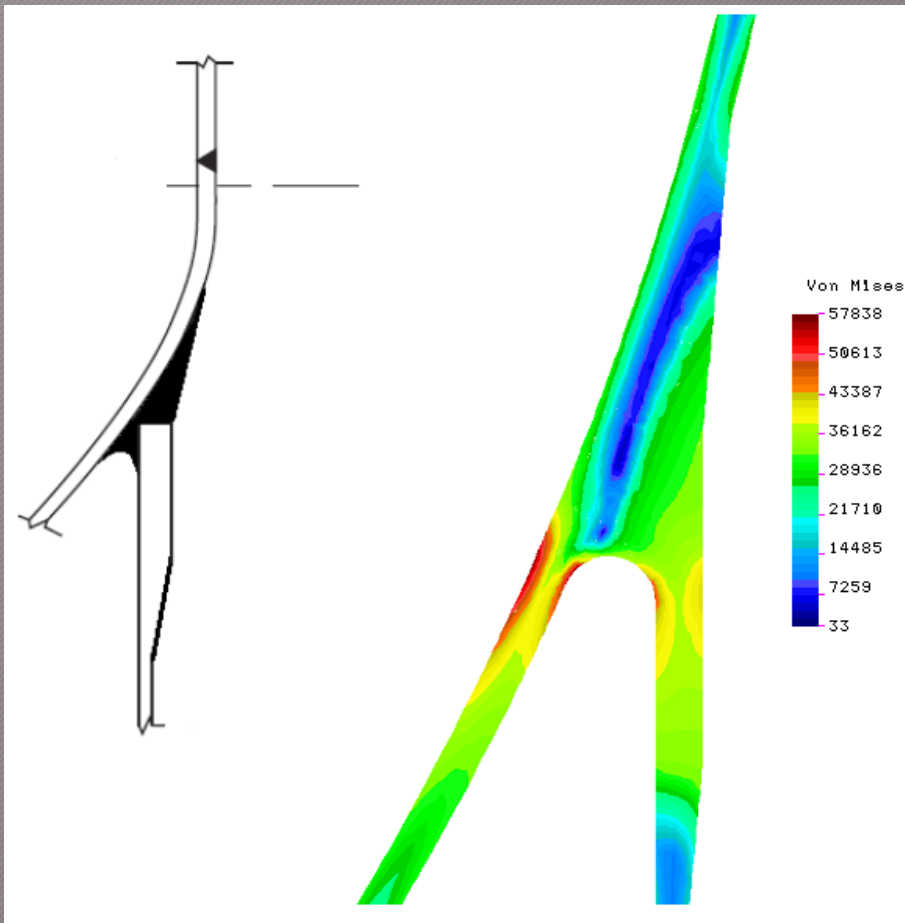
# Analysis of Common Joint Designs

Model / Stress Figure (1)	$\Delta \epsilon$ [ $\mu\epsilon$ ]	$N_f$ [cycles] (2)	Experience [cycles]	Years [nominal]
Figure 7(a') / 8	4,850	5,400	5,700 – 6,350 (3)	16 – 17
Figure 7(b') / 9	7,600	1,600	1,550 (3)	4 <sup>1/2</sup>
Figure 7(b'') / 10	5,120	4,650	test (4)	–
Figure 7(c) / 11	4,190	8,000	test (4)	–
Table 5 (5)	8,450 – 13,390	350 – 1,200		1 – 3 <sup>1/2</sup>
Sasaki [18]		5,920 – 10,057 (6)	partial (6)	16 – 27 <sup>1/2</sup>

(2) Cyclic life stated in cycles,  $N_f$  - for lower 99% confidence interval

- results for selected joint designs; some as recommended by API TR 934-G and OEM's
- 2 modifications tested
- better, worse and worst results

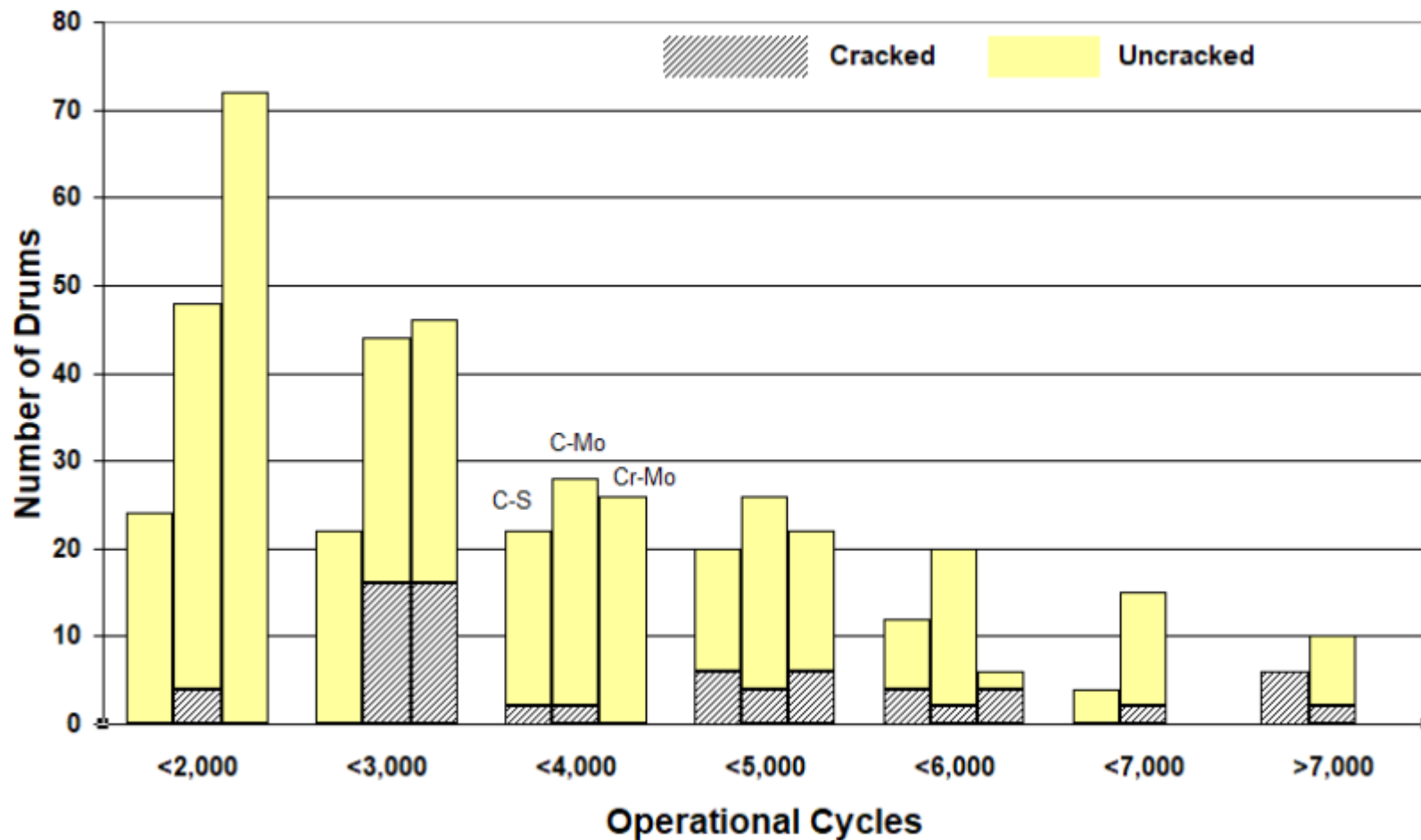
# Analysis of Common Joint Designs



- second poorest fatigue life result for this promoted, installed & failed configuration
- API TR 934-G states:  
*Typically, a sharp internal crotch weld can produce a stress concentration factor as high as 5 while a radiused internal crotch weld will produce a stress concentration factor which is half of that value”*
- possible design remedies apparent from visual review of this design
- industry survey, TR documents need updating & improvements



# Conclusions & Recommendations



- available data (API 1996 Survey) indicates some designs & operational conditions are providing superior performance results
- however; need better detailing, description & updates in:
  - industry survey
  - industry standards

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For the full length paper (20 pp), contact the author as indicated