

A Fresh Look at 3 Drum Cokers

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MORE PRODUCTION - LESS RISK!

Coking Safety & Reliability Seminar
Moody Gardens
Galveston, TX
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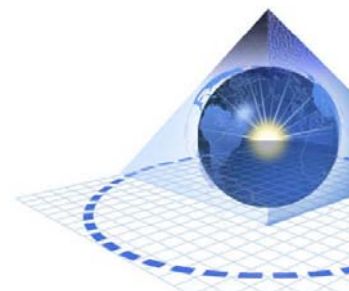
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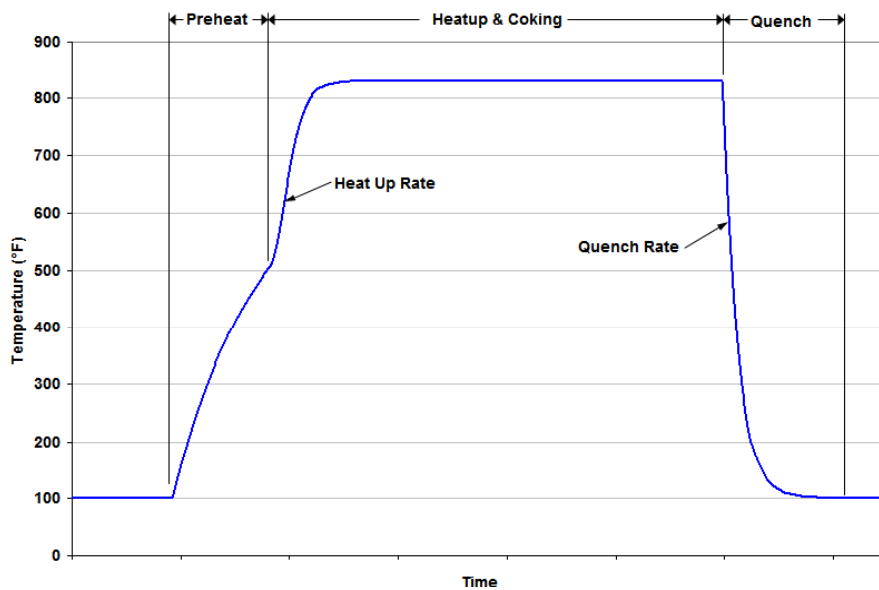
Outline

- ◆ Introduction
 - Common terms & historical trends
- ◆ Design Advantages for Adding A 3rd Coke Drum
 - 1. Cycle Advantages
 - 2. Operation Advantages
 - 3. Fatigue Advantage
- ◆ Economical Advantages for Adding A 3rd Coke Drum
 - New Coker unit
 - Existing Coker unit
- ◆ Summary & Conclusions

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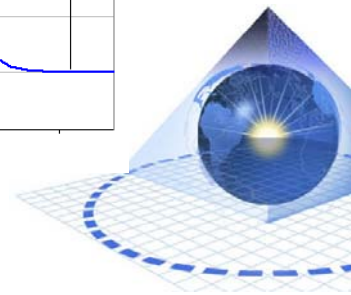


Common Terms



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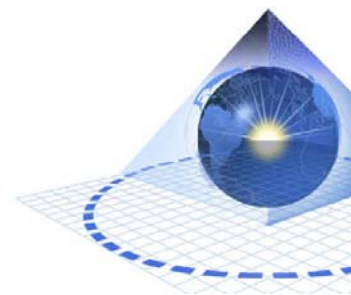


Why do Coke Drums fail ?

Severe Cyclic Thermal Conditions due to
Minimal Preheat Temperature
Aggressive Heat Up Rate
Aggressive Quench Rate

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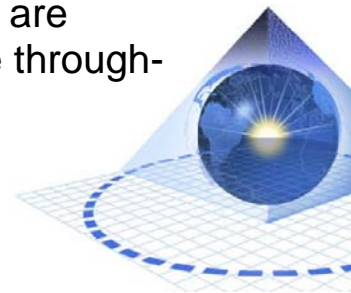


What do we do to Stop Failures ?

- ◆ Modify Operations
 - Increase preheat temp
 - Control cool down
 - Increase cycle time
- ◆ Improve Equipment
 - Innovation with new geometry and designs
 - Better materials
 - Manufacturing controls
 - Modify inlet flow conditions
- ◆ Most efforts are focused on trying to improve equipment because when the operations are modified we slow down the process, lose throughput and profits !

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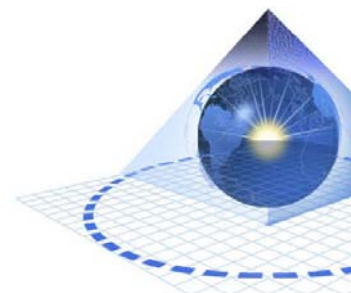


Why Install A 3rd Drum ?

- ◆ Higher than expected maintenance costs
- ◆ Need shorter drum cycles or more throughput
- ◆ Severe thermal cycles with a 2 drum unit – Reduce thermal impact
- ◆ Difficulty producing a design for the full design life
- ◆ Lower cost and improved reliability

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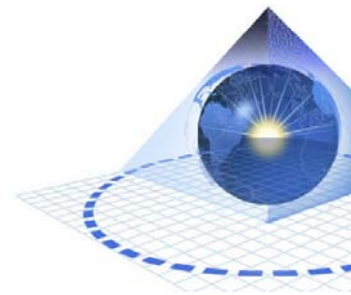


Historical Data & Trends

- ◆ Historically – The heat up rates controlled fatigue design
 - Heat up rates have not changed significantly
- ◆ Recent Trend – Shorter coke drum cycles
 - Less preheat
 - More aggressive quench

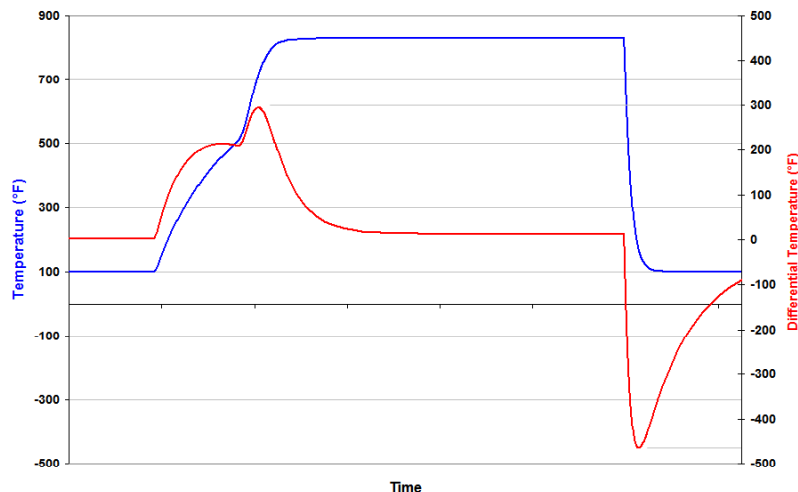
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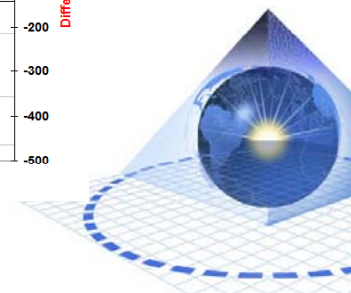
Historical Data & Trends

- ◆ Cyclic stresses are produced from large temperature differences between adjacent components



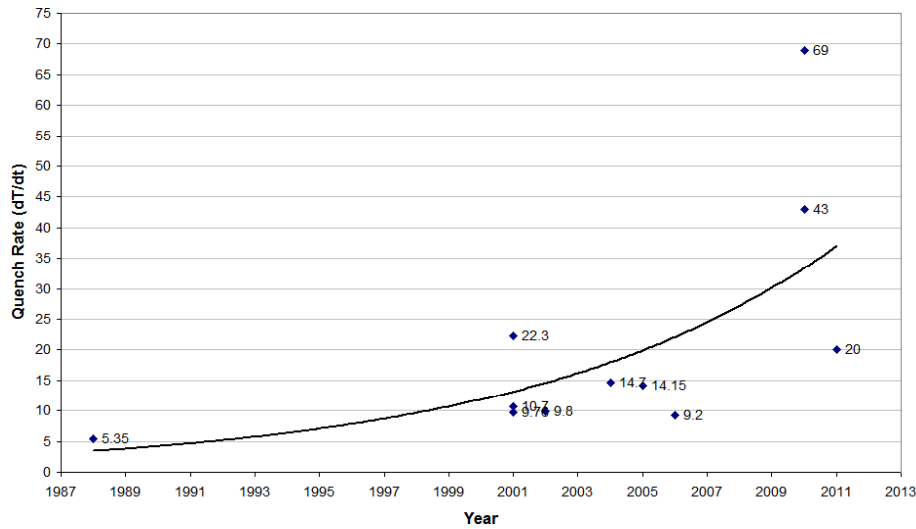
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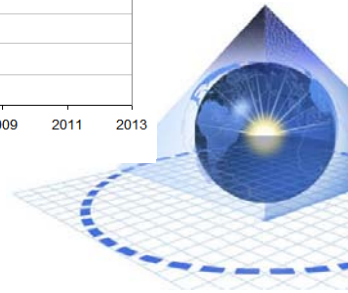
Historical Data & Trends

◆ Historical Data – Quench Rate



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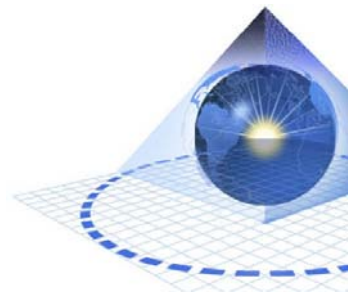
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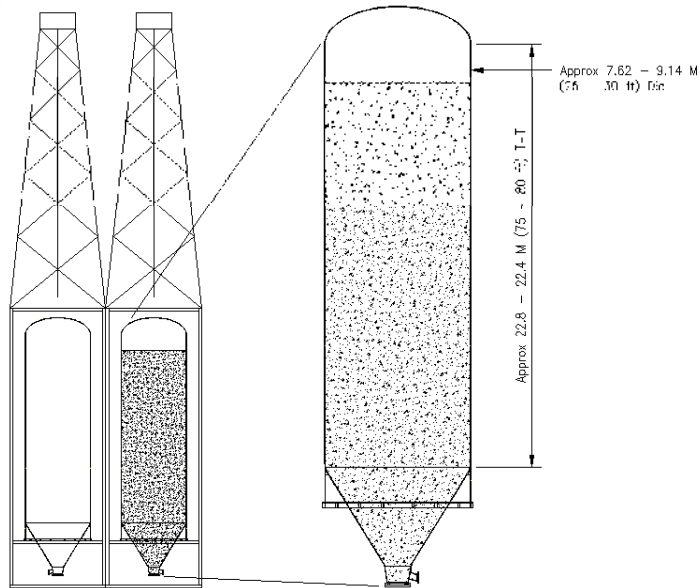
First Advantage Drum Cycle

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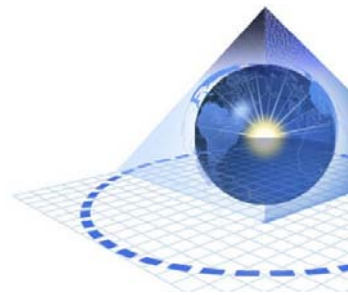


2 Drum Coker Cycle Advantage

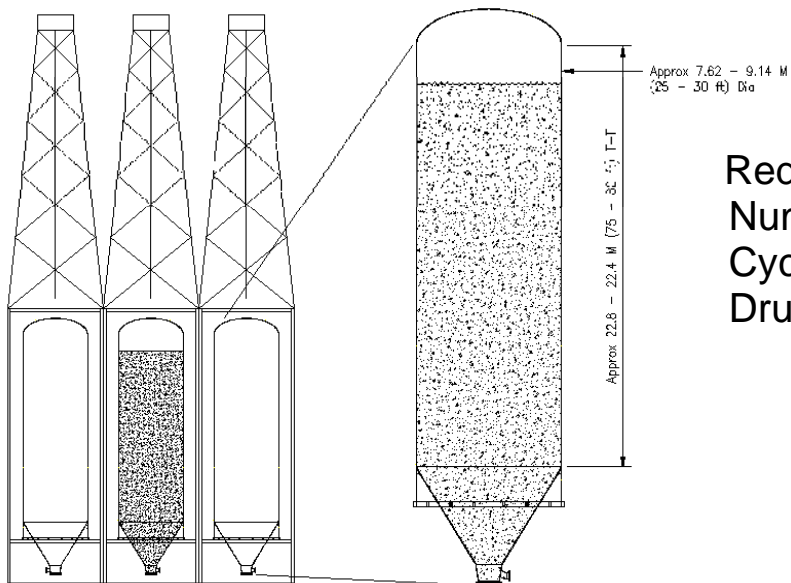


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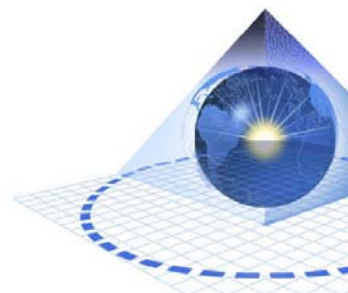
3 Drum Coker Cycle Advantage



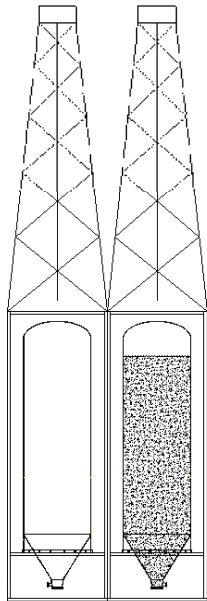
Reduced
Number of
Cycles per
Drum

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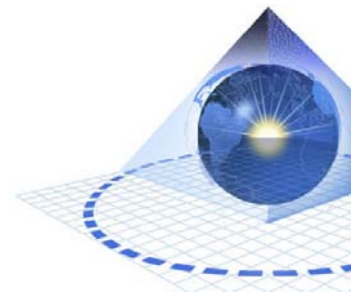


3 Drum Coker Cycle Advantage



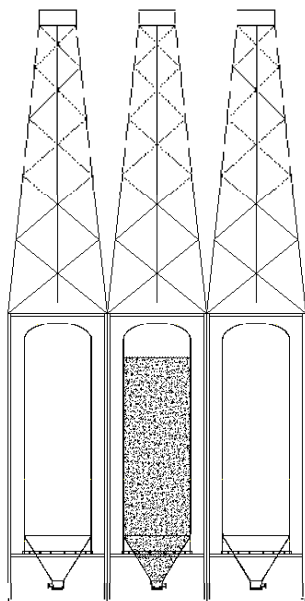
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- ◆ 2 Drum System
 - 30 Year Life
 - ~15 hr Cycle
 - 9,000 Cycles Per Drum
 - 18,000 Cycles Per Unit (9,000 * 2 Drums)



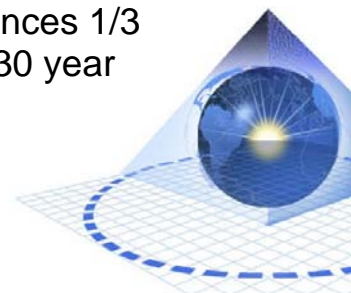
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3 Drum Coker Cycle Advantage



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- ◆ 3 Drum System
 - 30 Year Life
 - ~15 hr Cycle
 - 18,000 Total Unit Cycles
 - 6,000 Cycles Per Drum (18,000 / 3 Drums)
- ◆ 1.5 X Life Advantage for 3 Drums (9,000 / 6,000)
 - Each drum experiences 1/3 less cycles over a 30 year period



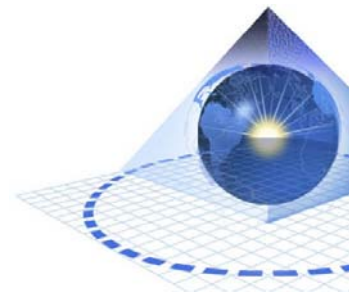
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3 Drum Coker Cycle Advantage – Example

- ◆ 2 Drum Coker
 - Repairs are Performed After 10 Years
- ◆ 3 Drum Coker
 - Identical operating conditions as 2 drum coker
 - **Would not expect to perform the same repairs until after 15 years ($10 * 1.5$) due to the reduced number of cycles per drum**

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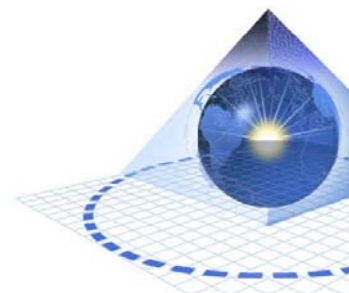
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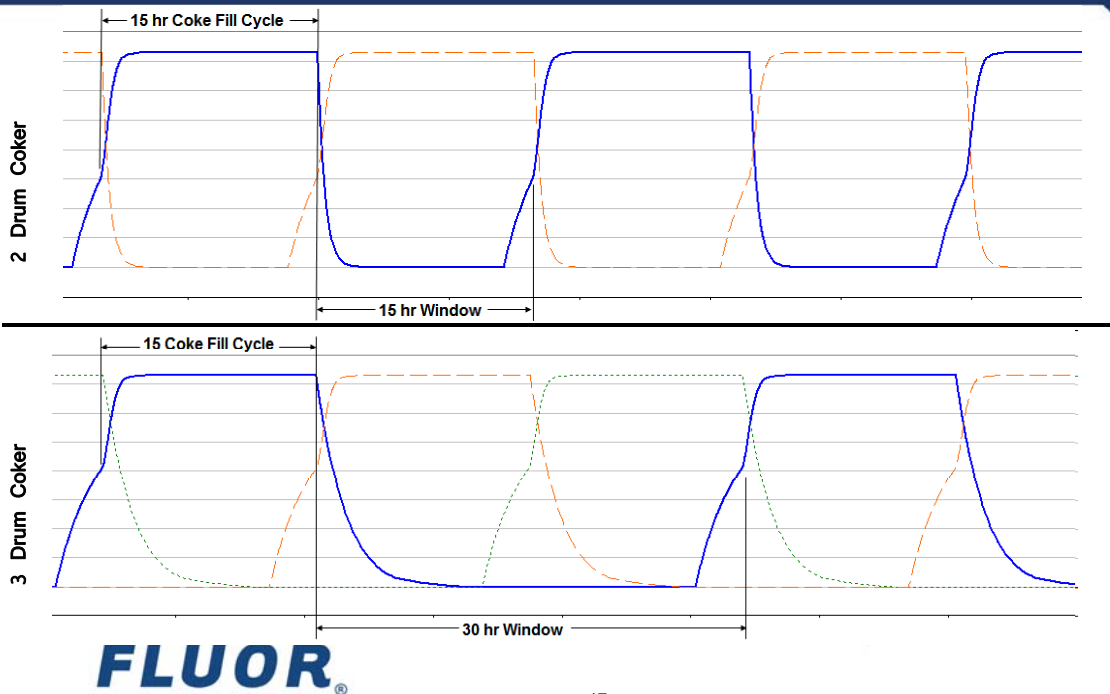
Second Advantage Operations

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3 Drum Coker Operations Advantage



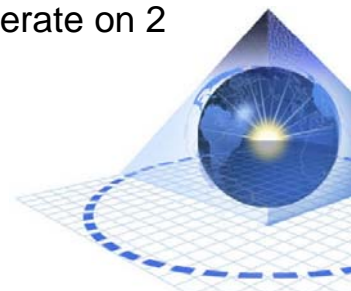
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3 Drum Coker Operations Advantage

- ◆ With a 3 drum coker there is twice the amount of time between coking to perform the following
 - Quench, Dehead, Cut, Rehead, Steam Test & Preheat
- ◆ Possible to block in 1 drum for a short period of time to perform
 - Routine maintenance
 - Drum inspection and repair
 - Deheading replacement and repair
 - Severely damaged drum – possible to operate on 2 drums until next turn around

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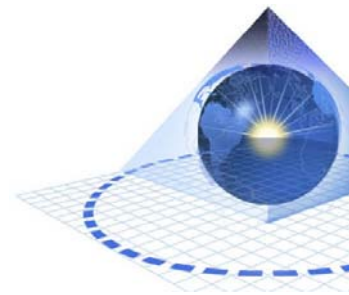
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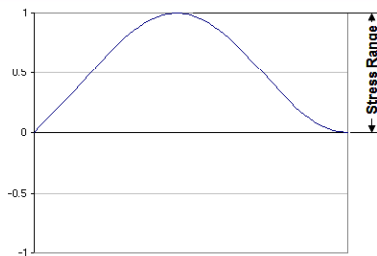
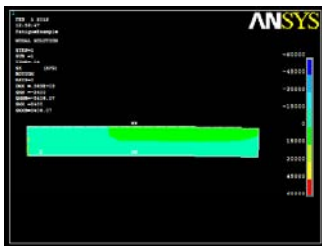
Third Advantage Fatigue

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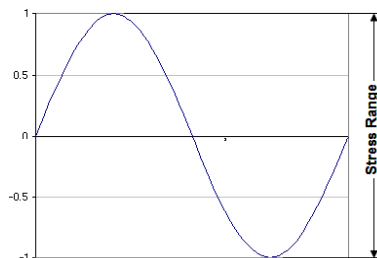
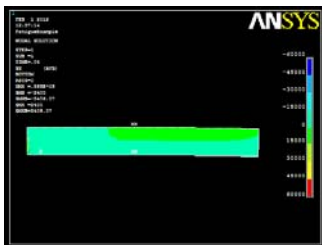
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3 Drum Coker Fatigue Advantage – Example 1



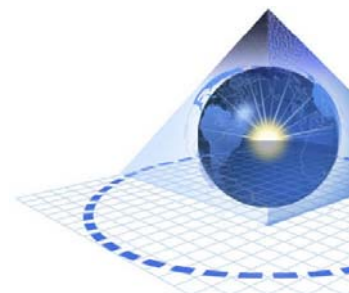
Alternating Stress = $0.5 \cdot \text{Stress Range}$
No Stress Reversals



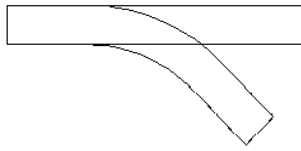
Alternating Stress = $0.5 \cdot \text{Stress Range}$
Full Stress Reversals

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3 Drum Coker Fatigue Advantage – Example 1



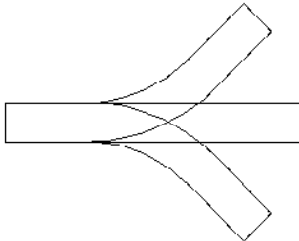
+ 60,000 psi

- 0 psi

Range = 60,000 psi

Sa = 30,000 psi

Cycles = ?



+ 60,000 psi

- 60,000 psi

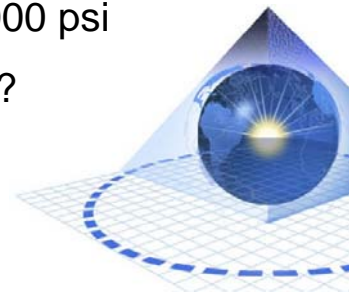
Range = 120,000 psi

Sa = 60,000 psi

Cycles = ?

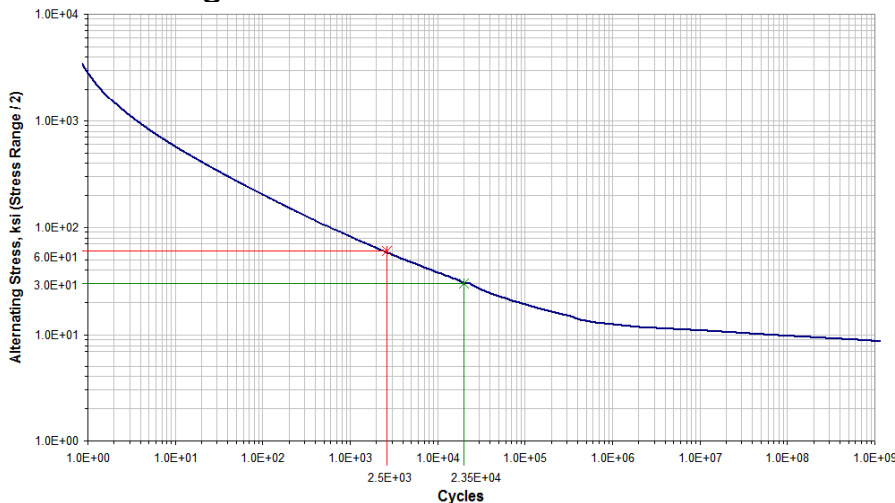
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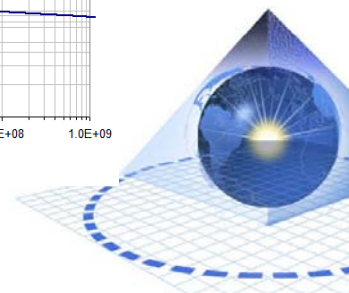
3 Drum Coker Fatigue Advantage – Example 1

- ◆ ASME Section VIII Division II Carbon, Low-Alloy Steel SN Fatigue Curve

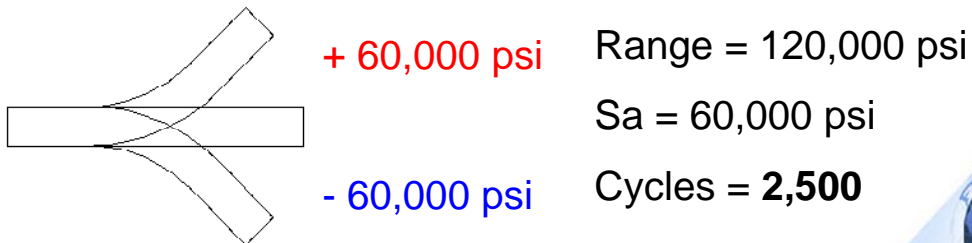
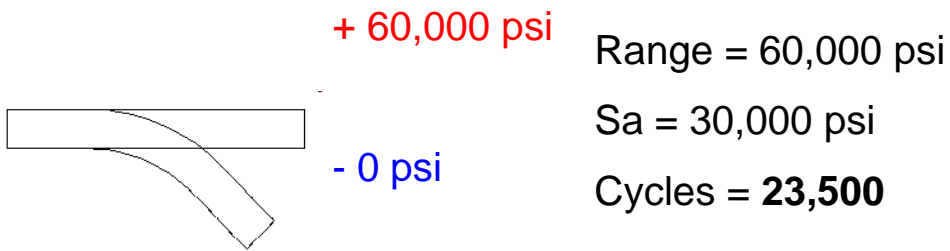


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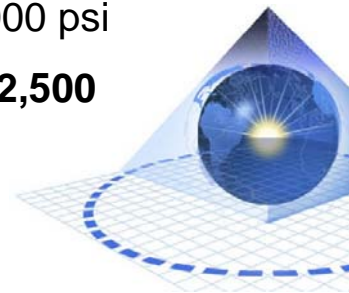


3 Drum Coker Fatigue Advantage – Example 1



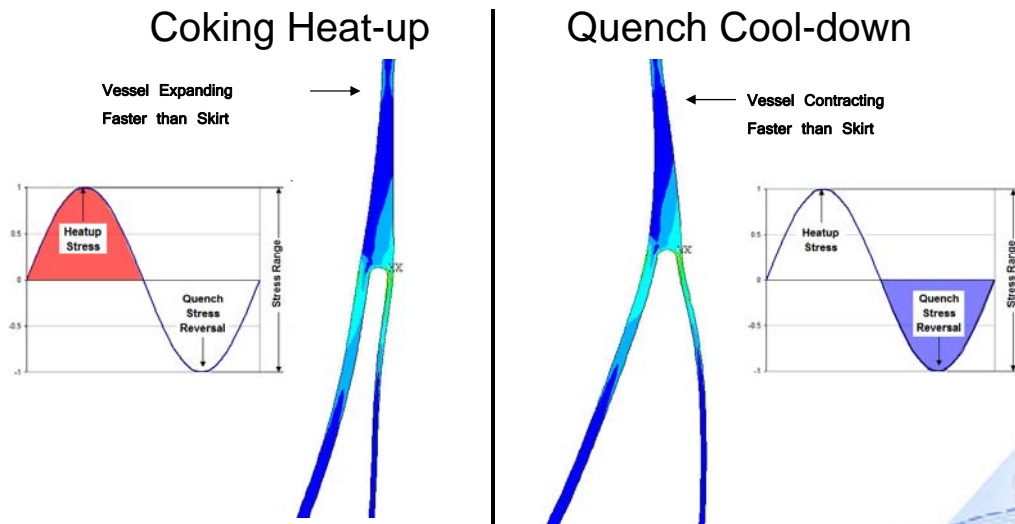
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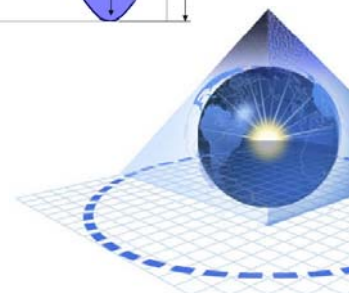
3 Drum Coker Fatigue Advantage – Example 1

- ◆ Exaggerated Skirt Displacements (10X)

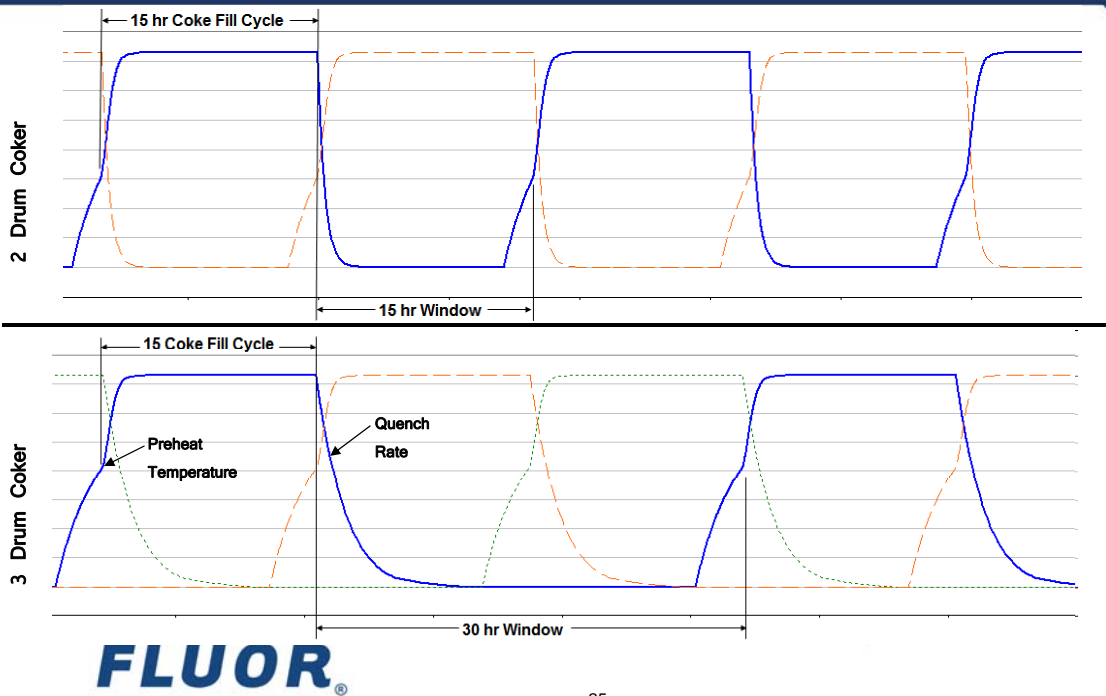


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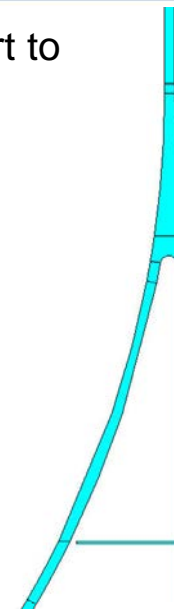
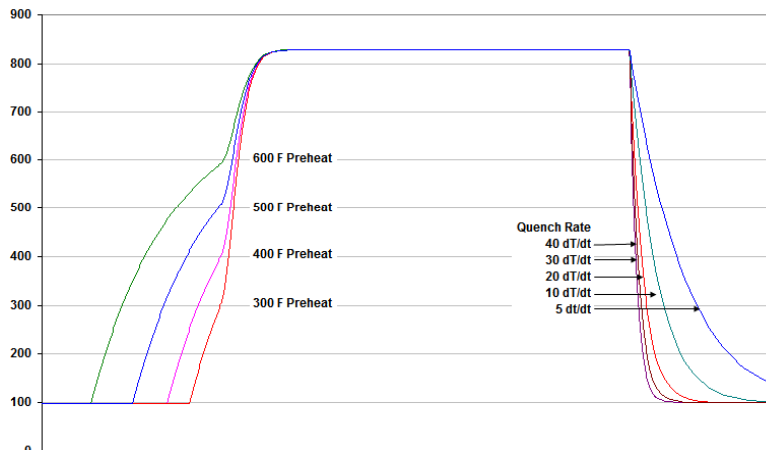
3 Drum Coker Fatigue Advantage – Preheat and Quench



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3 Drum Coker Fatigue Advantage – Example 2

- ◆ 9 Cases are evaluated using the typical skirt to shell juncture

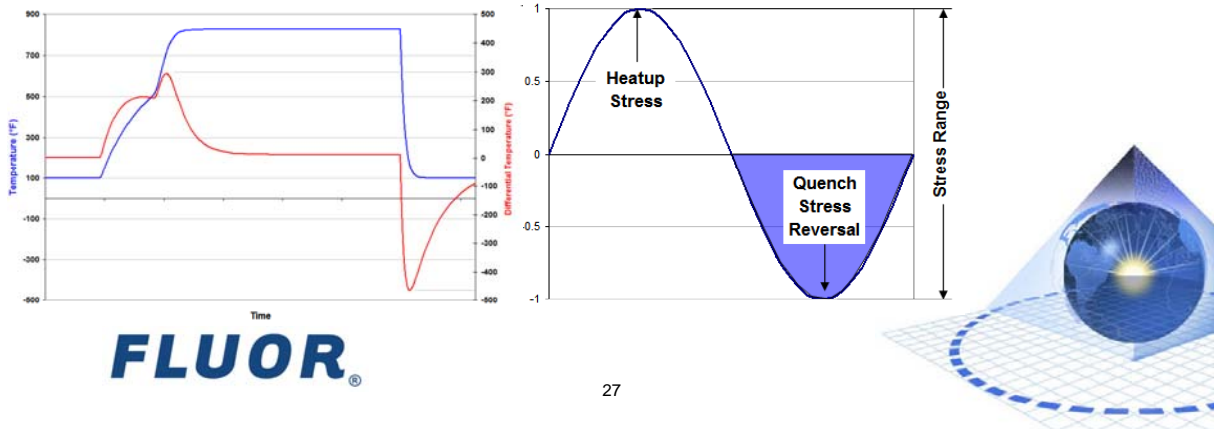


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3 Drum Coker Fatigue Advantage – Example 2

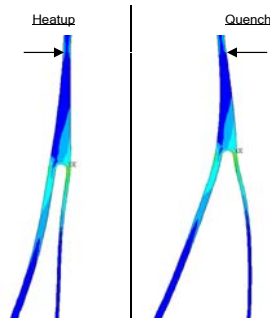
- ◆ Increasing the preheat has a small effect on the stress range since most stress in this region is due to coke being introduced into the vessel
- ◆ Reducing the quench rate has a large effect on the stress range since the reversal is directly affected



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3 Drum Coker Fatigue Advantage – Example 2



$$\text{Stress Range} = \text{Heatup Stress} - \text{Quench Stress}$$

N1 = Number of Cycles for Initial Quench Rate

N2 = Number of Cycles for Target Quench Rate

$$\text{Cycle Ratio} = N2 / N1$$

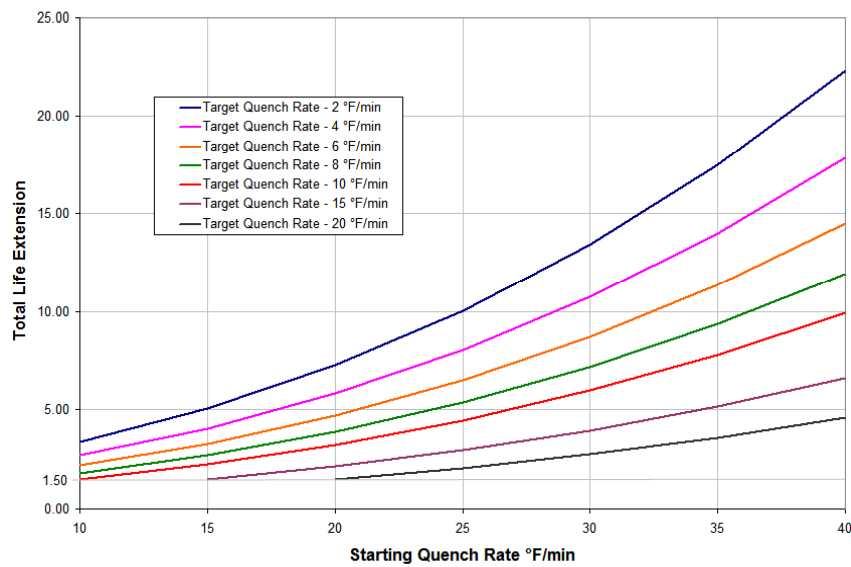
$$\text{Total Est Life Extension} = 1.5 * \text{Cycle Ratio}$$

Existing Rate	Target Rate	Cycles		Cycle Ratio	Drum Factor	Total Est Life Extension	Existing Life (yr)	Est Life (yr)
		N1	N2					
10	6	11416	16633	1.46	1.5	2.19	10.0	21.85
15	6	7564	16633	2.20	1.5	3.30	10.0	32.98
20	6	5271	16633	3.16	1.5	4.73	10.0	47.33
25	6	3821	16633	4.35	1.5	6.53	10.0	65.29
30	6	2859	16633	5.82	1.5	8.73	10.0	87.26
35	6	2196	16633	7.58	1.5	11.36	10.0	113.63
40	6	1723	16633	9.65	1.5	14.48	10.0	144.80

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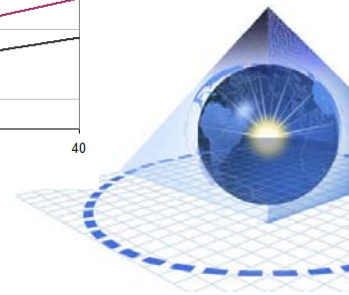
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3 Drum Coker Design Advantage Summary



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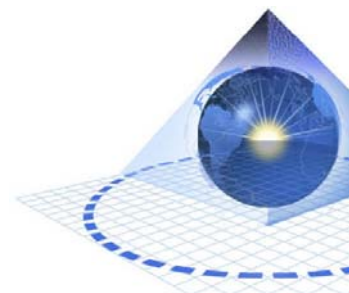
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Economical Advantages for Adding a 3rd Coke Drum

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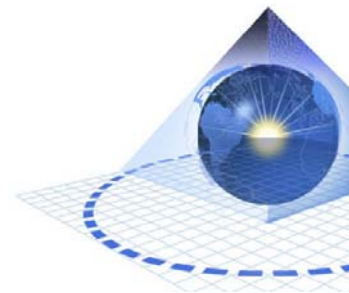


3 Drum Coker Economics Advantages – Assumptions

- ◆ No Escalation
- ◆ No Inflation
- ◆ Production Losses - \$10 Million
- ◆ Estimated Maintenance Costs - \$28 Million / Life of Drums

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3 Drum Coker Economics Advantages – Assumptions

New Coker

- ◆ **Entire 2 Drum Coker Unit** **\$1.38 billion**
 - Upstream Process Units, Coke Drum Area, Coke Pit, Coke Handling and Conveying System & Downstream Process Units
- Coke Drum Structure Portion **\$180 million**
 - ▲ Drums, Foundations, Bottom Unheading Device (BUD), Top Unheading Device (TUD), Drill Derricks, Jet Pumps & Piping
- ◆ **Additional 3rd Drum** **\$80 million**
 - Drum, Foundation, BUD, TUD, Drill Derricks & Piping

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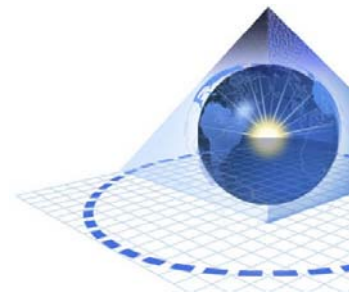
3 Drum Coker Economics Advantages – Assumptions

Existing Coker

- ◆ **2 Drum Coker Replacement** **\$70 million**
 - News Drums, Remove Derricks, Remove Drums, Remove Associated Piping, Remove TUD, Remove BUD, Replace Drums, Replace Derricks, Replace Associated Piping, Replace TUD & Replace BUD
- ◆ **Additional 3rd Drum** **\$90 million**
 - Drum, Foundation (pre-T/A), BUD, TUD, Derrick, Piping & Tie-Ins During T/A

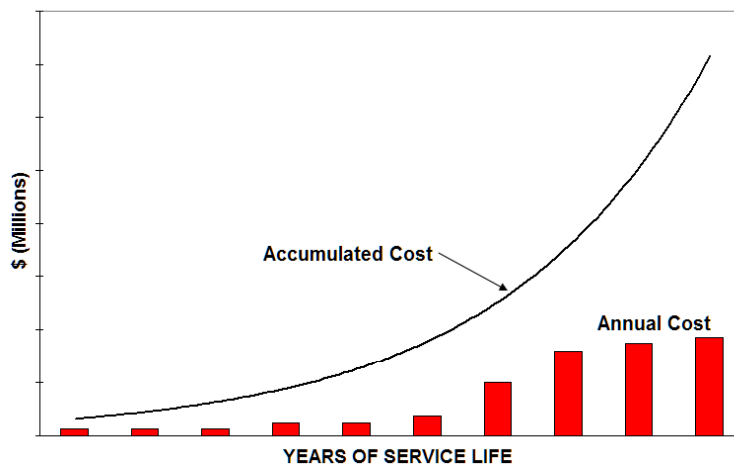
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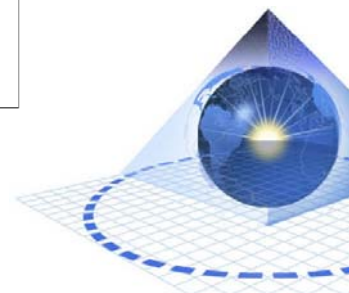
3 Drum Coker Economics Advantages – Assumptions

◆ Typical Coke Drum Maintenance Cost



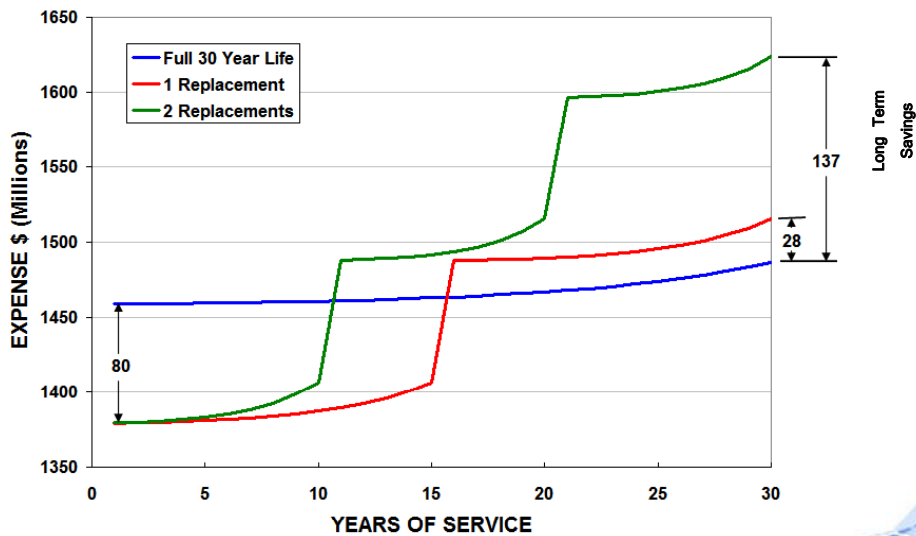
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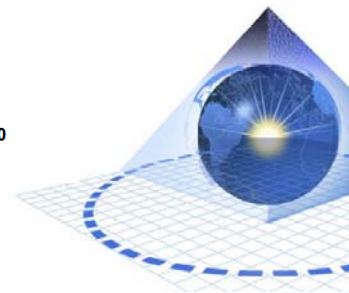


3 Drum Coker Economics Advantages

◆ New Installation

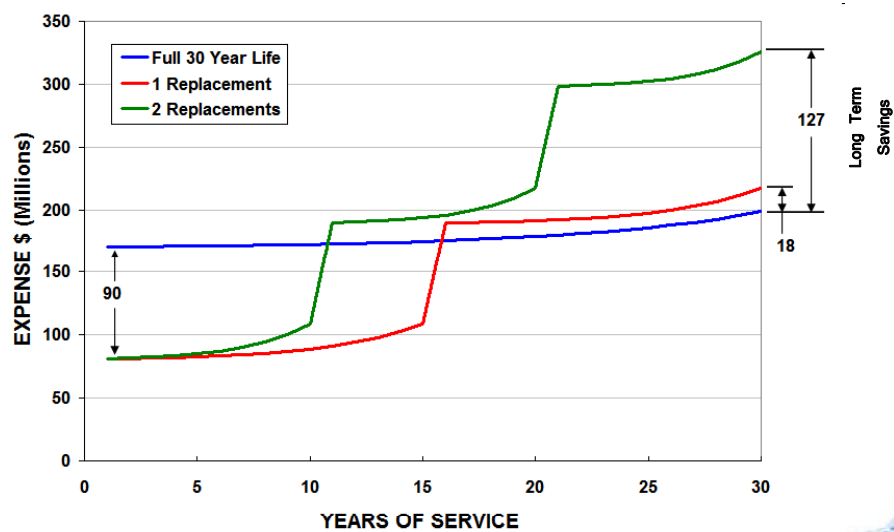


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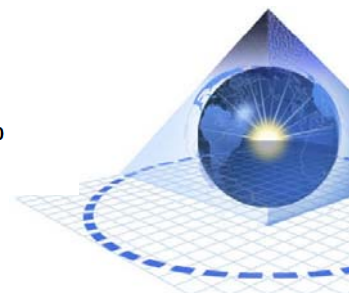


3 Drum Coker Economics Advantages

◆ Existing Installation



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3 Drum Coker Economics Advantages – Summary

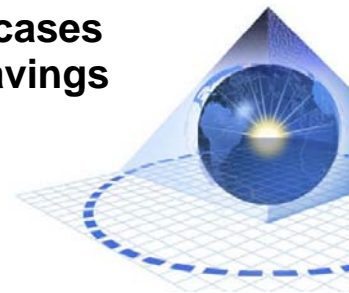
◆ Initial Investment VS. Long Term Savings

	Modification to Existing Unit	New Unit
Initial Investment	-\$90MM	-\$80MM
Long term savings 1 Drum Replacement	+18MM	+28MM
Long term savings 2 Drum Replacement	+\$127MM	+\$137MM

- ◆ Once all factors are considered both cases can be shown to provide long term savings

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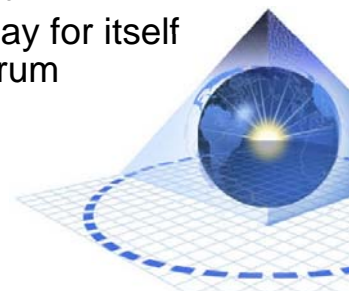


3 Drum Coker Summary & Conclusions

- ◆ 3 Drum Coker Advantages
 - Reduce the need to spend additional money on improved equipment designs
 - Ability to increase throughput without severely impacting the thermal cycle
 - More time between drum cycles for operations
 - Reduced maintenance costs and drum replacements
 - Ability to block in 1 drum for maintenance or repairs
 - Substantial fatigue life advantage by adding 1 drum to the cycle and reducing the thermal impact
 - Over the life of the unit the 3rd drum will pay for itself due to reduced maintenance costs and drum replacements
 - Improved reliability

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