
CHENIERE ENERGY, INC.

Bolted Joint Integrity Program, Standards and Application

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David K. Fontenot



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A decorative graphic at the bottom of the page consisting of several thick, light gray, curved lines that sweep across the width of the page, creating a sense of movement and depth.

Agenda

- Industry Knowledge
- Consensus Standards Landscape
- ASME PCC-1
 - Brief History
 - Appendix-O Concept
- Cheniere Joint Integrity Program Development
 - Optimized assembly loads
 - Assembler training and qualification program
- Conclusions and Cheniere/SES R&D

Industry Knowledge

Common Misconceptions

- Joint leakage = Insufficient gasket stress
- Code design ensures flange integrity
- 50 ksi target bolt assembly stress
- Spring washers
- Anti-Seize

What does this tell us?

- No quick fixes or “one-size fits all” solutions
- Inconsistencies in industry application

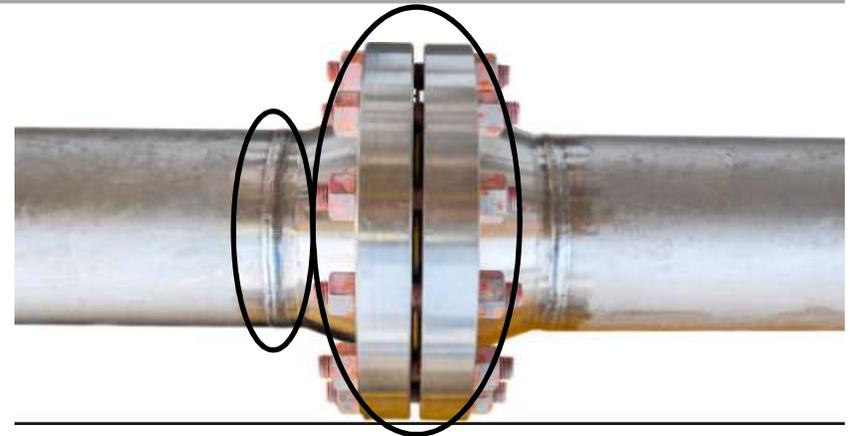
Consensus Standards Landscape

Welded Joints

- Qualified Procedure – WPS/PQR
- Qualified Personnel – WPQ
- Additional Inspection – RT/PT/UT etc.
- All driven by Code (ASME, API)

Flanged Joints

- Complex, many variables
- Inadequate Code requirements (ASME)
 - No Code assembly requirements
 - No Code qualification requirements
 - References ASME PCC-1



Welded vs. Bolted Joints

- Inconsistent quality control measures

History

ASME PCC-1

- **Guidelines** for Pressure Boundary Bolted Flange Joint Assembly
- First introduced in 2000
- Revised in 2010 to include Appendix O
 - Assembly Bolt Stress Determination
 - Simple Approach – Single equation for bolt stress
 - Joint Component Approach – Considers individual component limits
- 2013 revision expanded on Appendix A
 - Training and Qualification of Bolted Joint Assembly Personnel
 - 2010 – 4 paragraphs
 - 2013 – 16 pages

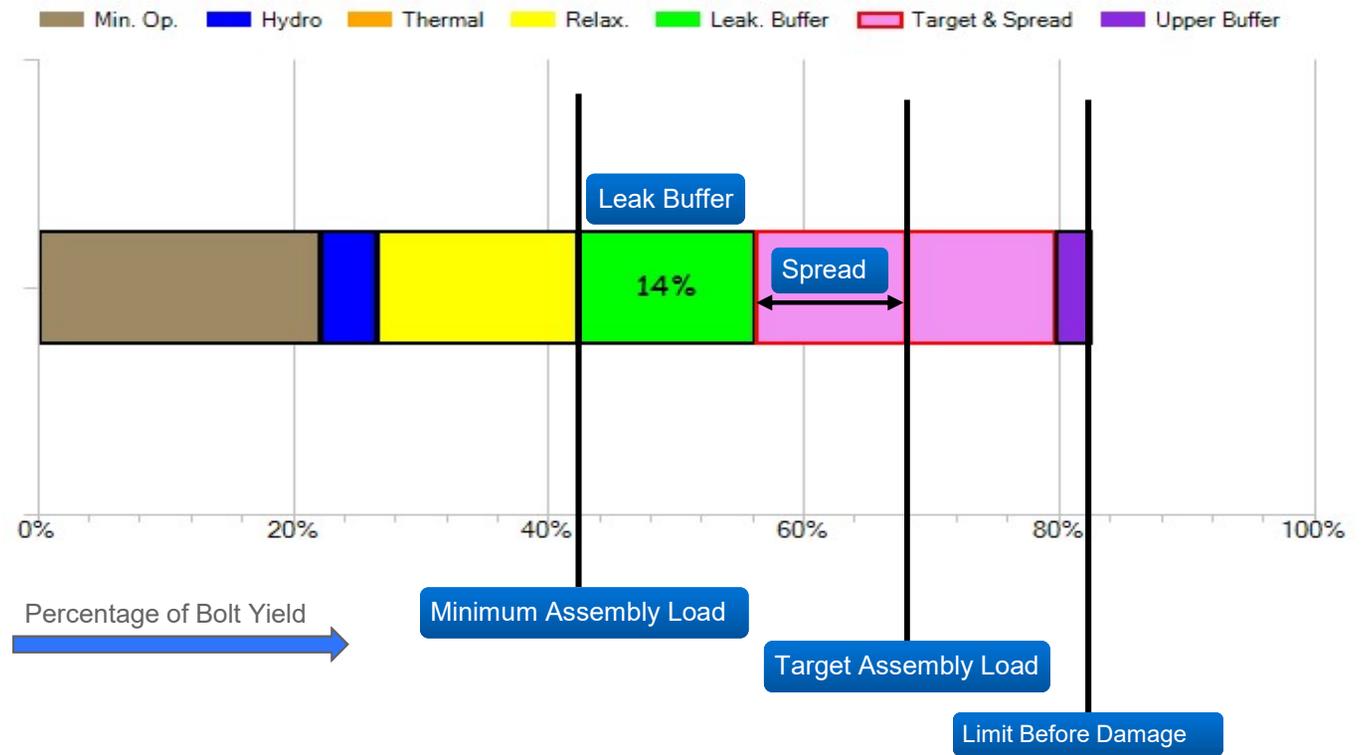
Appendix O Concept

10" 150# 304SS

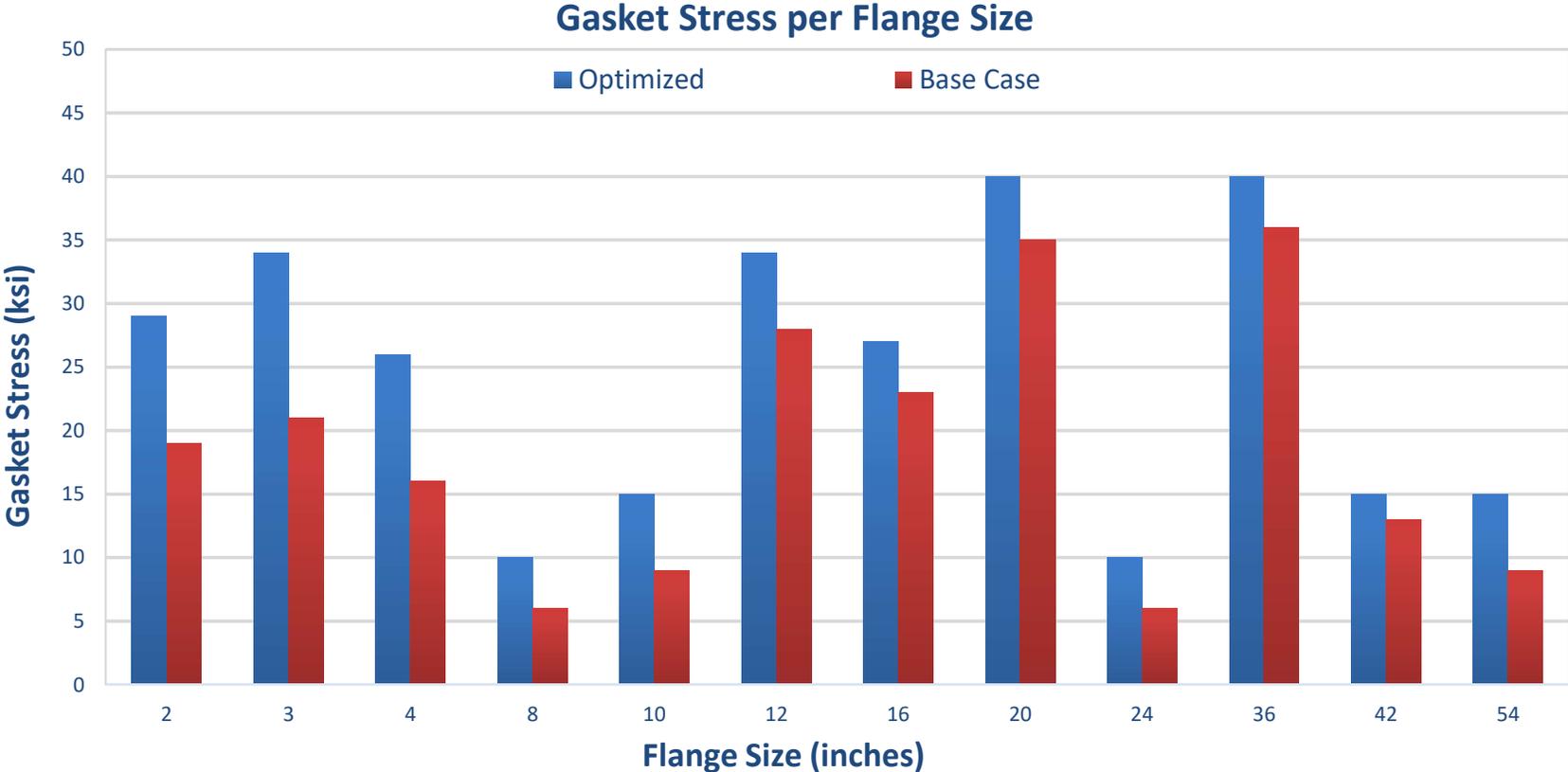
- Torque: 270 ft-lbs
- Gasket Stress: 12.3 ksi
- Bolt Stress: 54.2 ksi
- Design Temp: -265°F
- Design Press: 150 psig

Goal

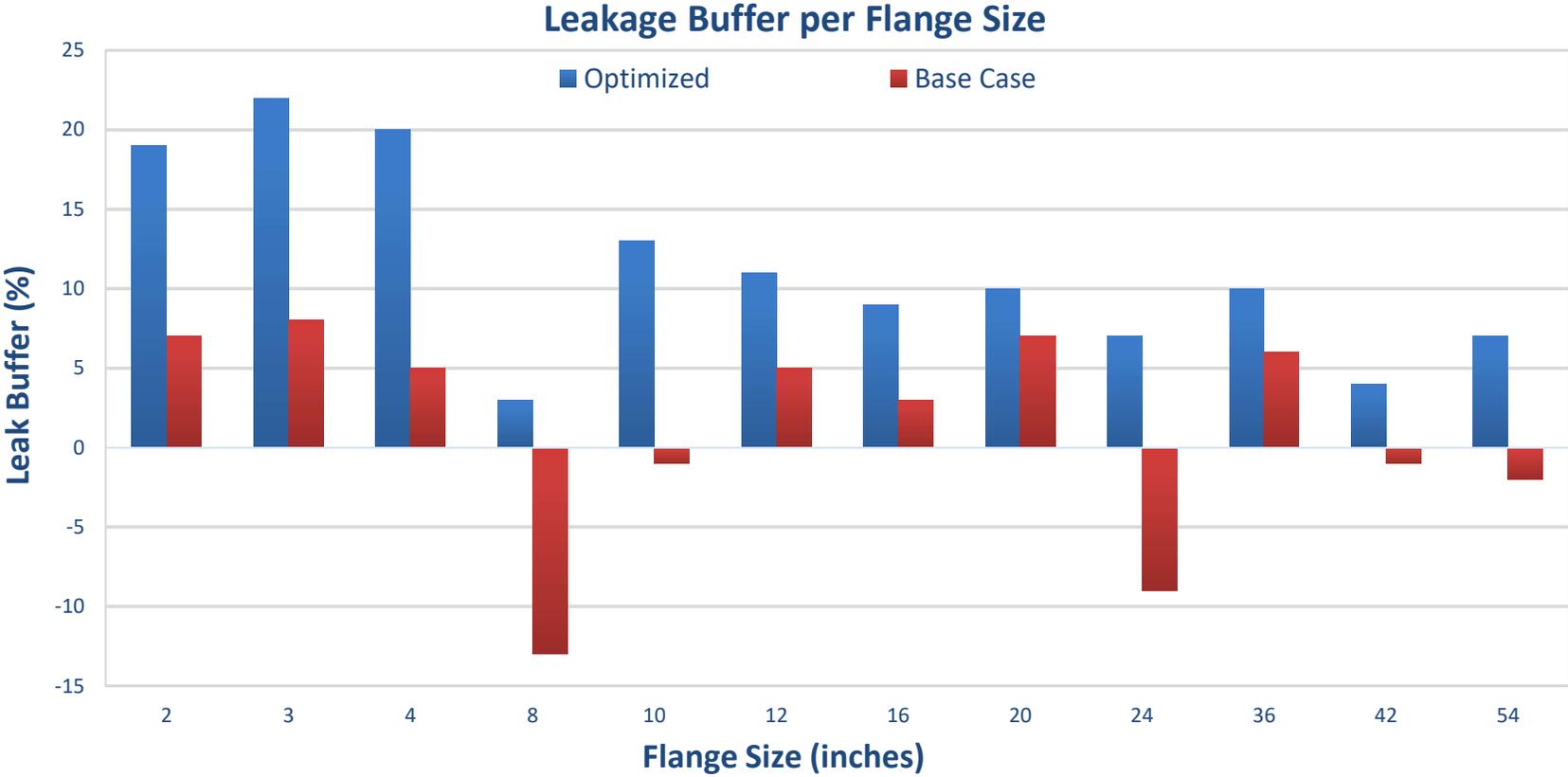
- Maximize leak buffer without causing damage



Gasket Stress



Leakage Buffer



Training/Qualification

Assemblers & QC/QA

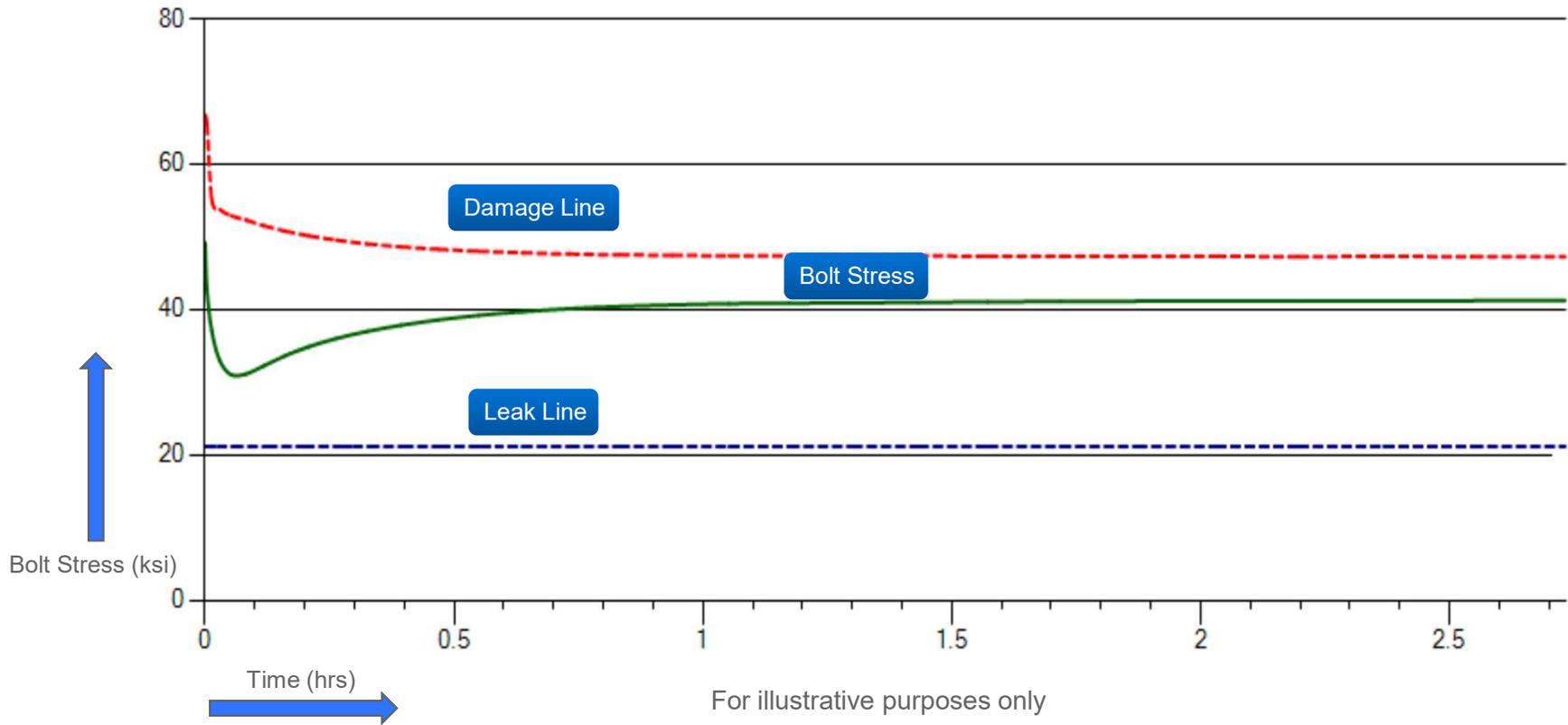
- Training program for all personnel involved with BFJ assembly
 - Appendix-A based competency qualification
- Utilize Demonstration of Effective Bolting (DEB)
 - Hands on learning tool
 - On-boarding of maintenance personnel
 - Before T/A's or major construction activities



End Result

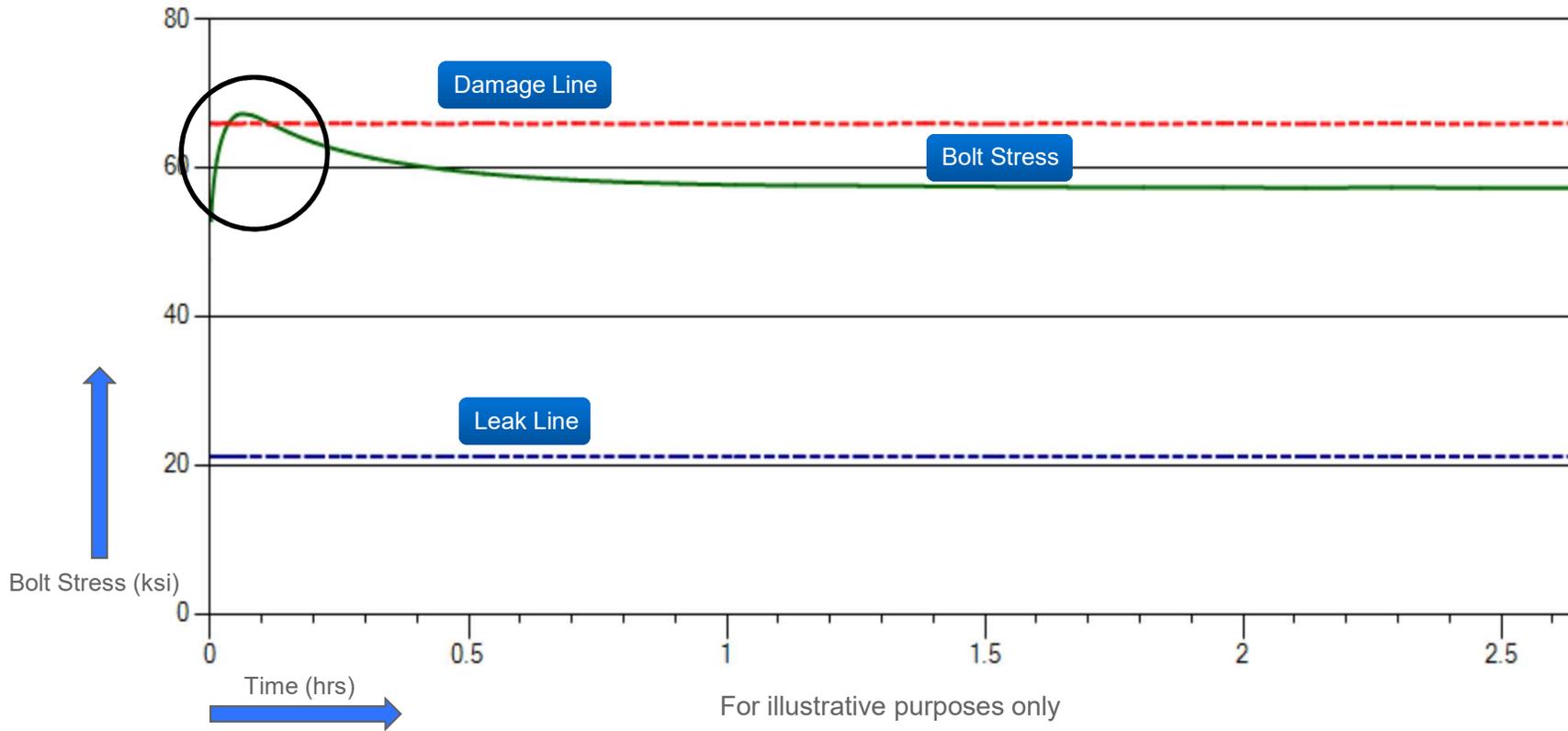
- Effective Joint Integrity Program
 - Simplistic assembly procedures
 - Knowledgeable assembly personnel

Thermal Transient Effects (70 to 405°F)



For illustrative purposes only

Thermal Transient Effects (70 to -265°F)



For illustrative purposes only

Conclusions and Cheniere/SES R&D

Bolted joint integrity can be improved by:

- Using software analysis tools and PCC-1 to optimize joint design and maximize joint integrity
- Maintaining a robust bolted joint assembler training and qualification program

Cryogenic applications will benefit from further study

- Calculating thermal effects difficult without software
 - WRC 510 outlines methodology
- Accuracy of predicted flange rotation
- Boundary conditions – Need actual field data
 - Instrument flanges with strain gauges
- Cheniere is pursuing this with a view to improve bolted joint performance in cryogenic applications and share findings with the Industry.

Questions



Low Pressure Fire



Jet Fire



Tesoro Anacortes - 2010



Heat Exchanger Leak

- Personnel using steam lance to mitigate “bad actor” during startup
- Leaking flange not root cause, but placed personnel in close vicinity of the exchanger.
- Leaks treated as normal occurrences
- 7 fatalities

Others

Belle Fourche Pipeline Company - 2011

- Flange leak, ~19,000 barrels of diesel

Sunco - 2010

- Flange leak, ~17,000 barrels of Vacuum Gas Oil

Citgo - 2012

- Flange leaked ~300-500lbs of HF