INDUSTRIAL PRODUCTS AND SERVICES

Flange Live loading

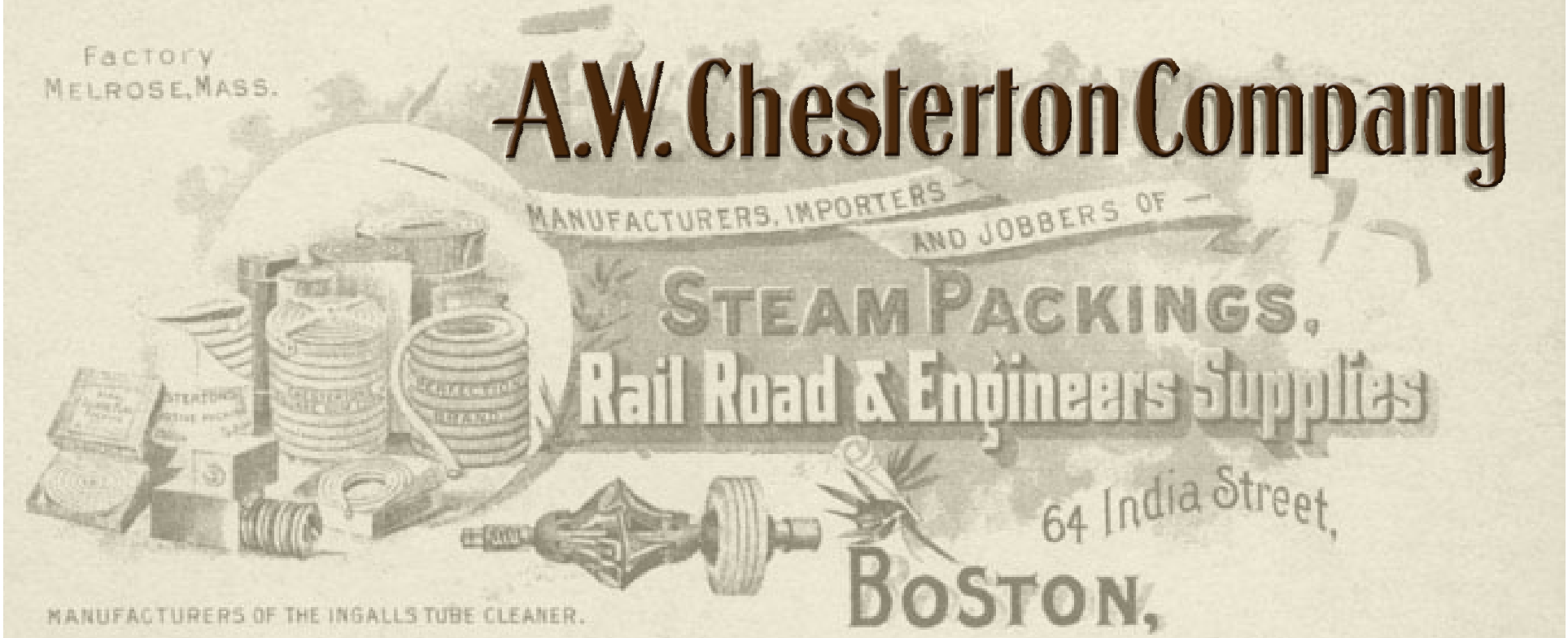
Advanced Technology for Flange Sealing

FLMUG August, 2009

Ron Frisard

AW Chesterton

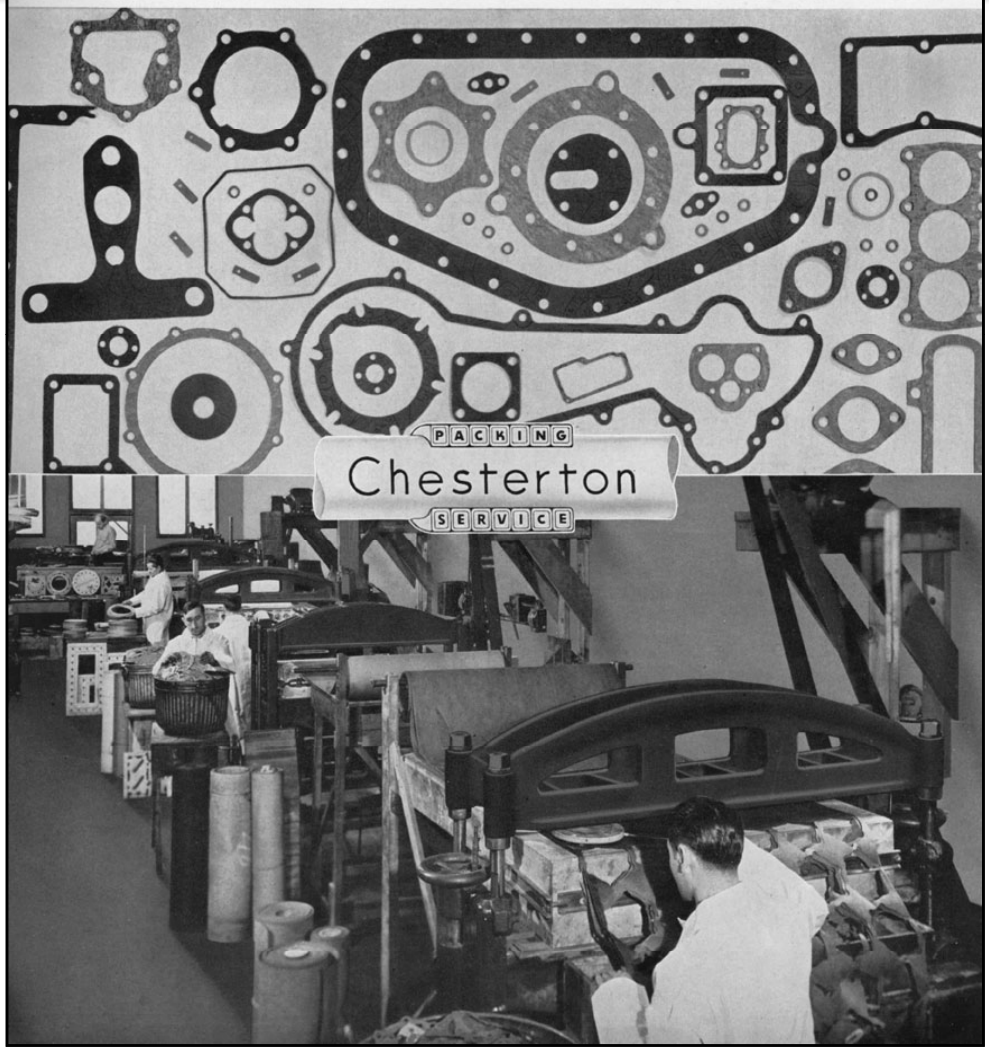
CHESTERTON
Global Solutions, Local Service.



Providing value to industry for 125 years

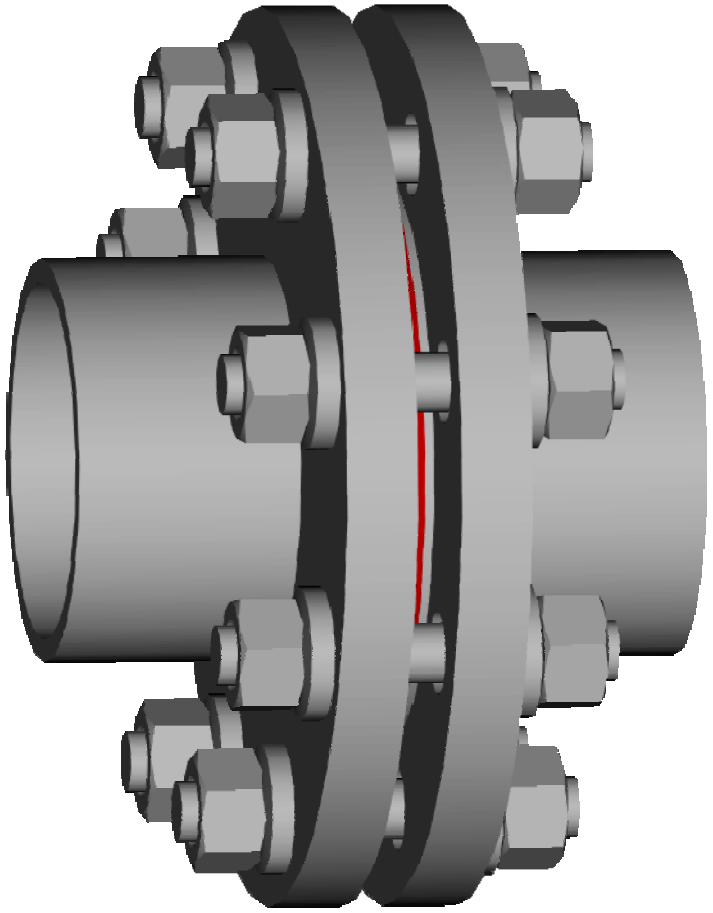
GASKETS FOR EVERY SERVICE

Complete factory facilities for quantity production of special gaskets to customer requirements. Original equipment manufacturers are invited to submit blueprints for cost estimates.



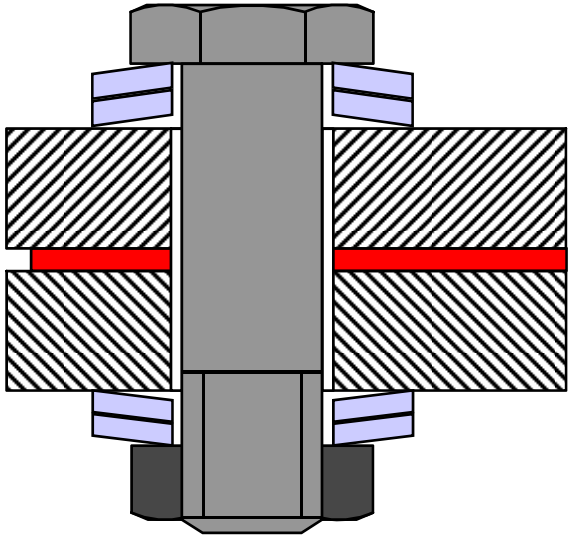
What are we going to cover??

- What is flange live loading
  - How does it work
  - What we offer
- Heat Exchangers



Flange sealing

- Correct gasket selection
- Proper bolting procedures
- Flange Live Loading for critical flange sealing situations



Flange sealing

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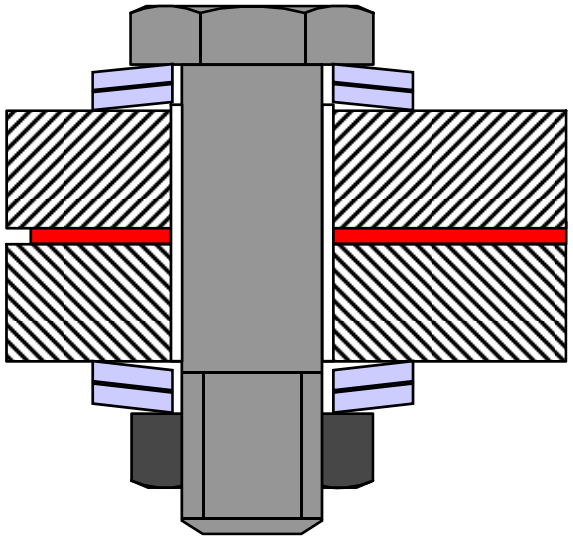


Flange Sealing Factors

- Requirements for a sealed flange connection:
  - Compressibility
  - Recovery (memory)
  - Temperature resistance
  - Chemical compatibility

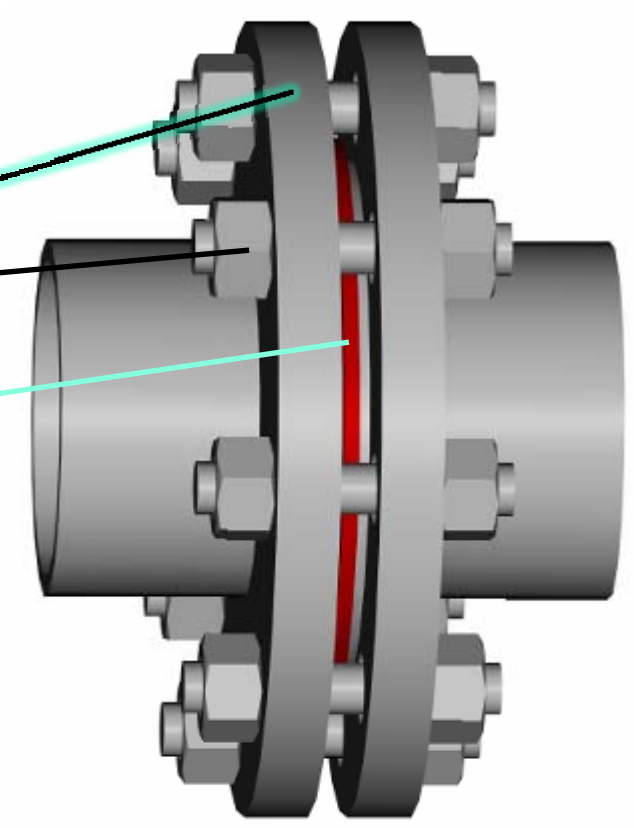
  } gasket material related

  - Gasket seating stress

  } flange connection related

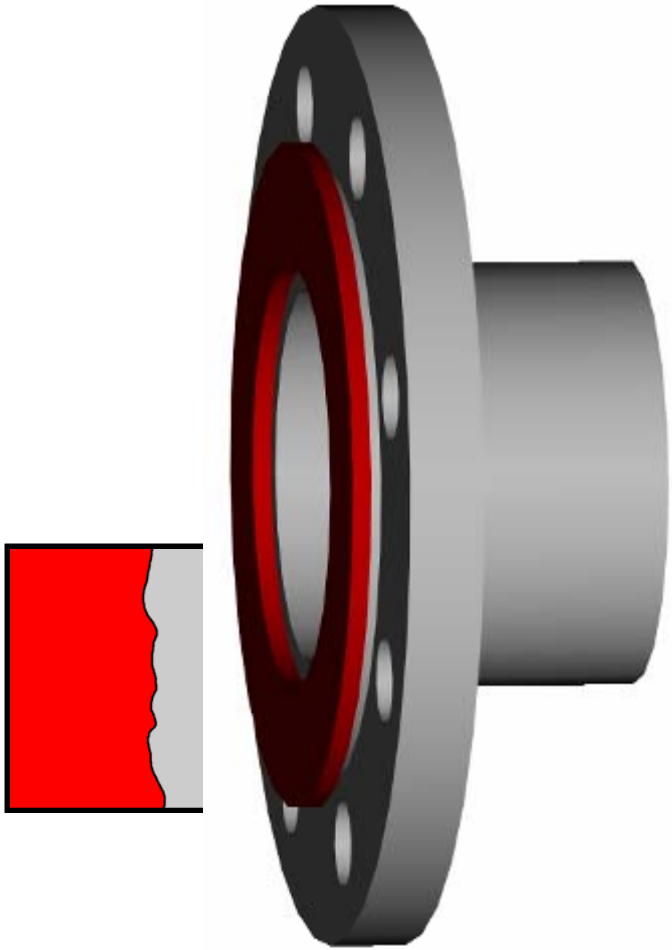
Flanges

A process flange connection is made up out of 2 flanges, tightened together with bolts, with a gasket in between to seal any liquid from leaking out.



Flanges

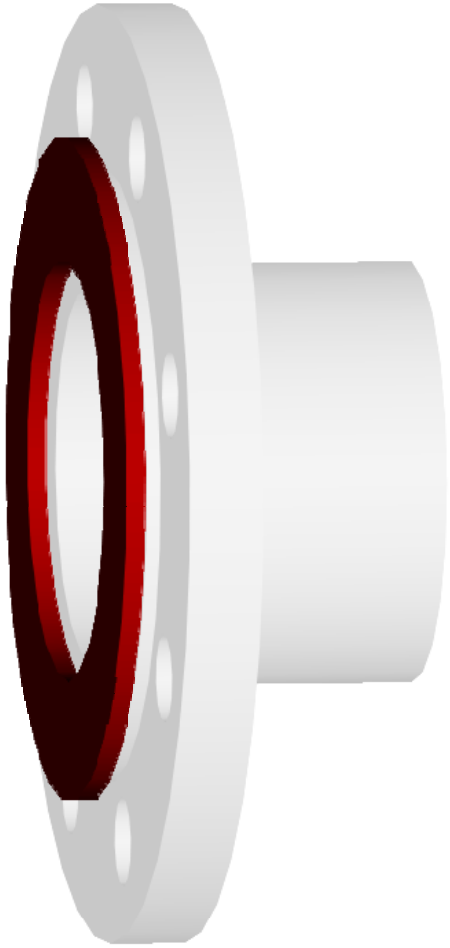
Flanges are not perfectly flat.



Flanges

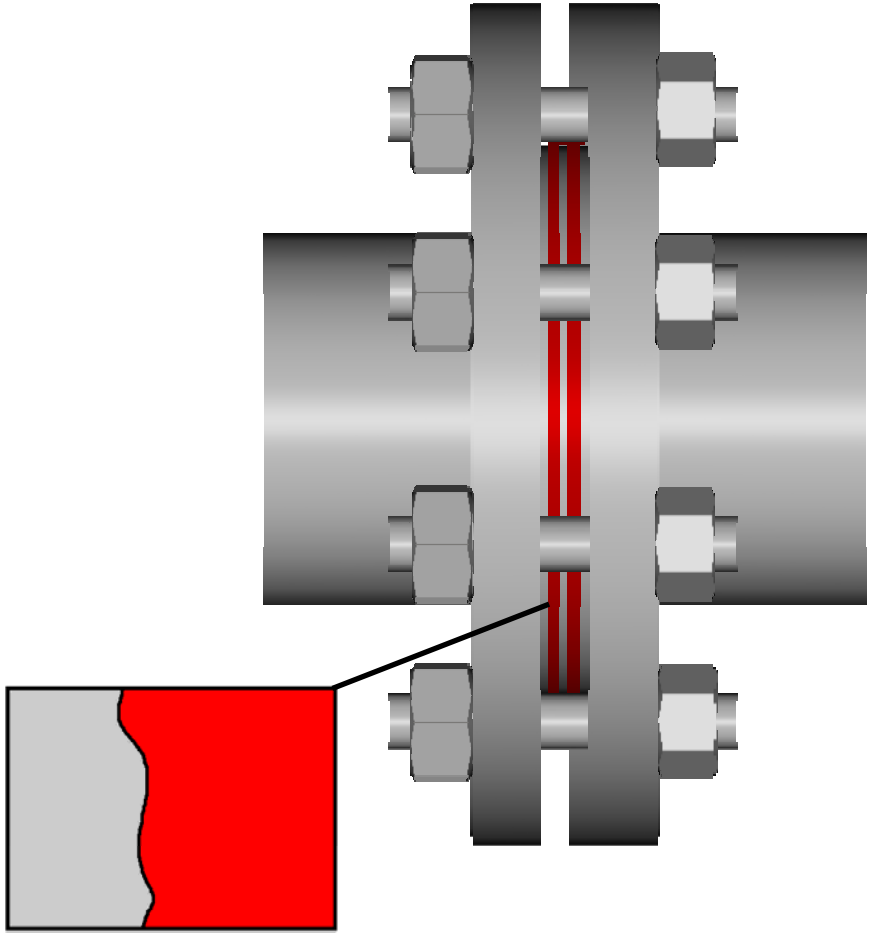
The gasket

- a compressible material
- or a combination of materials
- prevents leakage
- resistant to the medium being sealed
- able to withstand the application temperatures and pressures



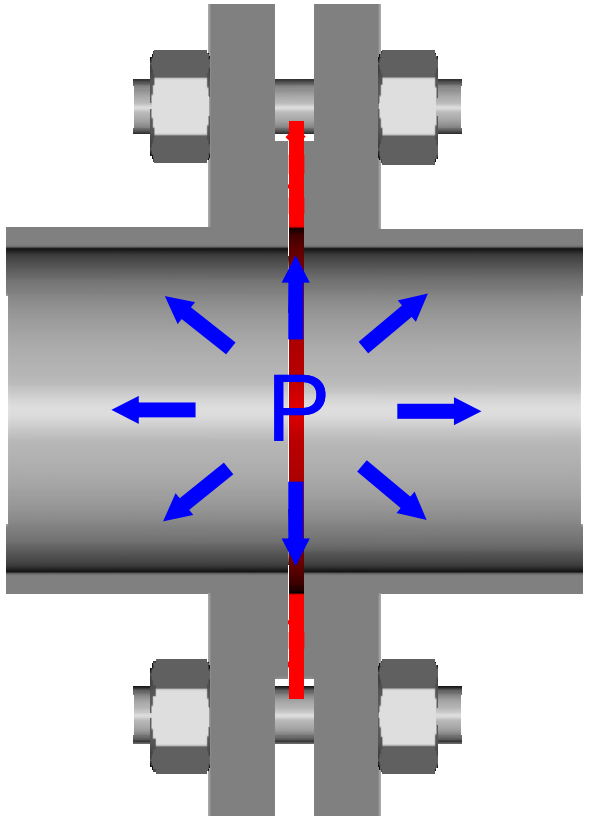
Flanges

A seal is effected by the action of force upon the gasket surface.



Forces On The Gasket

Sufficient stress must remain on the gasket surface to prevent leakage.



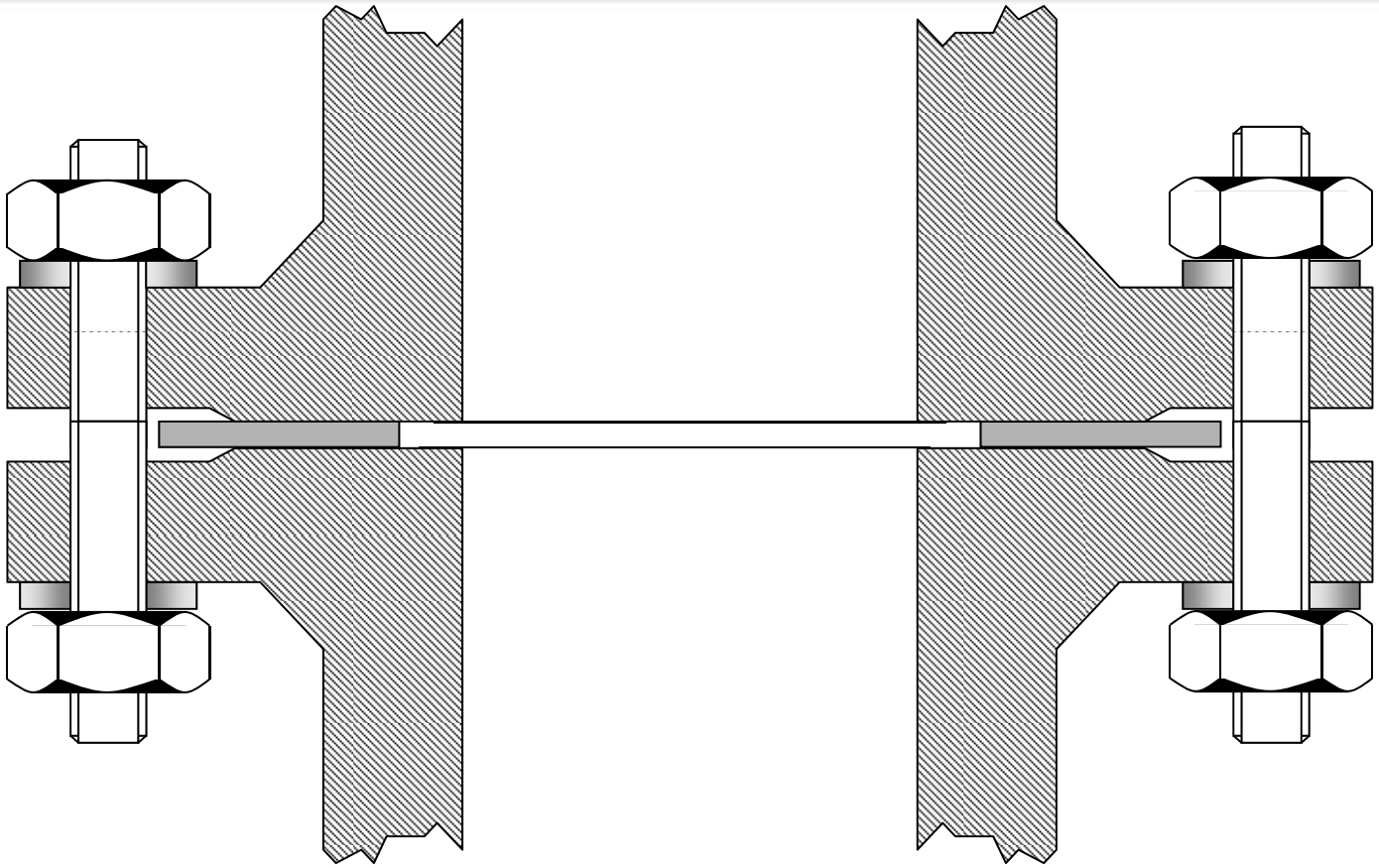
Flange Sealing Factors

- How can we influence and maintain:
  - Compressibility
  - Recovery (memory)
  - Temperature resistance
  - Chemical compatibility
    - By choosing the right gasket!

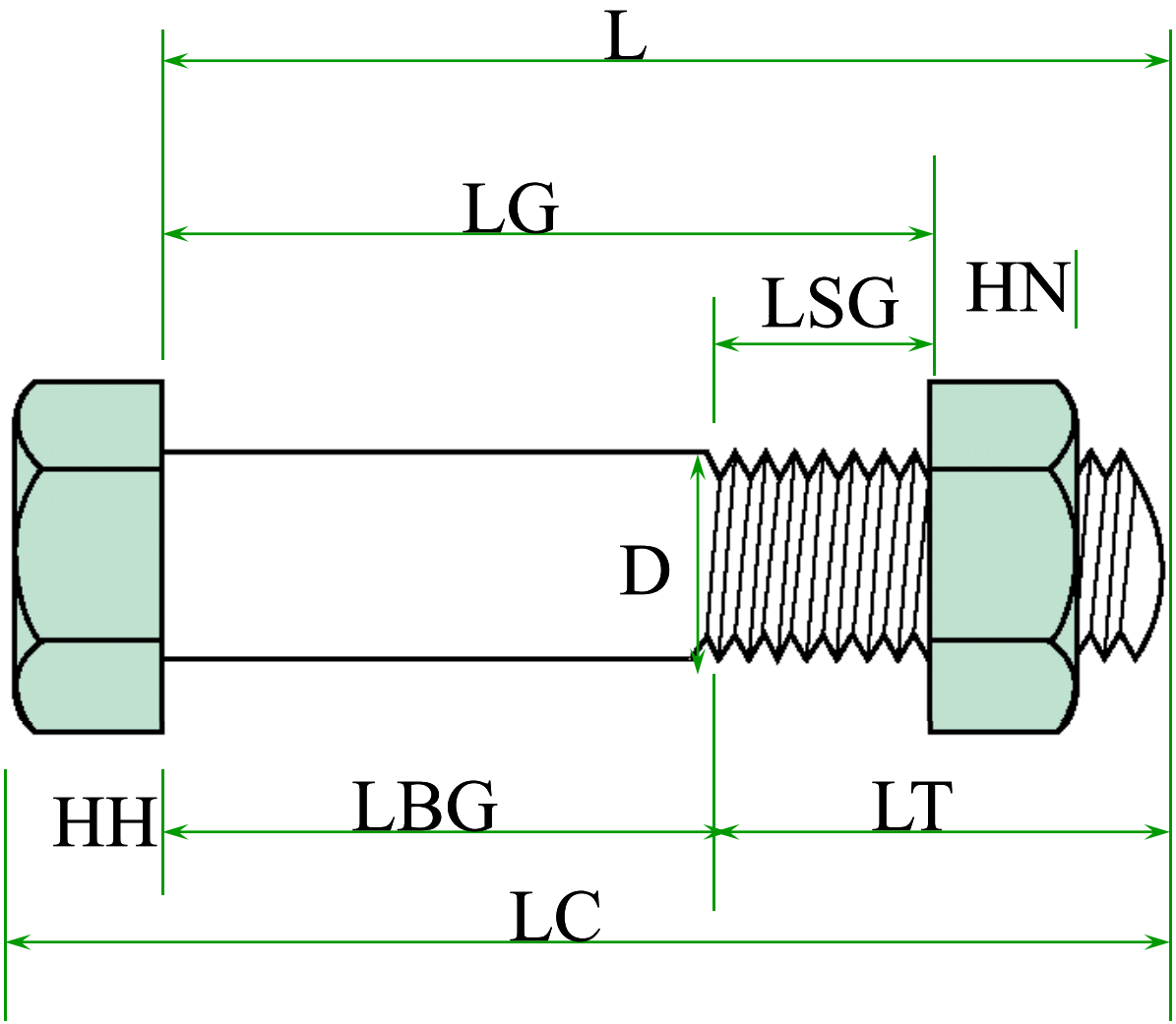
Flange Sealing Factors

- How can we influence and maintain:
  - Pressure resistance (friction & tensile strength)
  - Gasket surface tension
    - By having a good performing flange connection!

Stretch of the bolt

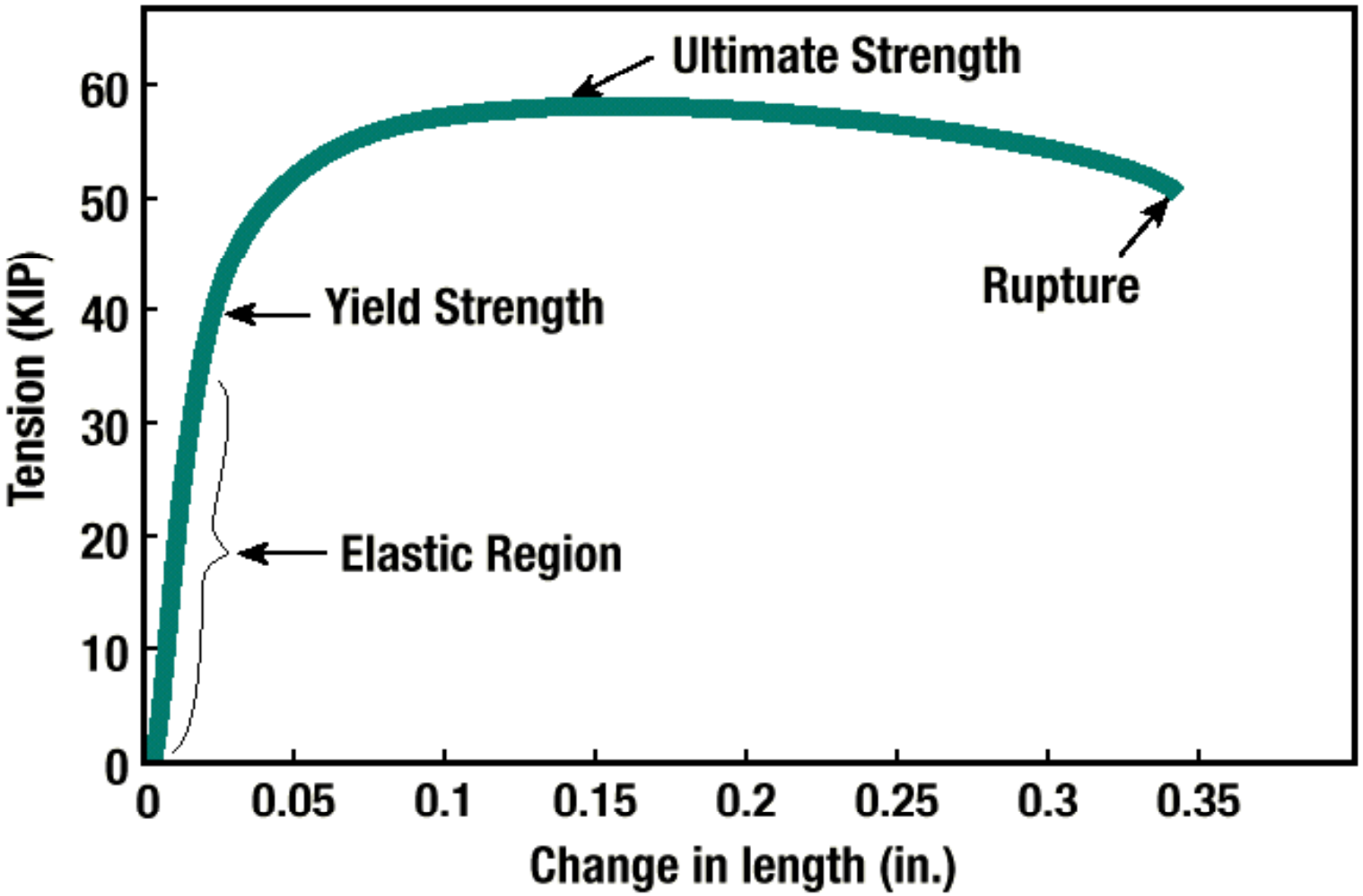


Bolting



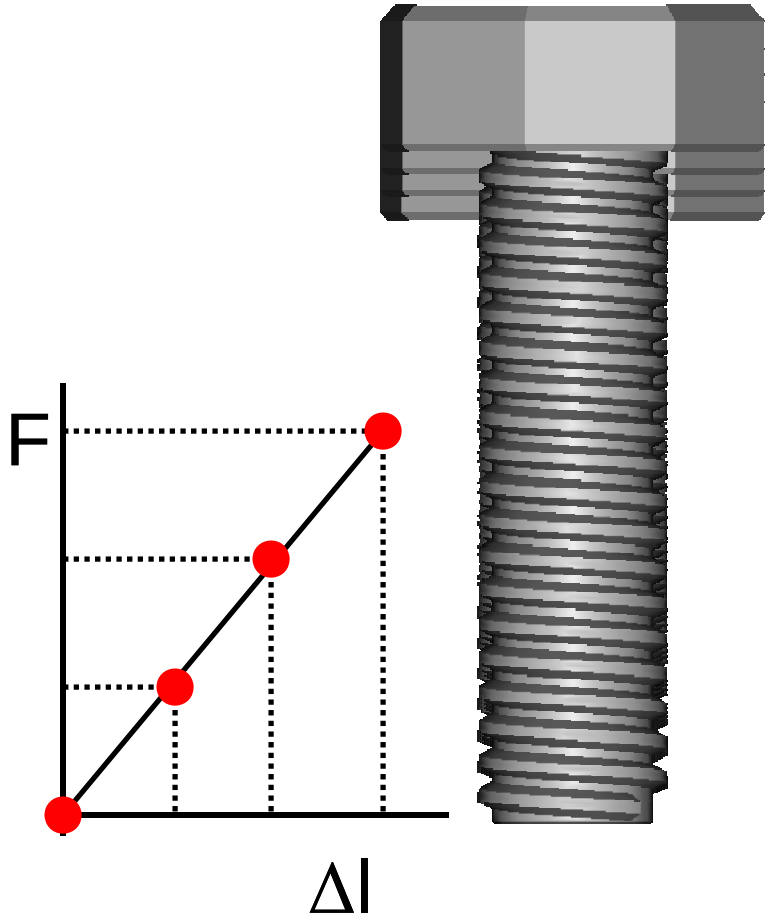
D = Nominal Diameter
L = Nominal Diameter
LBG = Length of Body
LC = Overall Length
LG = Grip Length
LT = Length of threads
LSG = Length of threads within grip
HH = Height of Head
HN = Height of nut

Typical Elastic Curve



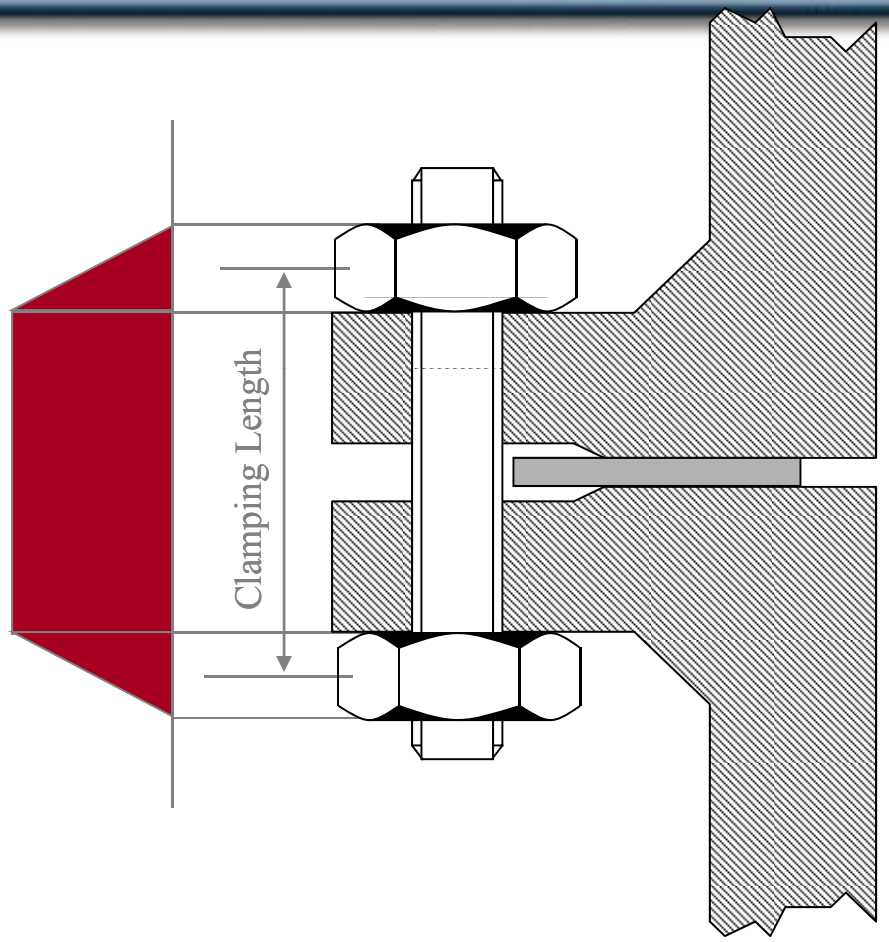
Bolts

- A bolt is an elastic element
- When you tighten a bolt, you stretch it
- The more you stretch it, the higher the bolt force
- The stretch of the bolt is limited by the yield strength
- If you stretch the bolt beyond this point the bolt will deform plastically



Clamping Length

- Bolt Clamping length.
- Distance from nut centres.



Young's Modulus

- $\lambda = \sigma / \varepsilon$

  $= Stress / Strain$

  $= (F/A) / (x/L)$

Bolt Stretch $x = FL/A\lambda$

Average bolt stretch / 100mm (3.94") of bolt clamping length is 0,1mm (.003").

10" of bolt ~ .0076"

Thermal Expansion/Contraction

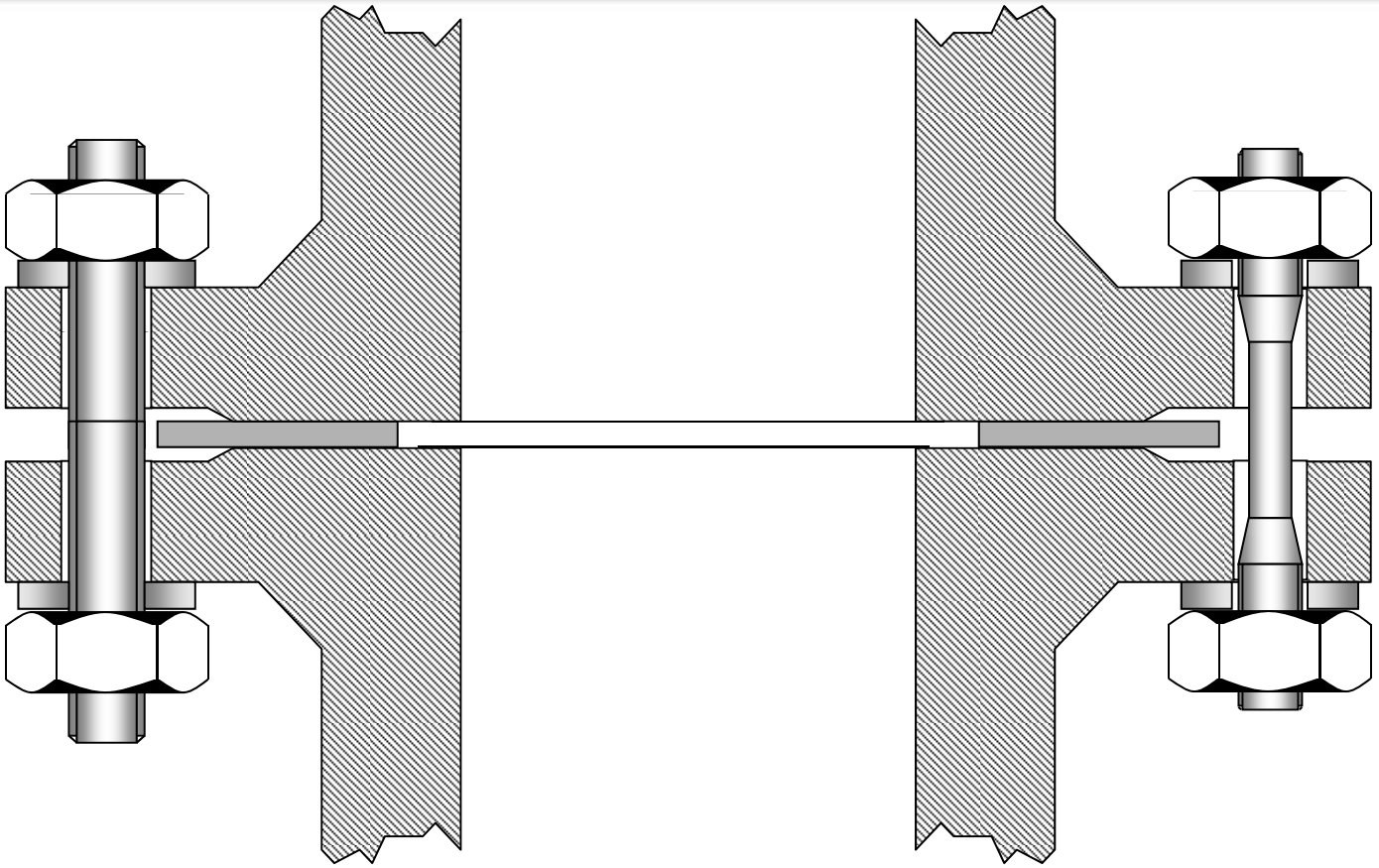
- $x_t = \alpha \,.\, l \,.\, \Delta T$

  α = Co-eff of Thermal Expansion

  e.g. 1,8 x 10-5 m/m.$^oC^{-1}$

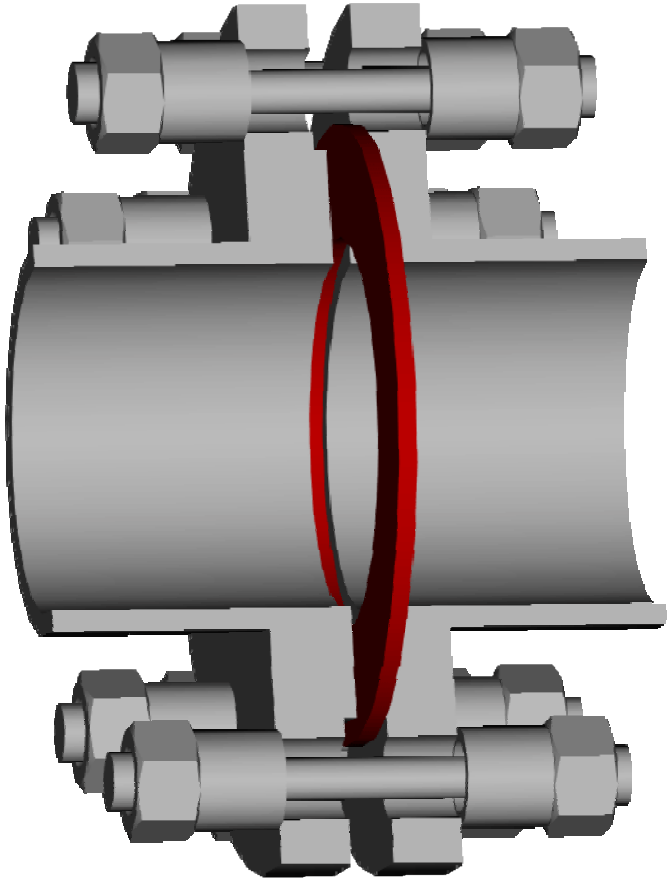
  Expansion / Contraction $x_t \approx$ 0,18mm (.007”) / 100mm (3.94”) length and 100^{o}C (212^{o}F)

  vs Average bolt stretch / 100mm (3.94”) of bolt clamping length is 0,1mm (.003”).



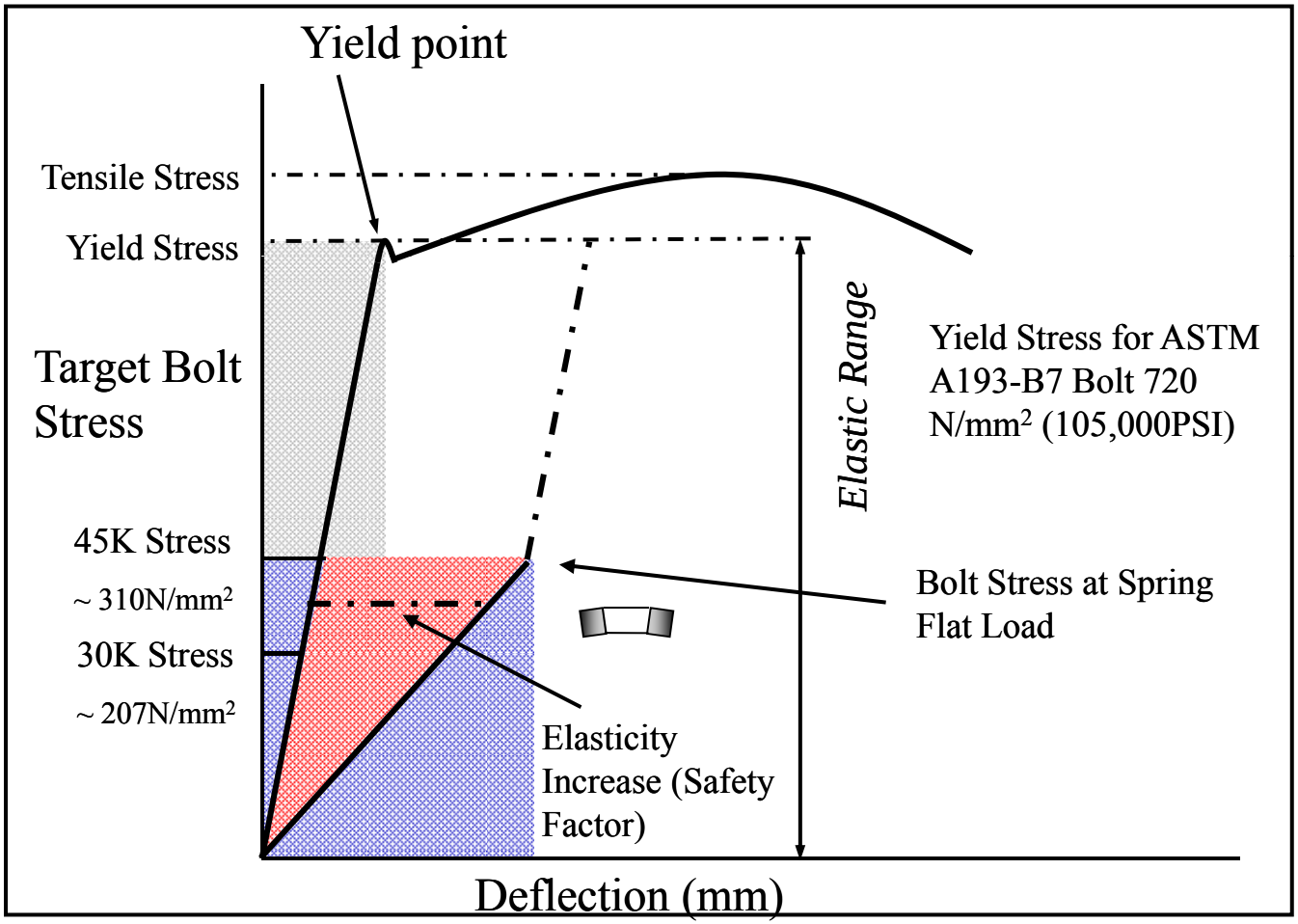
Bolts

- DN80 PN16 flange
- 8 bolts M16
- Normal bolts
  - Bolt stretch 0.003”
- Stretch bolts
  - Bolt stretch 0.0043”
- Extended bolts
  - Bolt stretch 0.0059”
- Combination
  - Bolt stretch 0.0075”



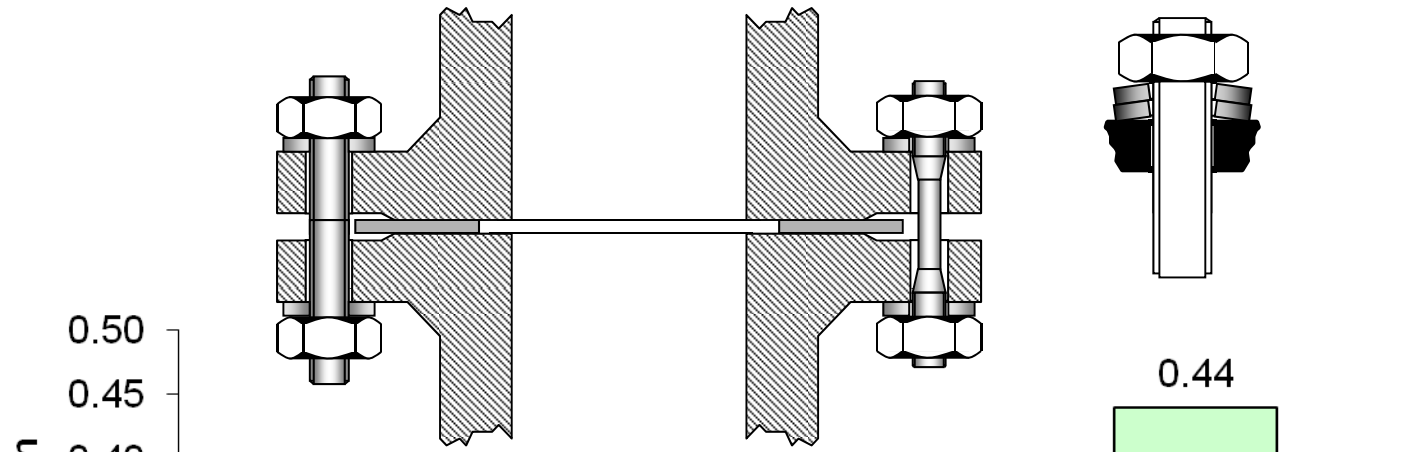
Basic Live loading principle

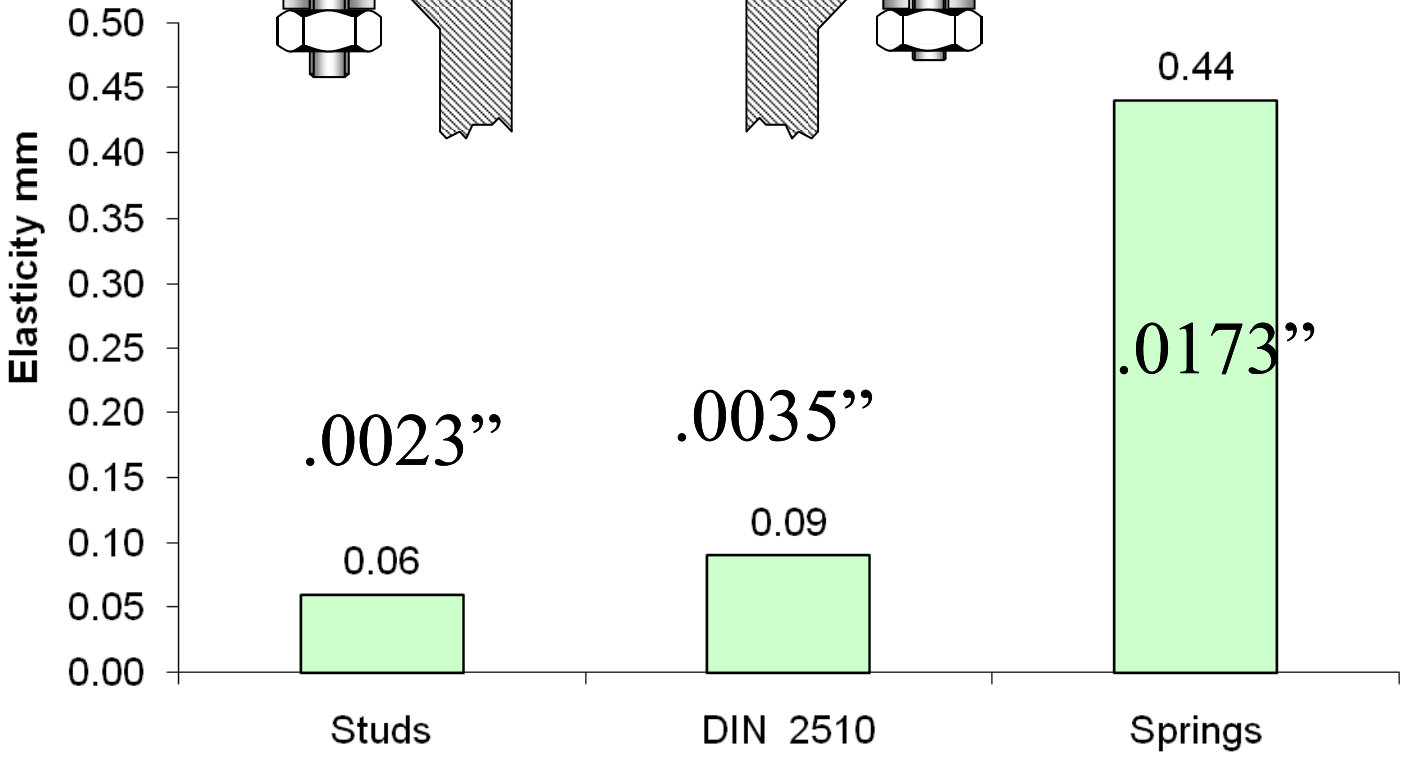
Bolt Load Curve



Bolt Stretch (travel) Comparison

DIN Flange DN65 / PN 40





ESTERTON
Global Solutions, Local Service.

ANSI 150 lb

				MM		MM
NPS (Inch)	OD	x	ID	Bolt Stretch	Spring Item	Spring Travel
1/2	47	x	21	0.04	1201	0.28
3/4	57	x	27	0.05	1201	0.28
1	66	x	33	0.05	1201	0.28
1 1/4	76	x	42	0.06	1201	0.28
1 1/2	85	x	48	0.06	1201	0.28
2	104	x	60	0.07	1202	0.44
2 1/2	123	x	73	0.08	1202	0.44
3	136	x	89	0.08	1202	0.44
3 1/2	161	x	102	0.08	1202	0.44
4	174	x	114	0.08	1202	0.44
5	196	x	141	0.08	1203	0.48
6	222	x	168	0.09	1203	0.48
8	279	x	219	0.10	1203	0.48
10	339	x	273	0.10	1204	0.51
12	409	x	324	0.11	1204	0.51

ANSI 300 lb

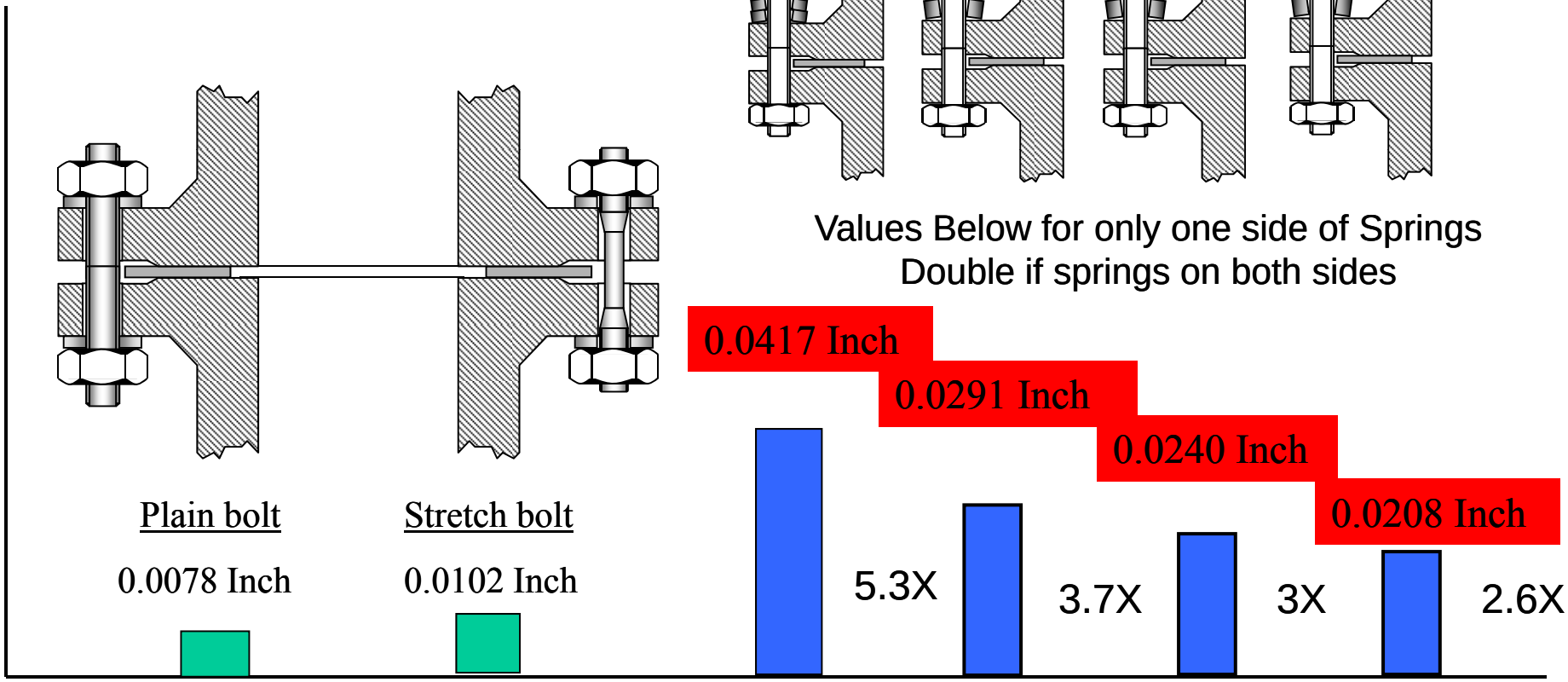
				MM		MM
NPS (Inch)	OD	x	ID	Bolt Stretch	Spring Item	Spring Travel
1/2	53	x	21	0.05	1201	0.28
3/4	66	x	27	0.06	1202	0.44
1	73	x	33	0.06	1202	0.44
1 1/4	82	x	42	0.06	1202	0.44
1 1/2	95	x	48	0.07	1203	0.48
2	111	x	60	0.08	1202	0.44
2 1/2	130	x	73	0.09	1203	0.48
3	149	x	89	0.10	1203	0.48
3 1/2	165	x	102	0.10	1203	0.48
4	180	x	114	0.10	1203	0.48
5	215	x	141	0.11	1203	0.48
6	250	x	168	0.11	1203	0.48
8	307	x	219	0.13	1204	0.51
10	361	x	273	0.15	1205	0.68
12	422	x	324	0.16	1206	0.76

Chesterton Flange Springs

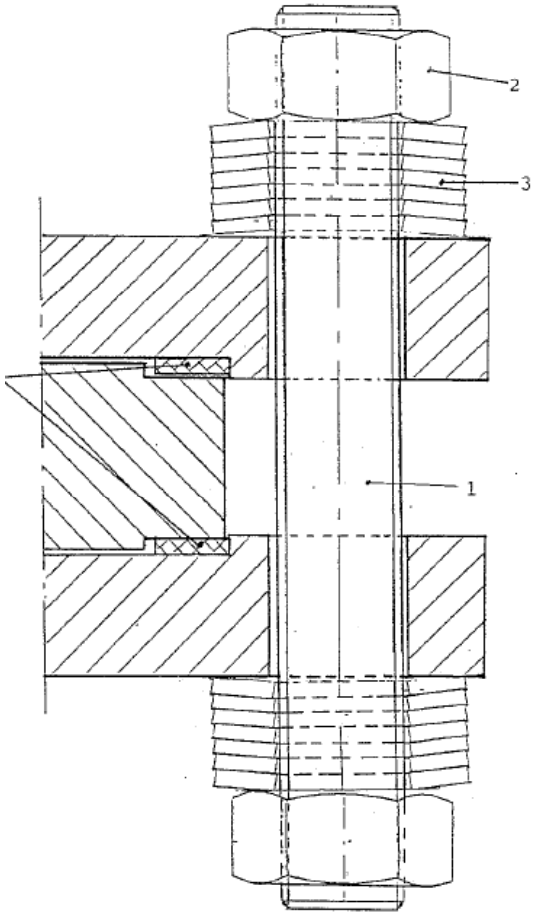
- Chesterton's flange live loading is intended to compensate for thermal cycling effects by storing elastic energy
- Stored elastic energy delays the loss of bolt stretch

Bolt Stretch Comparison
ANSI 24” 150lb Flange, 1-1/4”Bolt, Length 6.750”

Assembly Force 45,411 Lbs

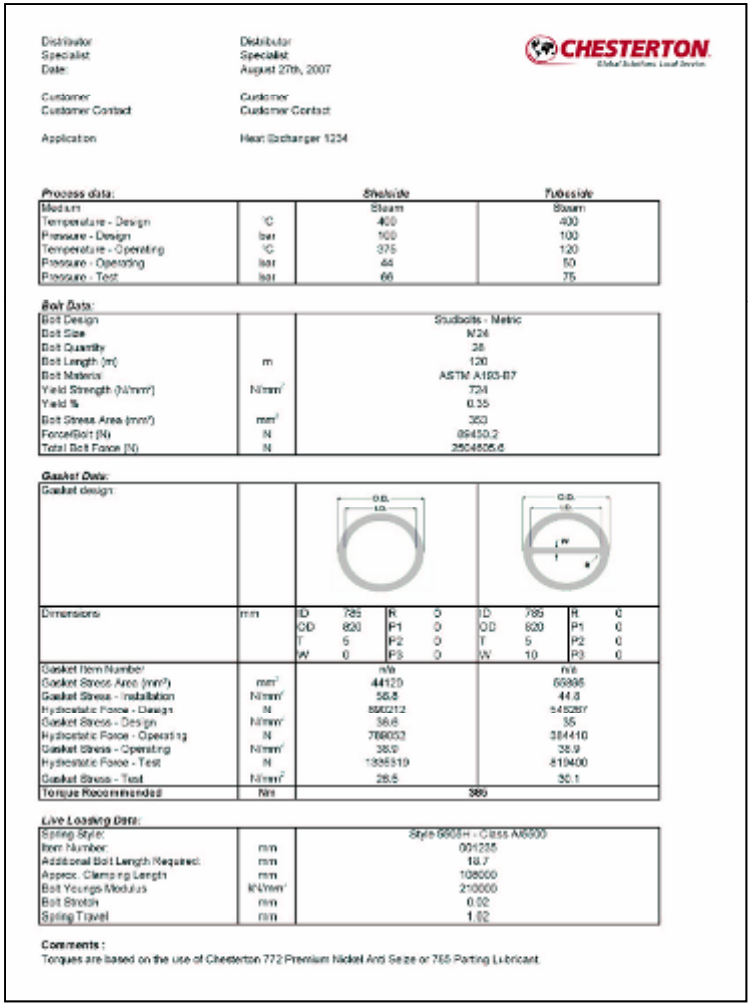


Poor Design due to frictional forces



Chesterton Differentiation

- Engineered Solution
- Focus on the entire system



Distributor
Specialist:
Date: August 27th, 2007

Customer
Customer Contact

Application: Heat Exchanger 1234

CHESTERTON

Process data:

		Shellside	Tubeside
Medium		Steam	Steam
Temperature - Design	°C	400	400
Pressure - Design	bar	100	100
Temperature - Operating	°C	375	120
Pressure - Operating	bar	44	50
Pressure - Test	bar	66	75

Bolt Data:

Bolt Design		Studbolts - Metric
Bolt Size		M24
Bolt Quantity		28
Bolt Length (m)	m	120
Bolt Material		ASTM A193-B7
Yield Strength (N/mm²)	N/mm²	724
Yield %		0.35
Bolt Stress Area (mm²)	mm²	353
Force/Bolt (N)	N	89450.2
Total Bolt Force (N)	N	2504605.6

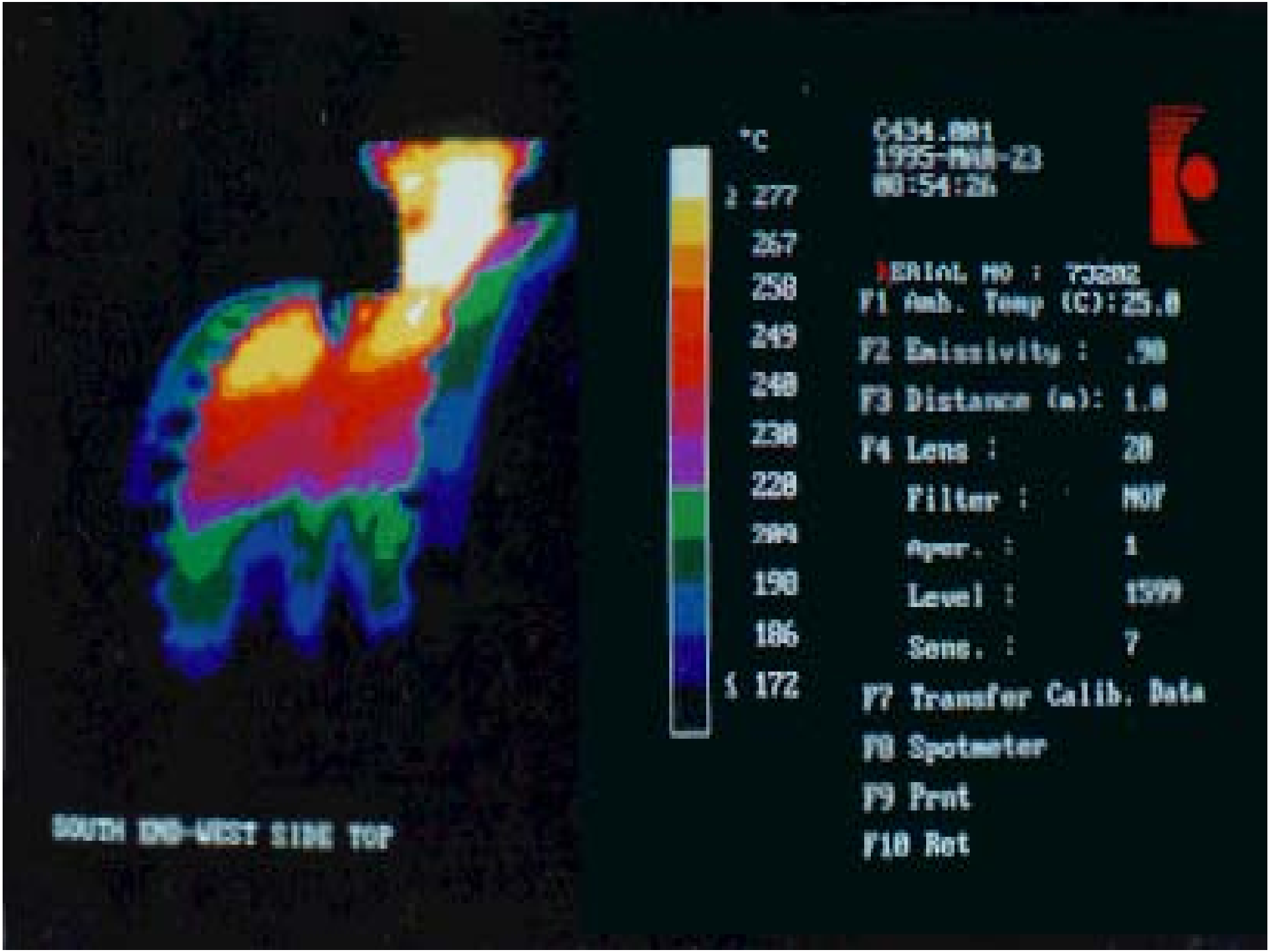
Gasket Data:

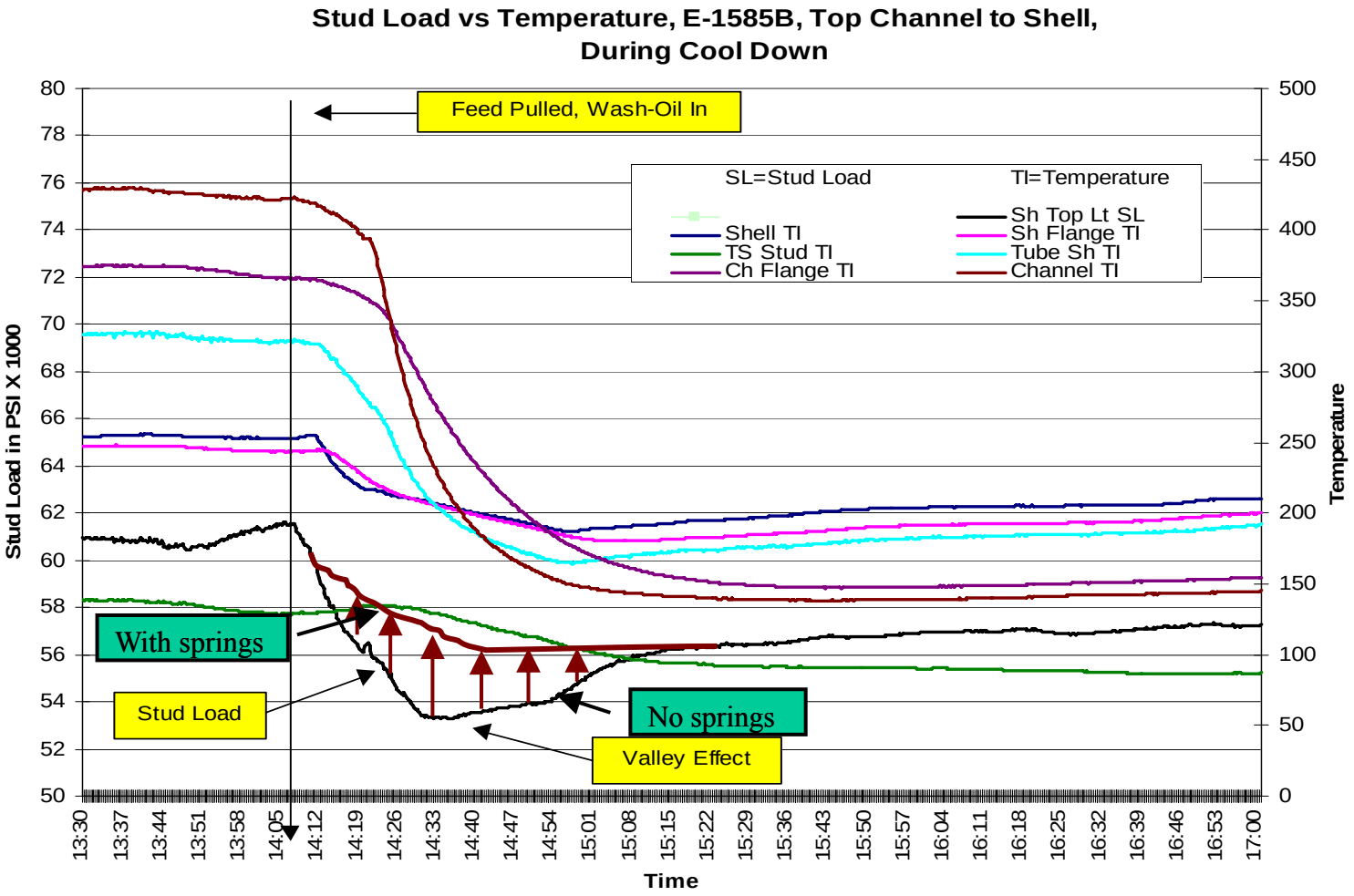
Gasket design			
Dimensions	mm	ID 785 R 5 OD 820 P1 0 T 5 P2 0 W 0 P3 0	ID 785 R 0 OD 820 P1 0 T 5 P2 0 W 10 P3 0
Gasket Item Number		n/a	n/a
Gasket Stress Area (mm²)	mm²	44120	69895
Gasket Stress - Installation	N/mm²	58.8	44.8
Hydrostatic Force - Design	N	5582212	5145287
Gasket Stress - Design	N/mm²	36.6	55
Hydrostatic Force - Operating	N	1766053	3844110
Gasket Stress - Operating	N/mm²	38.9	38.9
Hydrostatic Force - Test	N	1936519	4119400
Gasket Stress - Test	N/mm²	28.6	30.1
Torque Recommended	Nm	380	

Live Loading Data:

Spring Style		Style 6900H - Class A6900
Item Number		001355
Additional Bolt Length Required	mm	19.7
Approx. Clamping Length	mm	106000
Bolt Youngs Modulus	N/mm²	210000
Bolt Stretch	mm	0.02
Spring Travel	mm	1.02

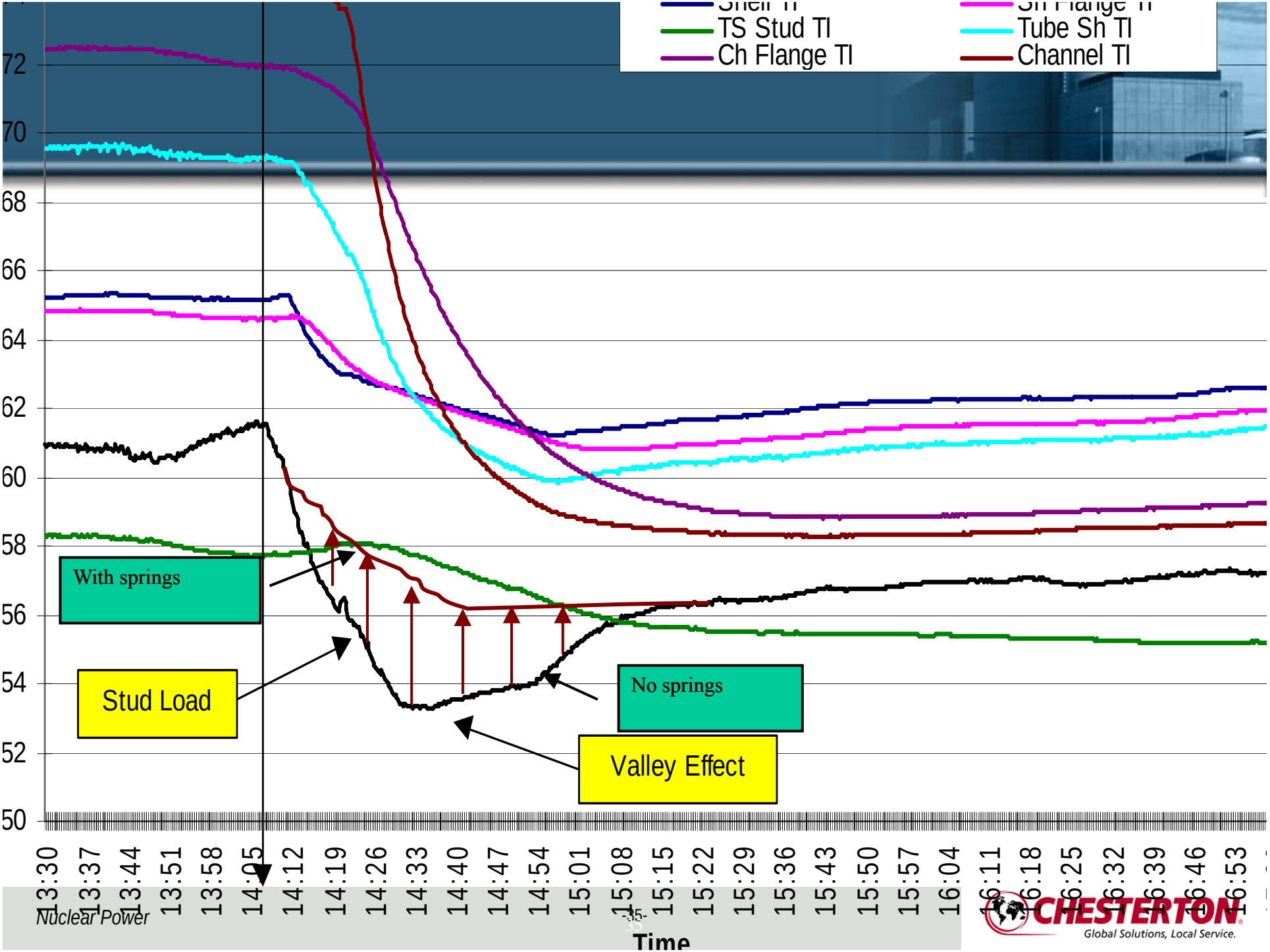
Comments :
Torques are based on the use of Chesterton 772 Premium Nickel Anti Seize or 765 Parting Lubricant


°C
277
267
258
249
240
230
220
209
198
186
172
0434.001
1995-MAR-23
08:54:26
SERIAL NO : 73282
F1 Amb. Temp (C): 25.0
F2 Emissivity : .90
F3 Distance (m): 1.0
F4 Lens : 20
Filter : NOF
Aper. : 1
Level : 1399
Sens. : 7
F7 Transfer Calib. Data
F8 Spotmeter
F9 Prnt
F10 Rot
SOUTH END-WEST SIDE TOP



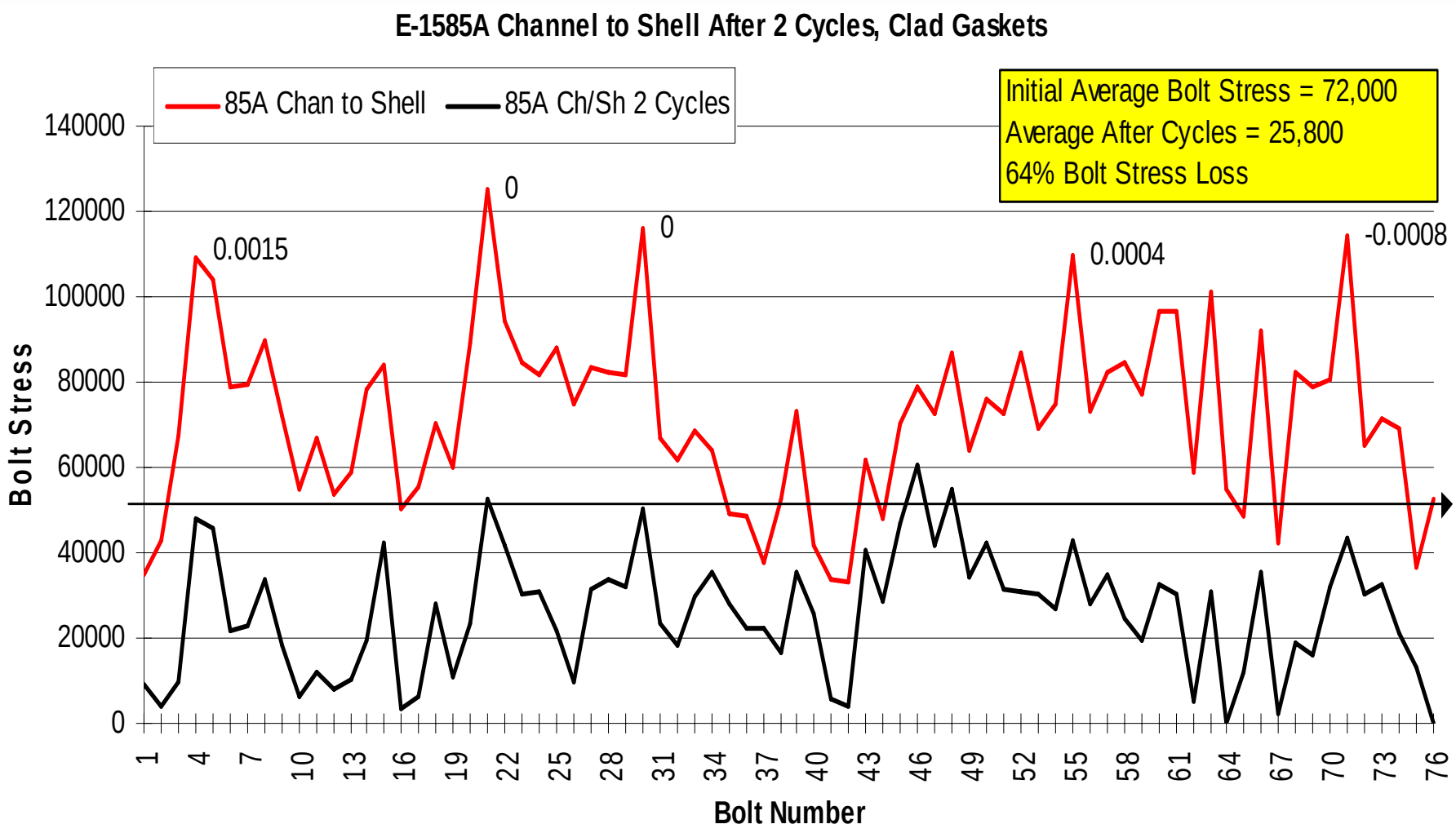
Nuclear Power

Approximate situation with Springs applied. Residual Stud load remains higher thus preventing gasket failure and leakage


Shell Tl
Sh Flange Tl
TS Stud Tl
Tube Sh Tl
Ch Flange Tl
Channel Tl
72
70
68
66
64
62
60
58
56
54
52
50
With springs
Stud Load
No springs
Valley Effect
13:30
13:37
13:44
13:51
13:58
14:05
14:12
14:19
14:26
14:33
14:40
14:47
14:54
15:01
15:08
15:15
15:22
15:29
15:36
15:43
15:50
15:57
16:04
16:11
16:18
16:25
16:32
16:39
16:46
16:53
Time

ChevronTexaco

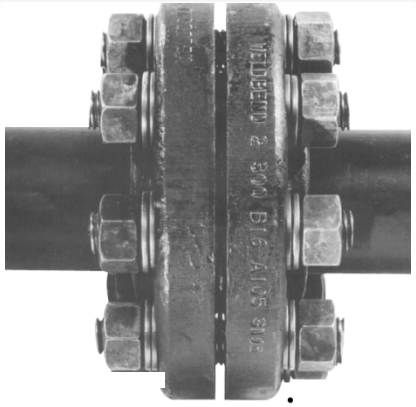
Metal Jacketed Gasket Relaxation



Flange Live Loading

- Chesterton's flange live loading is intended to compensate for thermal cycling effects by storing elastic energy.
- The use of Flange Live Loading resolves issues not considered in the various design codes ;
  - ASME, Stoomwezen, AD Merkblatt.

Product highlight: 5500/5505H Flange springs



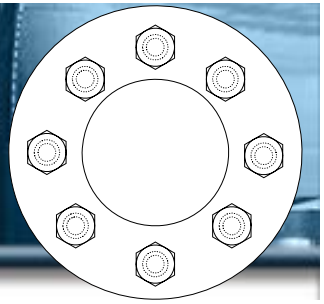
5500 Flange springs

- Made of 17-7 pH stainless steel
- Maximum flange temperature of 572°F (302°C)
- 2 springs per side for B7 bolting
- Come in one load range
- Can be made of special materials

5505H Flange springs

- Made of High strength Chromium based Steel
- Maximum flange temperature of 1100°F (595°C)
- 1 springs per side
- Come in three load ranges: 30K,45K, and 60K

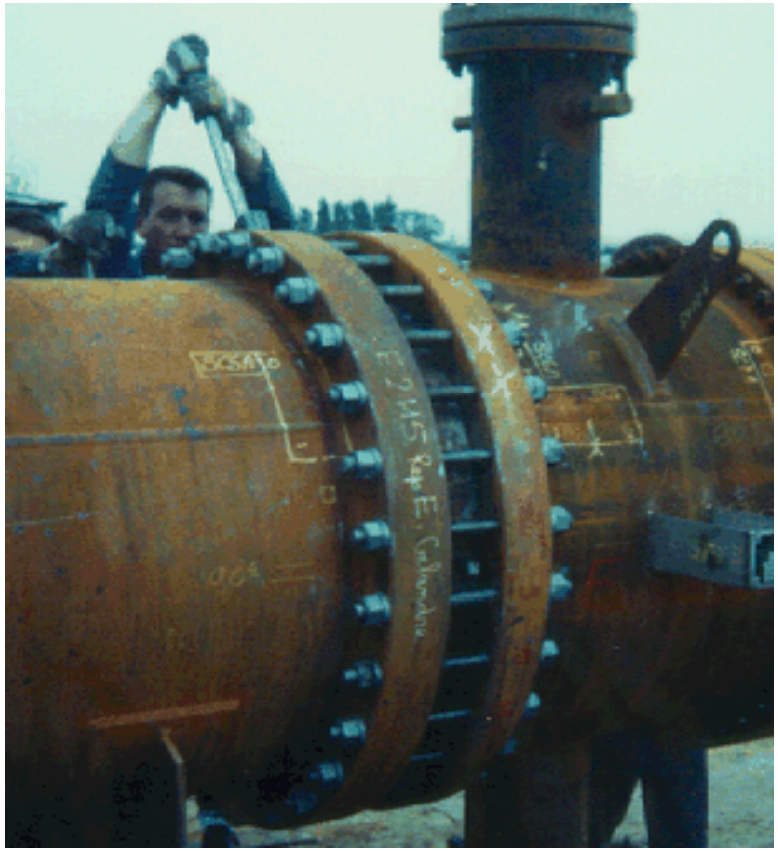
LIVELOAD
RECOMMENDED USAGE

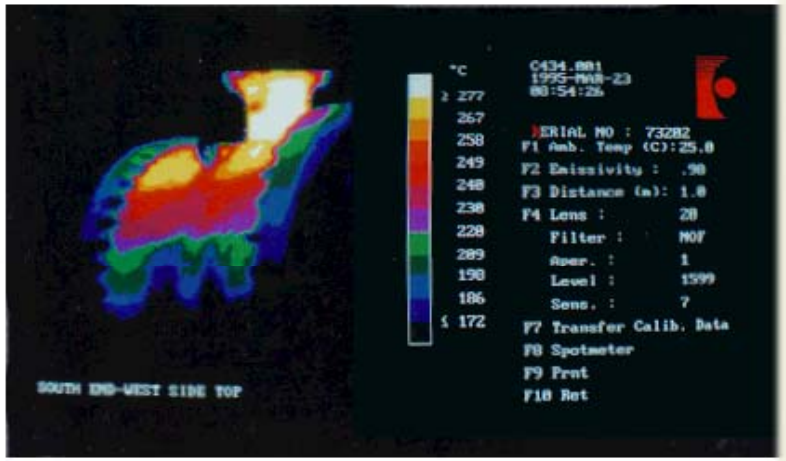


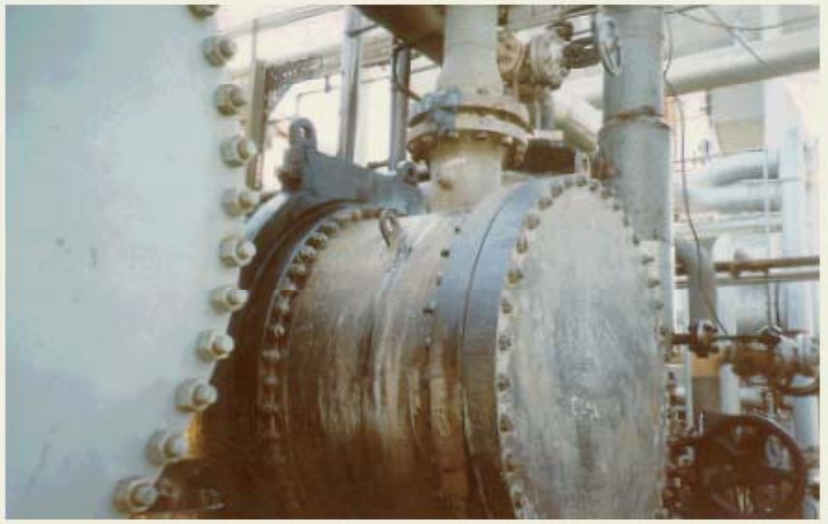
- PROBLEM FLANGE APPLICATIONS
- THERMAL CYCLING APPLICATIONS
- HEAT EXCHANGERS
- WHEN USING GASKETS WITH HIGH CREEP FACTORS

Heat Exchangers

- **CRITICAL**
- **PROBLEMATIC**
- **LABOR INTENSIVE**
- **NO INSTALLED SPARES**

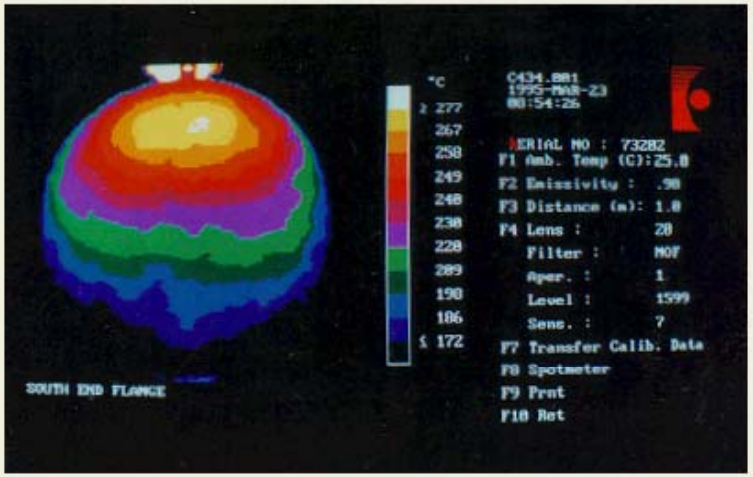






THERMAL - CAMERA

NORMAL CAMERA



Chesterton Critical Flange Sealing

- Engineering consolation on critical flanges
- Gasket and bolting recommendations
- Sealing stress calculations
- Flange live loading recommendations

Chicago Service Center

- Traceable B7 bolting to specific cut lengths
- Partners with Leader Spiral Wound gaskets for standards and special configurations

- Thanks you

- Questions???