INDUSTRIAL PRODUCTS AND SERVICES

Lessons learned on Valve & Pump Packing

What You Have Always Wanted to Know About Packing But Were Afraid to Ask

EGC 2006 Bismarck, North Dakota

CHESTERTON

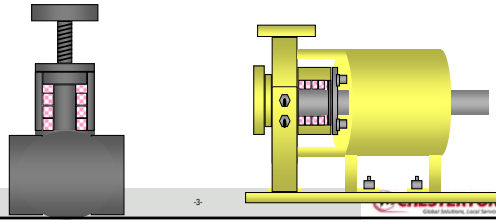
Introduction

- Ron Frisard
  - AW Chesterton
  - Power Marketing Manager
- This workshop will cover all aspects of mechanical packing including how to install and operate pump and valve packing more effectively in all areas of the power industry. Also, the subject of how to identify what packing materials should be installed in what applications to make the equipment have a longer MTBF and reduce the overall life cycle costs of the equipment.

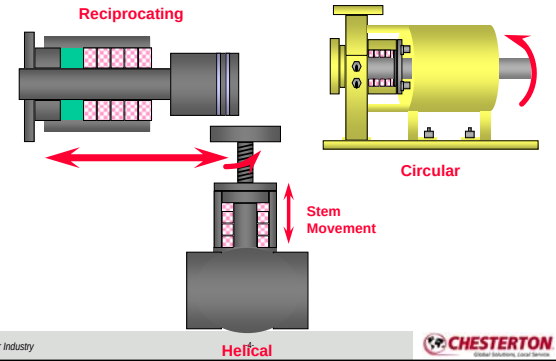
Packing Fundamentals

- **Compression packing….**
  is designed to control fluid leakage.

  effects a seal by reducing or completely blocking the voids between the shaft or stem and the bore of the stuffing box.

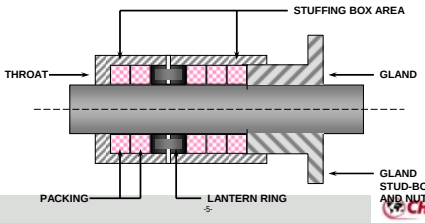


Motions to be sealed



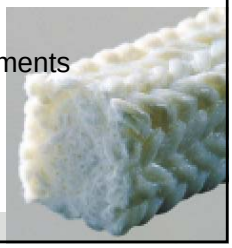
Stuffing box

- **Tightening the packing gland against the top ring transmits lateral force to the packing set. This expands the rings radially against the bore of the stuffing box and the dynamic member.**



Mechanical Packing

- Mechanical Packing is made of
  - Fibers
  - Lubricants
    - Break-in
    - Blocking
- Packing has three requirements
  - Resiliency
  - Chemical Resistance
  - Strength

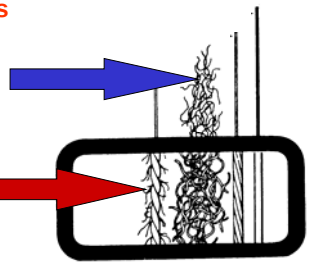


- **Resiliency;** This allows the packing to be deformed and the ability to recover from compression.
- **Chemical Resistance;** This prevents the packing from being attacked by the fluid medium that is being sealed.
- **Strength;** This protects the packing from the mechanical destruction such as “shaft whip”, high pressures, and crystallizing or congealing fluids.

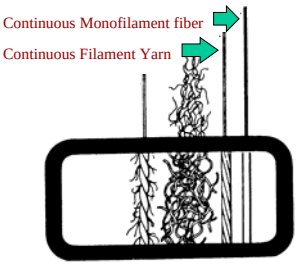
There are three (3) types of Yarns….

- Gang Spun
- Continuous Filament
- Combination

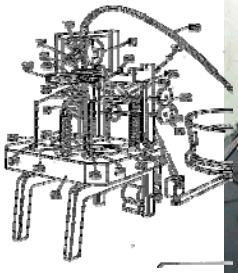
- **Gang spun yarns** are made by spinning **short, non-continuous staple fibers.**
- They are usually natural fibers.

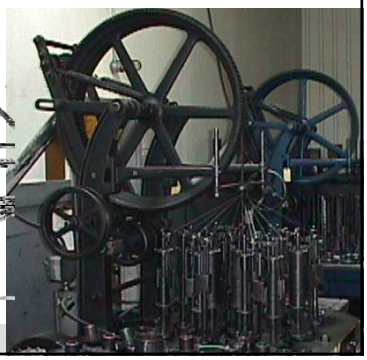


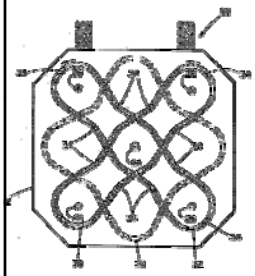
- Continuous filament fibers are unique to man made fibers with any desired length.

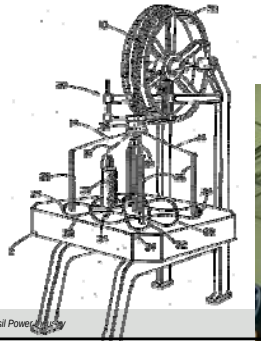


Braiding





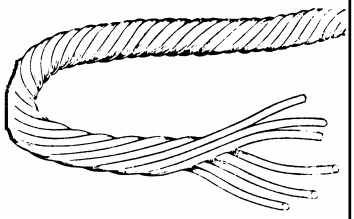




Types of Braiding

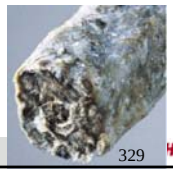
- **Twisted**

  Softest of all constructions.



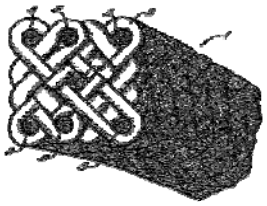
- **Square Braid**

  soft and absorbent, yarns not locked in place.



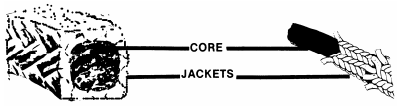
Interbraid

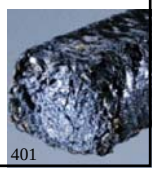
Braid over braid in a three (3) dimensional braiding pattern with each braid at 45 degrees to another.



Braid over Core

composed of one or more woven covers over the other.





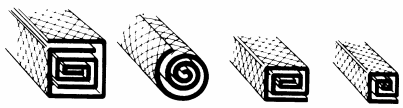
401

- **Crimped or Spiral Wound**

  Packings made of lead, copper, bronze, etc.

- **Laminated or Folded**

  A fabric / rubber combination construction in variable shapes and sizes.



- Natural Fibers are..
  - **Flax -** obtained from plant stalk.
  - **Jute -** obtained from stalk of Jute plant
  - **Ramie -** is a grass grown in tropical climates
  - **Cotton -** is a vegetable fiber
- Characteristics
  - soft — poor temperature range
  - poor tensile strength — poor thermal properties
  - limited coefficient of friction — limited pH range

- Natural Fiber….
  - **Asbestos -** incombustible and has a unique fiber structure. It is resistant to heat, moisture, and corrosion.
- Characteristics
  - superior tensile strength
  - excellent temperature range
  - poor thermal conductivity and coefficient of friction.

Made Man Fibers consist of:

- **Glass**
- **PTFE**
- **Aramid**
- **Acrylic**
- **Carbon & Graphite**

- Glass Fiber…

  has superior thermal properties, dimensional stability, and tensile strength. Available in continuous filament or staple form
- Characteristics
  - good tensile strength limited pH range
  - good temperature range
  - limited heat dissipation

- PTFE Fiber…

  has an unusual high resistance to chemicals, as well as exceptionally low levels of friction and adhesion.
- Characteristics
  - superior pH range
  - superior coefficient of friction
  - limited temperature range
  - limited thermal conductivity

- Aramid Fibers…

  have good resistance to high temperatures and offer superior strength compared to other fibers.
- Characteristics
  - superior tensile strength
  - good heat resistance
  - poor coefficient of friction
  - poor thermal conductivity

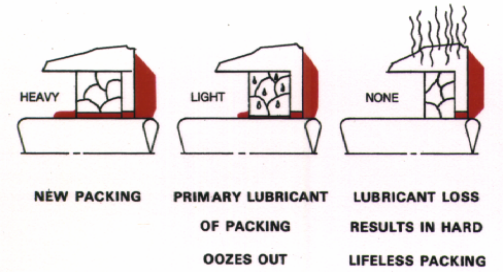
- Acrylic Fibers…

  are thermoplastic and become soft and sticky at temperatures approaching 350 degrees F (204 degrees C). Shrinkage can also occur.
- Characteristics
  - low cost
  - good pH range
  - poor thermal conductivity
  - poor tensile strength and temperature range

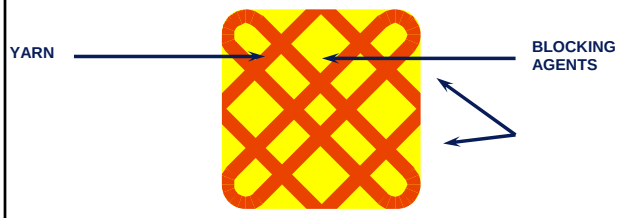
- Carbon & Graphite Fibers…

  are made from a process called pyrolization. Base fibers of rayon, acrylic and Pitch are thermally treated in the presence of oxygen to drive off impurities.
- Characteristics
  - superior thermal conductivity
  - excellent coefficient of friction
  - excellent pH range
  - excellent temperature range

WHY PACKINGS FAIL



PACKING CONSTRUCTION



LATTICE / CONSTRUCTION

Lubricants:

- By definition, a lubricant is any substance which prevents two objects in relative motion from touching.
- This reduces friction & wear.

Lubricants perform two (2) critical roles in compression packing….

Sealing

Heat Control

There are two (2) types of lubricants in quality mechanical packings….

- **Break-in**
- These lubricants provide protection against excessive heat build up until the fresh packing becomes more pliable and is seated properly during the initial break-in period.
- When a lubricant is used exclusively for this purpose, it is sometimes referred to as a “sacrificial” lubricant.
- under load.

- **Built-in**

These lubricants can perform a number of purposes:

- provide a continual source of lubrication
- provide lubrication and sealing at start-up
- functions as a blocking agent to prevent “wicking” through the packing set.
- provides resiliency that allows the packing to deform and recover

Lubricants

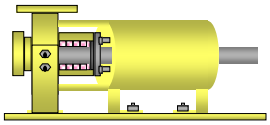
- As lubrication is added, the packing and lubrication goes through a baking process that bakes off 98% of the water. (Chesterton)
- This water reduction ensures packing life and reduces packing consolidation.

- It is important to understand that….

Packing life is directly related to the quality and quantity of the lubrications used in its construction!

pH Scale

0-14 range
0 = Acid
7 = Neutral
14 = Caustic



- Measure of intensity \ severity of a solution: acid \ caustic (base)
- Concentrations of hydronium & hydroxyl ions
- 7 Neutral; concentrations are equal
- Acid; Hydronium ions greater
- Caustic (base); Hydroxyl ions greater

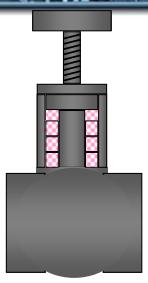
Electrolysis \ Galvanic Corrosion

Galvanic Scale

Magnesium
Zinc
Aluminum
Cadmium
Cast Iron
Mild Steel
316 Stainless Steel
Tin
Lead
Nickel
Monel
Titanium
Graphite
Gold
Platinum

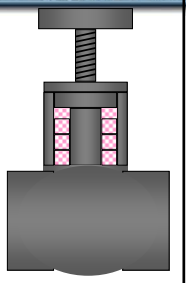
Anodic

Cathodic

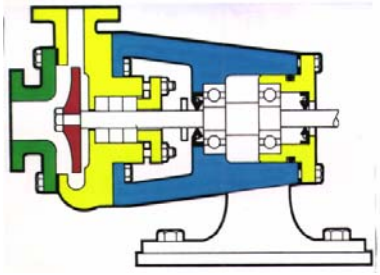


Inhibitors

- active
  - – Reacts imediately, until used up
  - – short effect
  - – oxidizes easily
    - » Zinc Magnesium Aluminum
- passive
  - – more absorbent, slower reation time
  - – longer lasting
  - – more stable
    - » Molybdate Salts Phosphorous

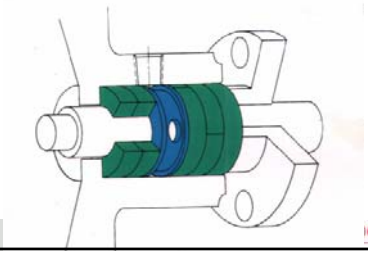


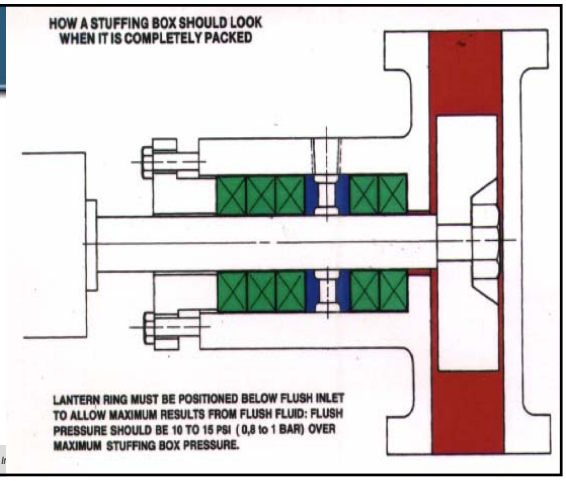
Impeller Design and Stuffing Box Pressure



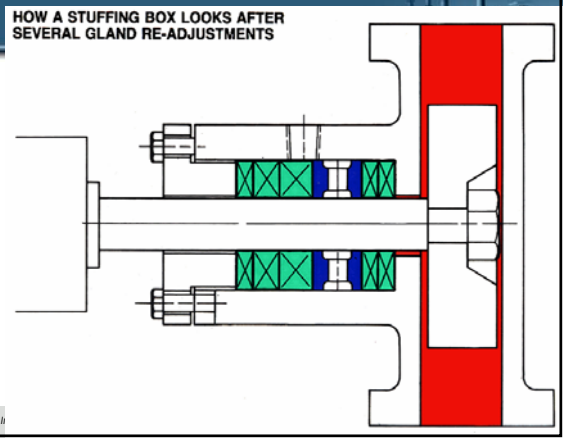
The lantern ring was designed for two reasons.

1) To maintain a vacuum.
2) to cool & lubricate packing.



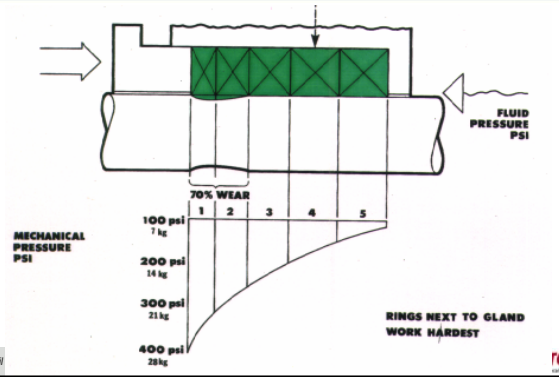


HOW A STUFFING BOX LOOKS AFTER SEVERAL GLAND RE-ADJUSTMENTS



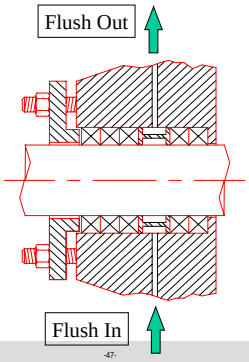
Fossil Power I

Packing Wear



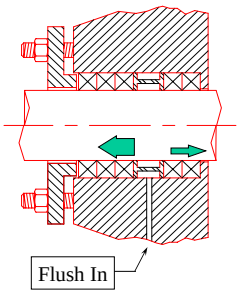
Fossil

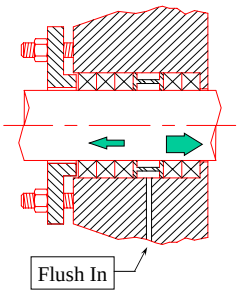
Flush Configurations



Fossil Power Industry -47-

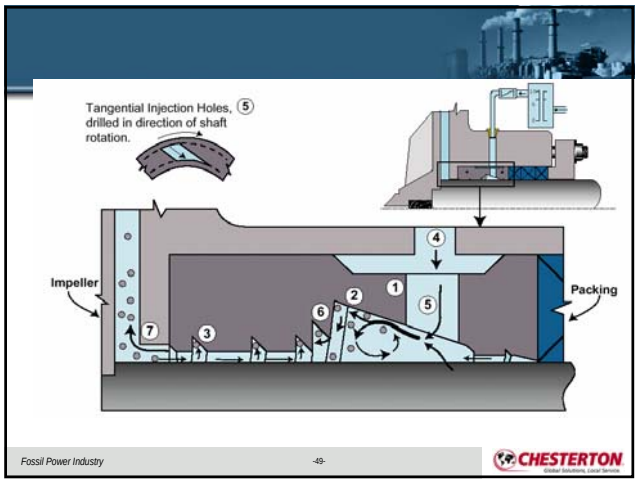
CHESTERTON

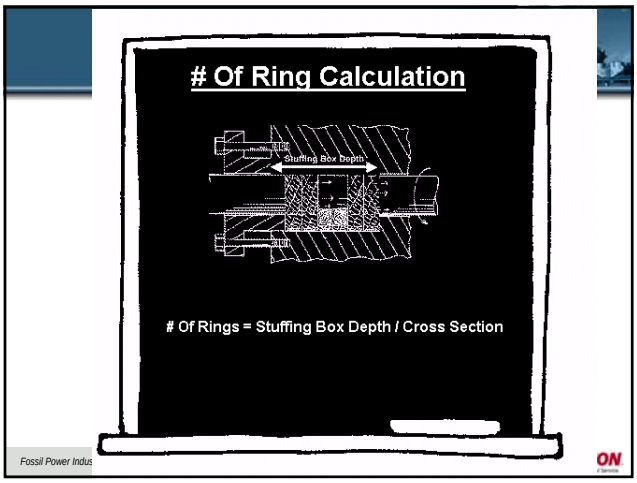


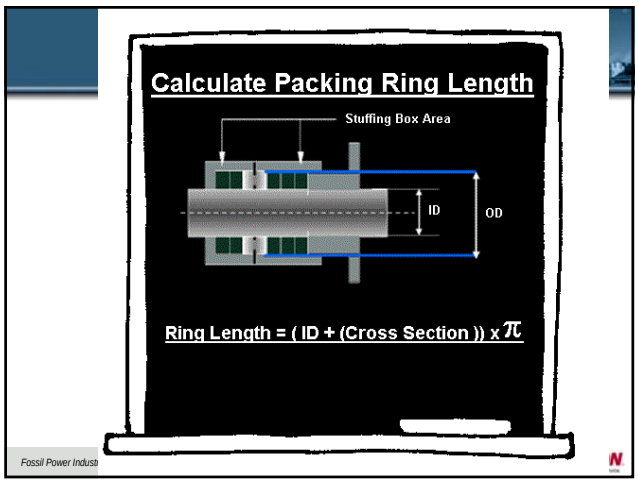


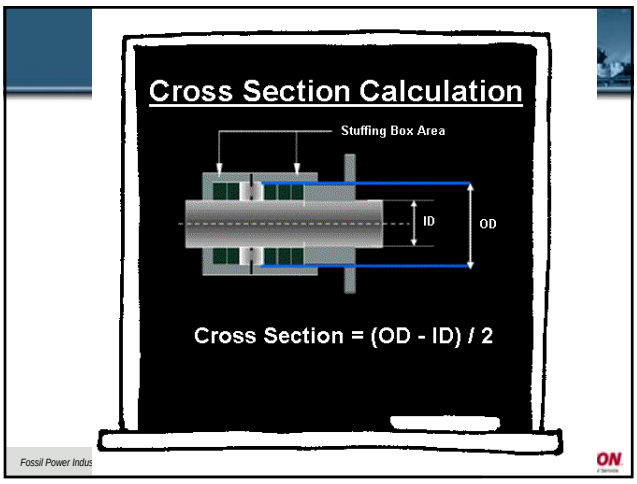
Fossil Power Industry -48-

CHESTERTON

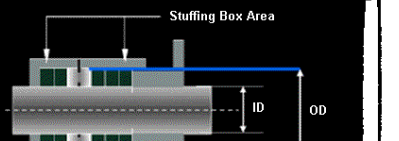

Tangential Injection Holes, 5
drilled in direction of shaft
rotation.
Impeller
Packing
1
2
3
4
5
6
7
Fossil Power Industry
-49-
CHESTERTON


Of Ring Calculation
Stuffing Box Depth
Of Rings = Stuffing Box Depth / Cross Section
Fossil Power Indus


Calculate Packing Ring Length
Stuffing Box Area
ID
OD
Ring Length = (ID + (Cross Section)) x π
Fossil Power Indust

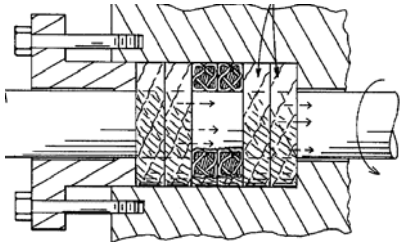

Cross Section Calculation
Stuffing Box Area
ID
OD
Cross Section = (OD - ID) / 2
Fossil Power Indus

Shaft Speed Calculation



RPM x Dia(inch) x PI /12 = Feet per Min

Installing pump packing



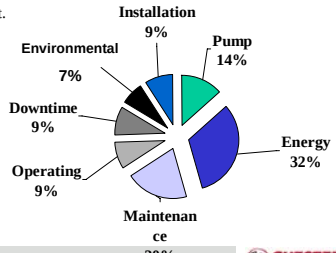
1. Follow normal cleaning procedures. Remove all old rings of packing. Make sure shaft is true (.003" (0,08mm) run out maximum) and smooth with no burrs or grooves.
2. Make butt-cut rings. The preferred way is to wind the desired number of rings on a mandrel the same diameter as the shaft, and cut rings by making one straight cut parallel with mandrel.
3. Insert rings into stuffing box — not more than two at a time, and seat to location by tamping, preferably by using a Chesterton 176 Tamping Tool. Stagger all ring joints at 90° intervals. Turn shaft occasionally to assist seating packing rings.
4. Take up gland nuts finger tight only. Make sure there is initial leakage (a minimum of 20–30 drops per minute). Back off gland nuts if necessary. Never allow gland to heat up. Allow ample time before subsequent adjustments are made to allow for proper break-in. Take up 1/12 turn (½ flat) at a time, no more than every 15 minutes. Make sure gland adjustments are applied evenly.

Cost Components

Life Cycle Cost is the total lifetime cost to purchase, install, operate, maintain and dispose of that equipment.

HI/EP Oct. 2000

The purchase price is typically less than 15% of the total ownership cost.



Energy & Maintenance costs

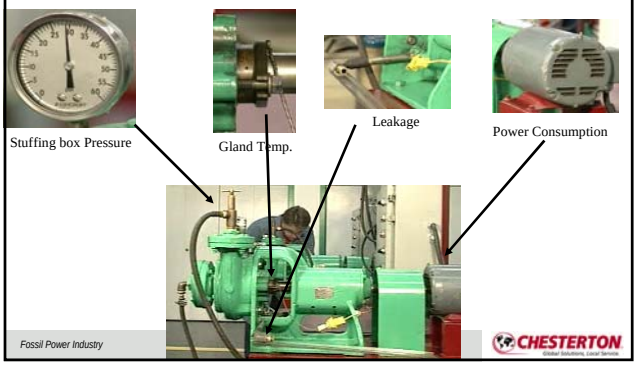
70% of U.S. energy production drives electric motors

70% of electric motors drive pumps, compressors and fans

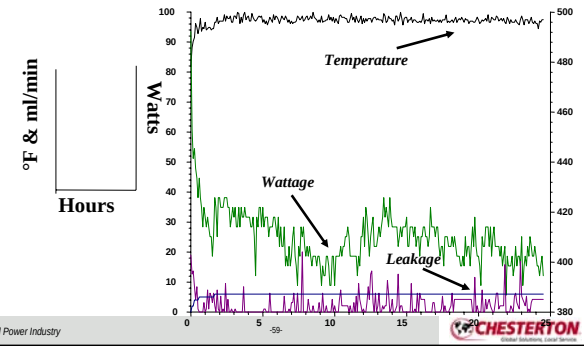
Pumped systems account for 20% of the world's electric energy demands

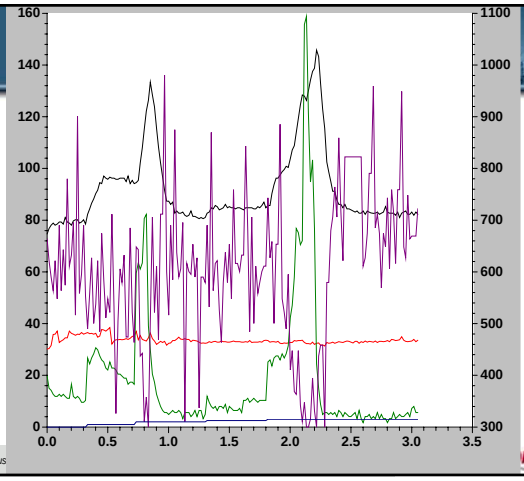
Energy and maintenance costs during the life of a pump system are usually more than10 times its purchase price

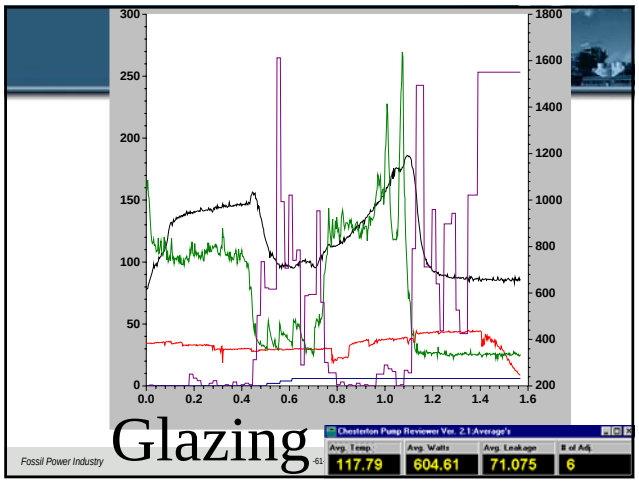
Pump packing Test Area

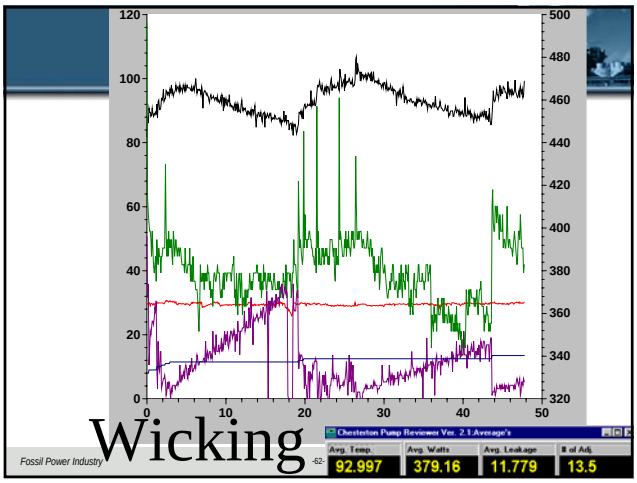


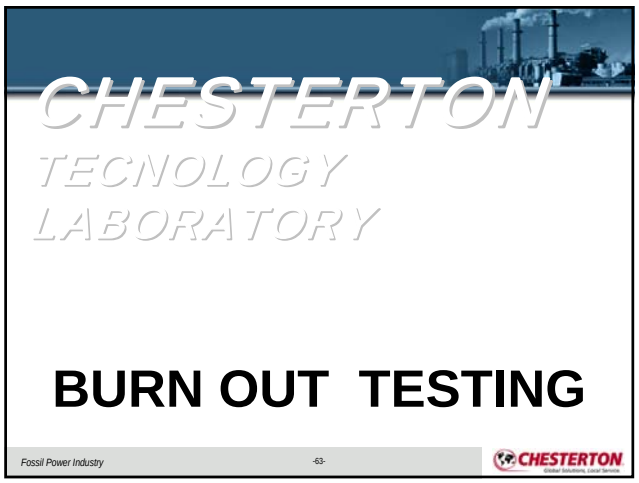
Anatomy of a Pump Packing Curve

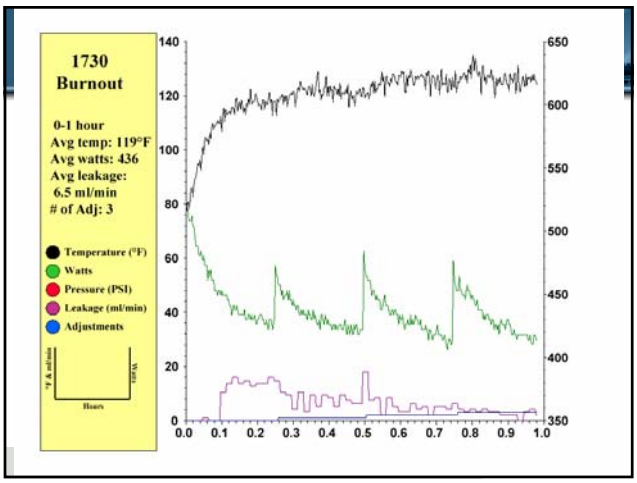


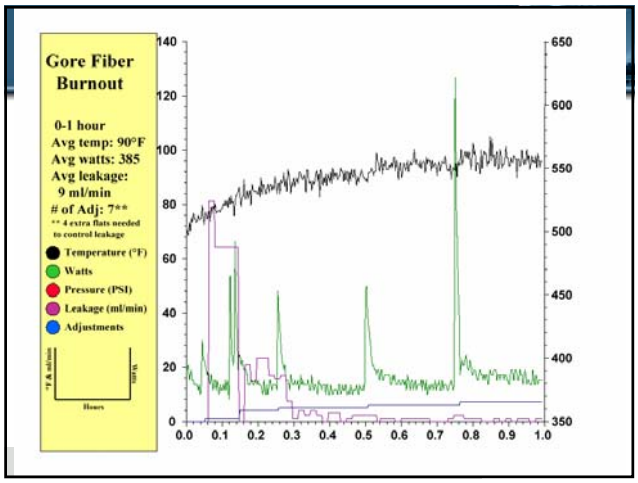


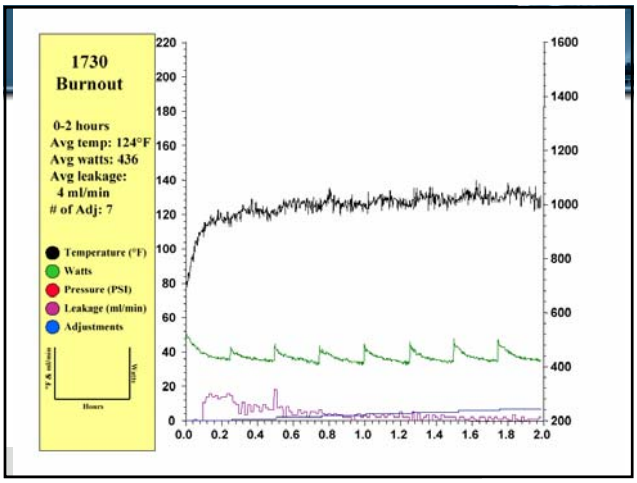

Glazing
Chesterton Pump Reviewer Ver. 2.1:Average's
Avg. Temp.
Avg. Watts
Avg. Leakage
# of Adj.
117.79
604.61
71.075
6
Fossil Power Industry
-61-

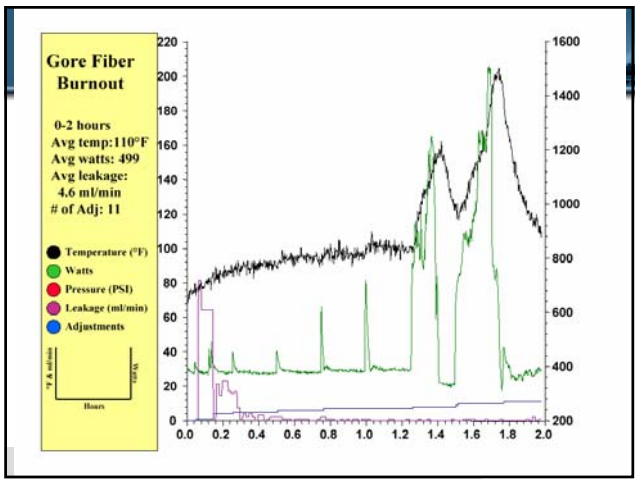

Wicking
Chesterton Pump Reviewer Ver. 2.1:Average's
Avg. Temp.
Avg. Watts
Avg. Leakage
# of Adj.
92.997
379.16
11.779
13.5
Fossil Power Industry
-62-

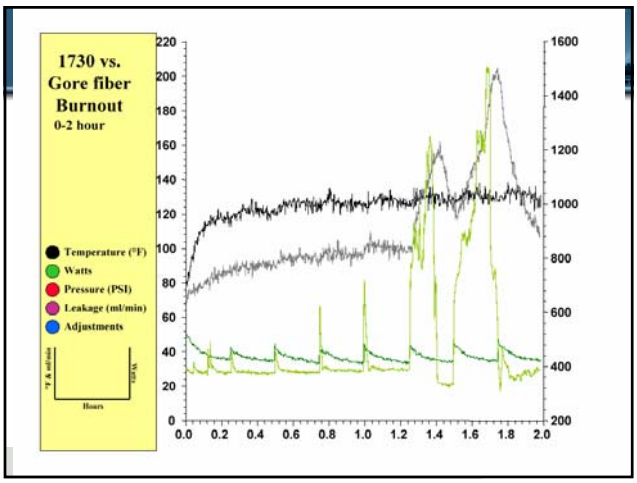

CHESTERTON
TECNOLOGY
LABORATORY
BURN OUT TESTING
Fossil Power Industry
-63-
CHESTERTON

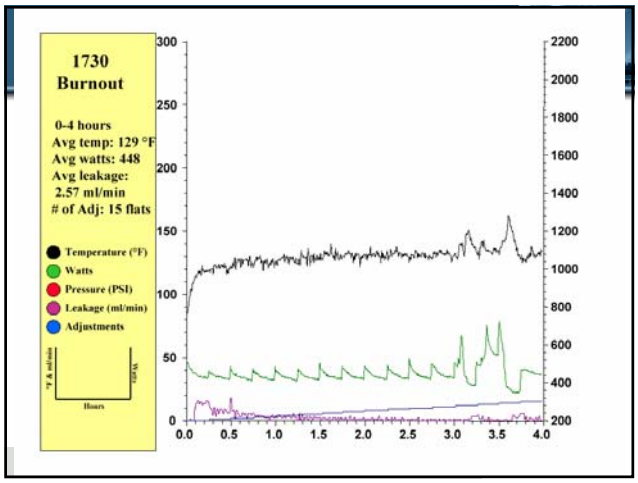

1730
Burnout
0-1 hour
Avg temp: 119°F
Avg watts: 436
Avg leakage:
6.5 ml/min
# of Adj: 3
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours

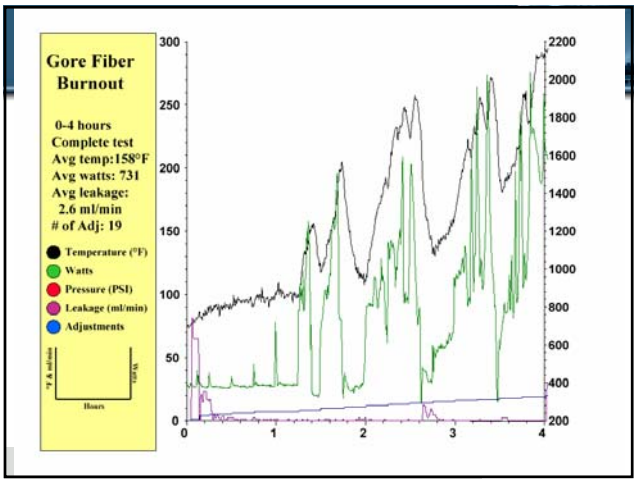

Gore Fiber Burnout
0-1 hour
Avg temp: 90°F
Avg watts: 385
Avg leakage: 9 ml/min
# of Adj: 7**
** 4 extra flats needed to control leakage
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours

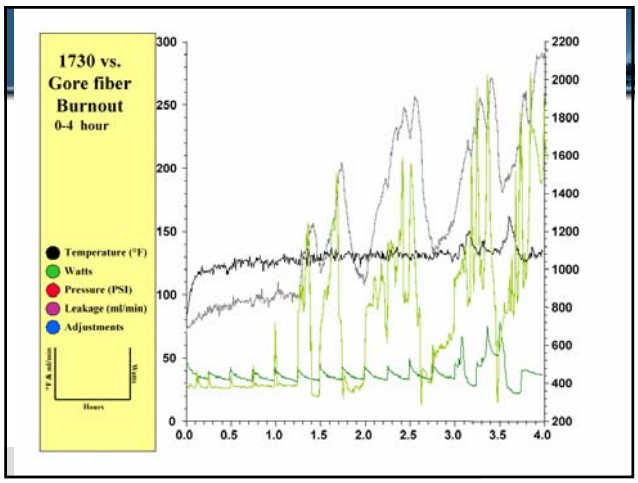

1730 Burnout
0-2 hours
Avg temp: 124°F
Avg watts: 436
Avg leakage: 4 ml/min
# of Adj: 7
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours


Gore Fiber Burnout
0-2 hours
Avg temp:110°F
Avg watts: 499
Avg leakage: 4.6 ml/min
# of Adj: 11
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours

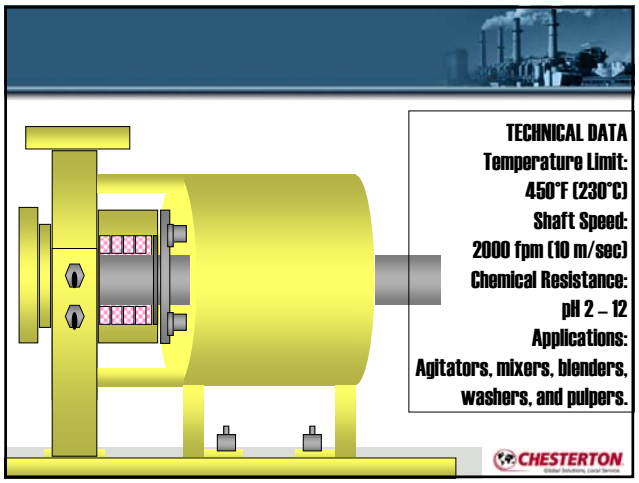

1730 vs. Gore fiber Burnout
0-2 hour
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours


1730
Burnout
0-4 hours
Avg temp: 129 °F
Avg watts: 448
Avg leakage:
2.57 ml/min
# of Adj: 15 flats
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours

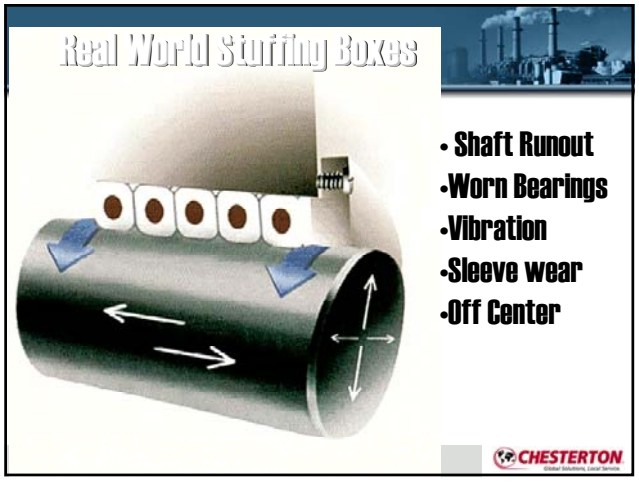

Gore Fiber
Burnout
0-4 hours
Complete test
Avg temp:158°F
Avg watts: 731
Avg leakage:
2.6 ml/min
# of Adj: 19
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours

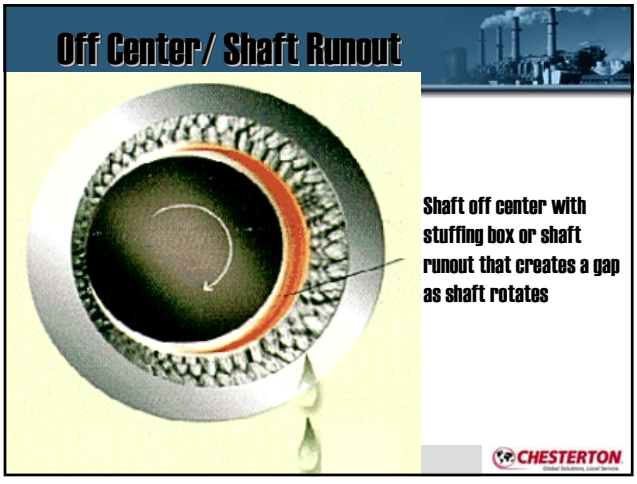

1730 vs.
Gore fiber
Burnout
0-4 hour
Temperature (°F)
Watts
Pressure (PSI)
Leakage (ml/min)
Adjustments
Hours


Chesterton 1730 SC
Chesterton 1730SC combines a resilient silicone rubber core with the heat resistant, thermoset fiber of Chesterton's MillPack 1730.
The elastic rubber core gives the packing better memory, allowing it to withstand radial shaft motion and vibration while maintaining excellent leakage control with minimal gland adjustments.
CHESTERTON

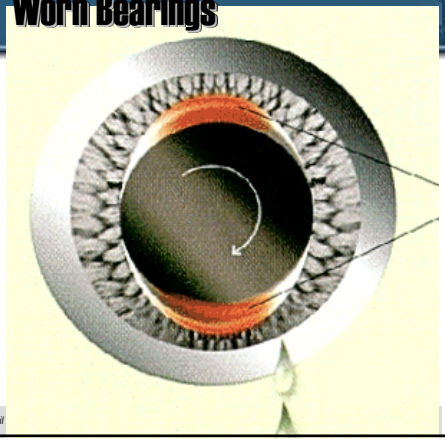

TECHNICAL DATA
Temperature Limit:
450°F (230°C)
Shaft Speed:
2000 fpm (10 m/sec)
Chemical Resistance:
pH 2 – 12
Applications:
Agitators, mixers, blenders,
washers, and pulpers.
CHESTERTON


Normal Stuffing Box
CHESTERTON


Real World Stuffing Boxes
• Shaft Runout
•Worn Bearings
•Vibration
•Sleeve wear
•Off Center
CHESTERTON


Off Center/ Shaft Runout
Shaft off center with
stuffing box or shaft
runout that creates a gap
as shaft rotates
CHESTERTON

Worn Bearings



Shaft moves from top to bottom or left to right

Fossil

CHESTERTON

Sleeve wear

Loose and worn Sleeve

CHESTERTON

Injectable Packings

Fossil Power Industry

CHESTERTON

Injectable

- Designed for Rotating Equipment
- No Flush Water Required
- Cannot Wear Shaft Sleeves
- Virtually Zero Leakage
- White in Color / Non-Staining
- No Future Pump Shut Down Required

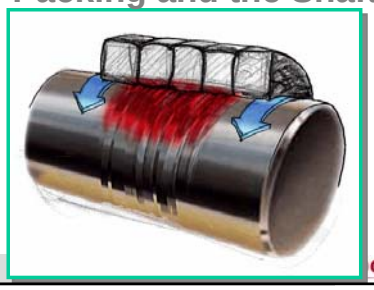
Fossil Power Industry -80-

CHESTERTON

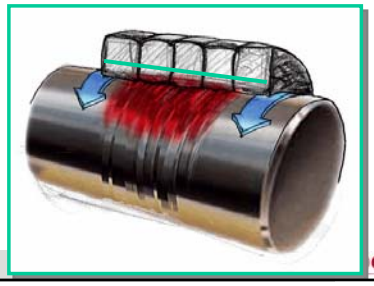
- **Works on Worn Shaft Sleeves**
- **No Shaft Sleeve Replacement Necessary**

Standard Packing

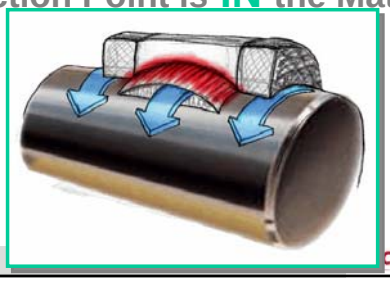
Friction Occurs Between The Packing and the Shaft



Because of **Laminar Shear**, the Friction Point is **IN** the Material

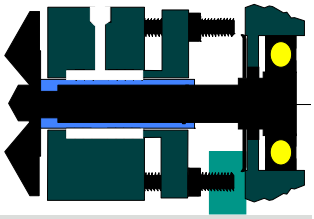


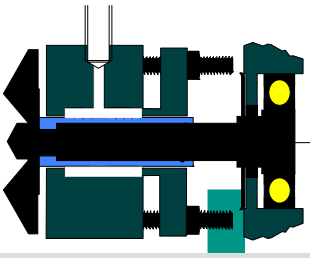
Because of **Laminar Shear**, the Friction Point is **IN** the Material

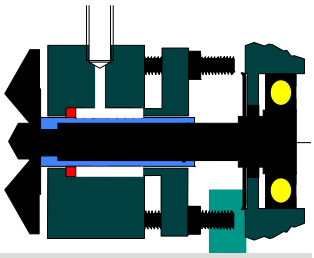


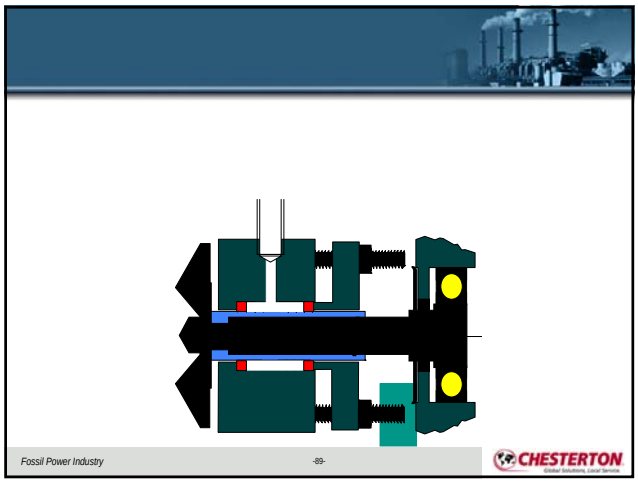
Operating Parameters

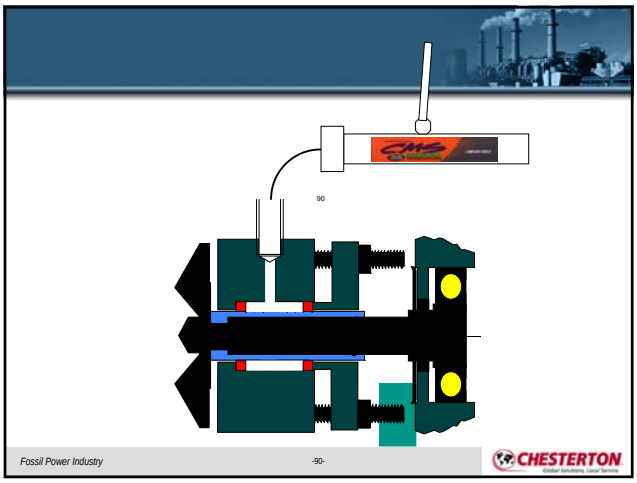
- **Temperature Limit -** 200 deg. C
  NOTE: Including Frictional Heat
- **Maximum Shaft Speed -** 10 mps
- **pH Range -** 1 -13 **Primarily Designed for Water Based Mediums**
- **Maximum Pressure -** 7 bar

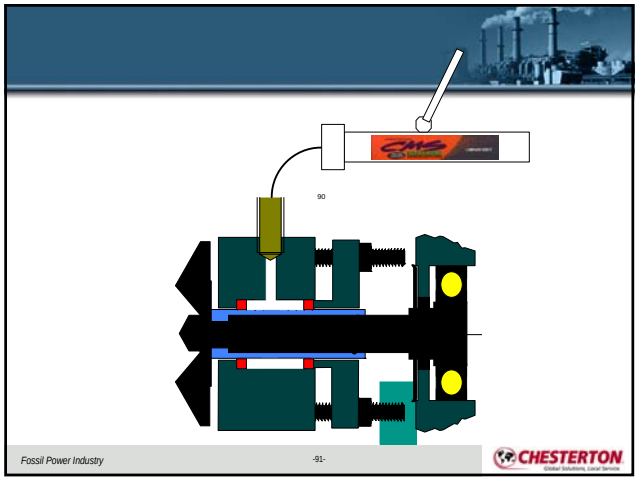


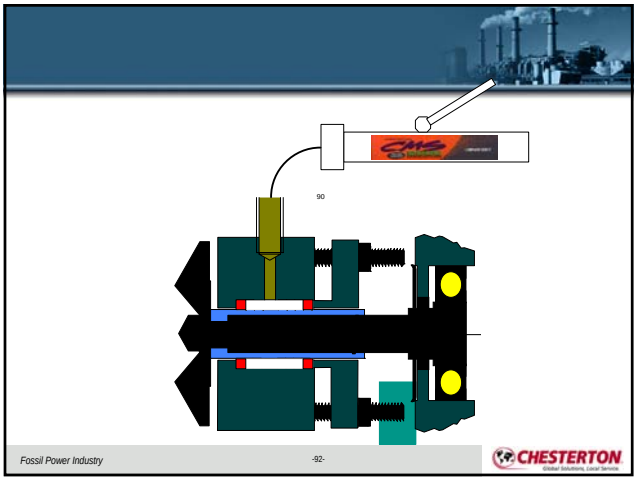


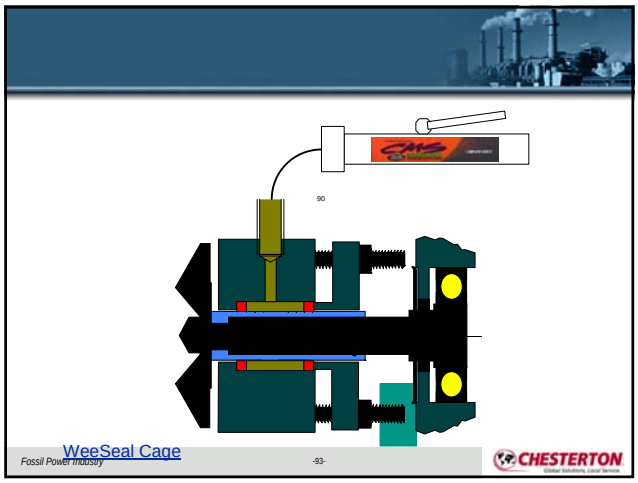



Fossil Power Industry
-89-
CHESTERTON


90
Fossil Power Industry
-90-
CHESTERTON

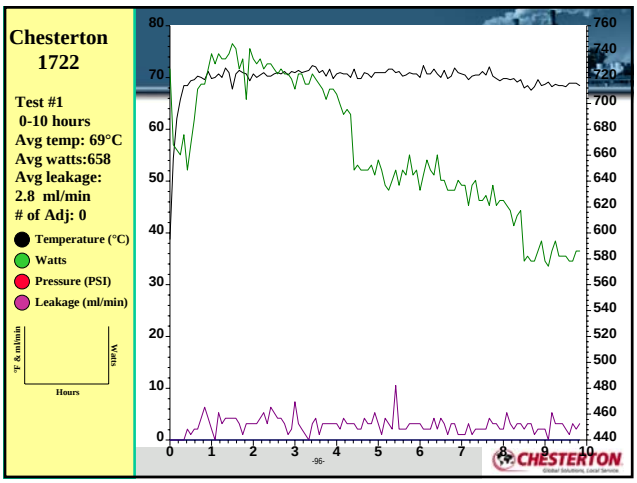

90
Fossil Power Industry
-91-
CHESTERTON

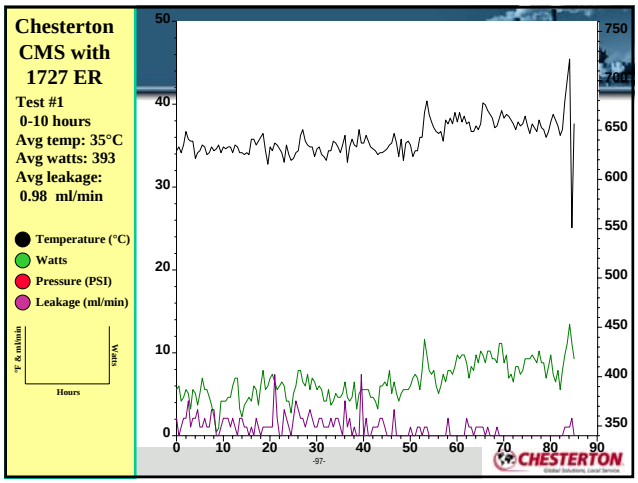

90
Fossil Power Industry
-92-
CHESTERTON

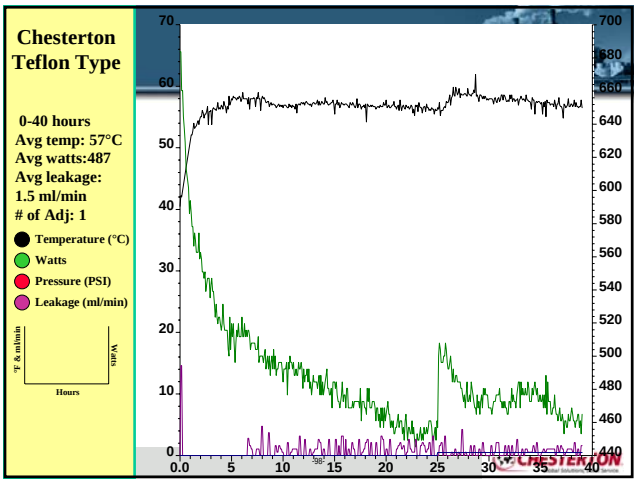

90
WeeSeal Cage
Fossil Power Industry
-93-
CHESTERTON


Fossil Power Industry
-94-
CHESTERTON


Fossil Power Industry
-95-
CHESTERTON


Chesterton
1722
Test #1
0-10 hours
Avg temp: 69°C
Avg watts:658
Avg leakage:
2.8 ml/min
# of Adj: 0
Temperature (°C)
Watts
Pressure (PSI)
Leakage (ml/min)
°F & ml/min
Watts
Hours
80
70
60
50
40
30
20
10
0
760
740
720
700
680
660
640
620
600
580
560
540
520
500
480
460
440
0
1
2
3
4
5
6
7
8
9
10
-96-
CHESTERTON





Energy Savings

1722 ASBESTOS PACKING

AVERAGE WATTS = 658
AVERAGE LEAKAGE = 2.8 ml/min.
AVERAGE TEMPERATURE = 69 C

Injectable With END RINGS

AVERAGE WATTS = 393
AVERAGE LEAKAGE = 1 ml/min.
AVERAGE TEMPERATURE = 35 C

64% Lower Leakage & 40% Energy Reduction

Energy Savings

TEFLON TYPE PACKING

AVERAGE WATTS = 487
AVERAGE LEAKAGE = 1.5 ml/min.
AVERAGE TEMPERATURE = 65 C

Injectable With END RINGS

AVERAGE WATTS = 393
AVERAGE LEAKAGE = 1 ml/min.
AVERAGE TEMPERATURE = 35 C

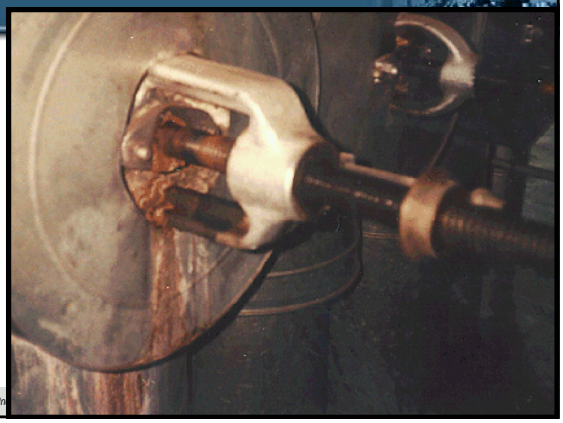
33% Lower Leakage & 20% Energy Reduction

Leakage & Energy Savings

- **Asbestos vs Injectable**
  64% Lower Leakage
  40% Energy Reduction
- **Teflon Type vs Injectable**
  33% Lower Leakage
  20% Energy Reduction

WeeSeal Cage

Fossil Power Industry -101- CHESTERTON

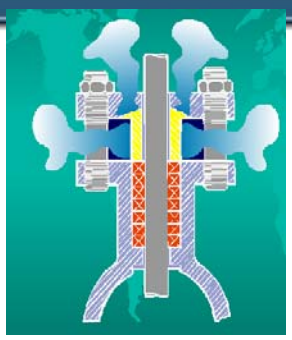


Fossil Power In

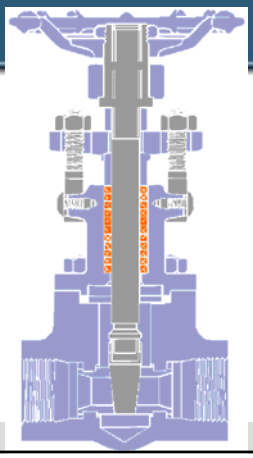
Fossil Power Industry

Fossil Power Industry -104- CHESTERTON

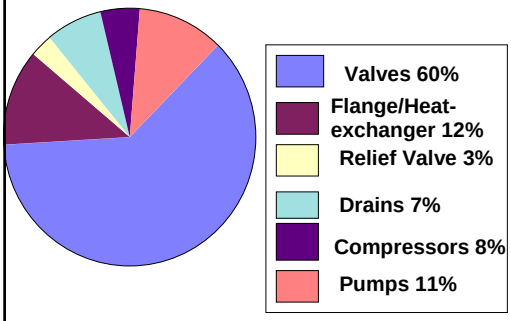
CAUSES OF VALVE LEAKAGE



- VALVE DESIGN
- PACKING MATERIALS
- PRESSURE
- TEMPERATURE
- TEMPERATURE CYCLING
- VALVE ACTUATION
- HORIZONTALLY MOUNTED VALVES
- VALVE CONDITION
- MAINTENANCE PRACTICES



National Emission Standards for Equipment Leaks



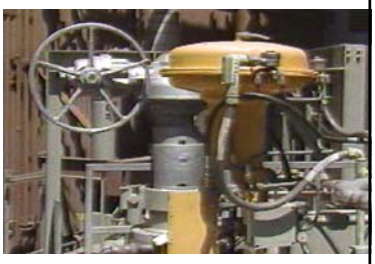
Valve Emission Limits

EPA 500 ppm

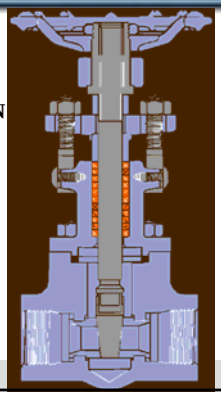
Bay Area Air Quality Management District 100 ppm

Under Sized Actuators

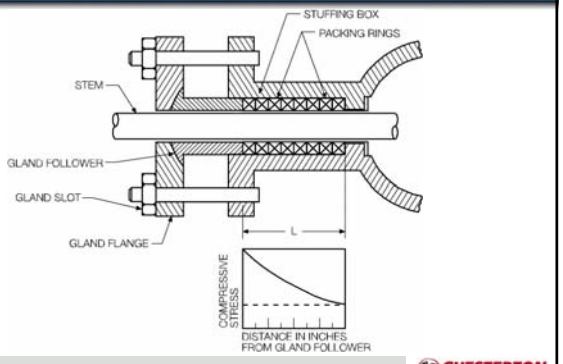
- Expense
- Teflon V-Rings Vs. Graphite
  - Fire Safe
  - Slip Stick

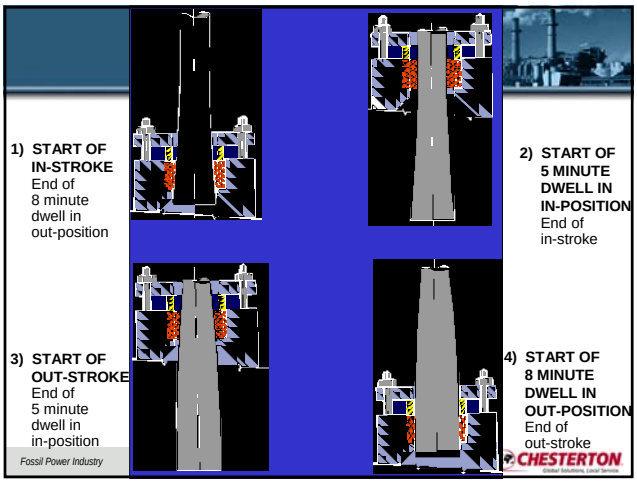


NEW TECHNOLOGY	OLD TECHNOLOGY
LESS IS BETTER	MORE IS BETTER
FLEXIBLE SEALS	DEEP STUFFING BOXES
ANTI-EXTRUSION RINGS	TORTUROUS PATH GREATER % CONSOLIDATION
5 RING SETS	DIFFICULT TO UNPACK
CARBON BUSHINGS	HIGH STEM FRICTION
TORQUE SPECIFICATIONS	



COMPRESSIVE STRESS IN DEEP STUFFING BOXES





1) **START OF IN-STROKE** End of 8 minute dwell in out-position

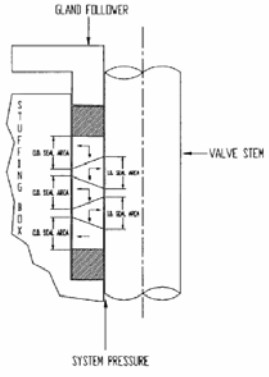
2) **START OF 5 MINUTE DWELL IN IN-POSITION** End of in-stroke

3) **START OF OUT-STROKE** End of 5 minute dwell in in-position

4) **START OF 8 MINUTE DWELL IN OUT-POSITION** End of out-stroke

5800 WEDGE EMISSIONS CONFIGURATION

5800 WEDGE SET WITH 477-1 BRAIDED END RINGS



"Bulk" Valve Installation Procedure

PRECAUTION: Installer must follow all plant procedures and safety practices of the equipment into which this product is to be installed.

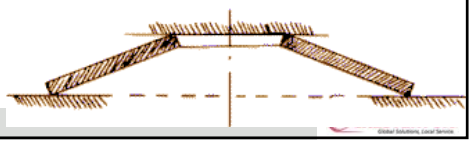
1. Make sure that the pressure has been released and that the valve has cooled to a safe level.
2. Remove all old packing material (follow safe extraction procedures).
3. Before installing packing, inspect the stem and stuffing box wall to make sure that they are free of wear, scale or corrosion. Valve stem must also be free of nicks, scratches and burrs. Carefully clean stem and stuffing box wall to remove any residual material that could affect the packing set. Repair or replace as necessary.
4. Use the correct cross section of packing. To determine the correct packing size, measure the diameter of the shaft inside the stuffing box area, if possible, to give the I.D. of the ring. Then measure the diameter of the stuffing box to give the O.D. of the ring. Subtract the I.D. measurement from the O.D. measurement and divide by 2. The result is the desired cross section size.
5. Always cut the packing into separate rings. Never wind a coil of packing into the stuffing box. The most desirable method of cutting rings for valves and expansion joints is to skive cut (45 degrees). Cut one ring at a time making sure first ring fits packing space properly. Each ring is cut at a 45 degree angle to the axis of the mandrel.

6. Install first ring of packing making sure ring is firmly seated (tamped) into the bottom of the stuffing box, preferably by using Chesterton 176 Tamping Tool. Install remaining rings in the same manner staggering joints 180 degrees if only two rings are installed. Space joints 120 degrees for three rings, or 90 degrees if four or more rings are in the set.
7. Install the gland nose so it is resting on the top ring of packing and tighten the gland nuts finger tight. Using the gland nose as a reference, tighten the gland nuts until the packing set is compressed approximately 30% to 35% of its uncompressed height. Always make sure the stem is free to move by cycling the valve during the tightening procedure.
8. Readjust gland bolts after the valve has been actuated a number of times and when the valve has been put in the closed stroke position.
9. Follow normal safety precautions and procedures when returning the valve to service.
10. It is advisable to check gland adjustment after a few hours of service. Take up as necessary.

Live-Loaded Packing Set

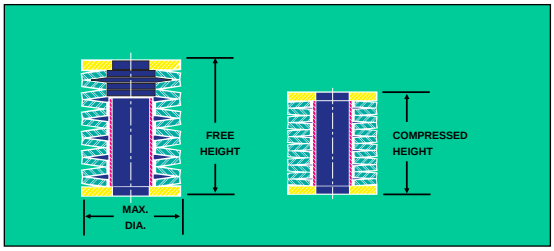
- Maintain Packing Load- Long Term
- Allow for the Effects of Thermal Stem Taper
- Dampen Vibration
- Dramatically Enhance Performance

Belleville Washer



LIVE LOADING SPRING ASSEMBLY

ALLOWS STORED ENERGY TO BE TRANSMITTED THROUGH A CERTAIN DEGREE OF TRAVEL TO THE GLAND



Why Live Load Valves?

- Thermal Cycling
- Vibration
- Packing Set Adjustments
- Critical Dynamic Applications

BLOCK VALVE PACKINGS
RELIABLE, IN REAL WORLD, CONDITIONED VALVES

CHESTERTON