Equipment Life Expectancy

Phosphate Maintenance Roundtable

Advancing Sulfuric

and

Phosphoric Acid Plant Maintenance

2006

Factors Affecting Equipment Life

- Type of plant
  - sulphur burner
  - metallurgical (Zn, Cu, Pb)
  - acid regeneration
  - wet catalysis
- Materials of construction
- Design of equipment
- Operating conditions (pressure, temperature, etc.)
- Maintenance
- Operation of the plant
- Desire to increase plant capacity

Criteria for Deciding to Replace Equipment

- Maintenance cost
- Safety (gas leaks, acid leaks)
- Plant operability and on-line time
- Plant capacity
- Regulatory requirements
- Cost to replace versus repair

Equipment

- Converters
- Gas-to-Gas Heat Exchangers
- Brick Lined Vessels (Towers and Pump Tanks)
- Quench/Humidifying Towers
- Refractory Lined Vessels
- Acid Piping
- Acid Pumps
- Gas Ducting

Converters

Typical Problems

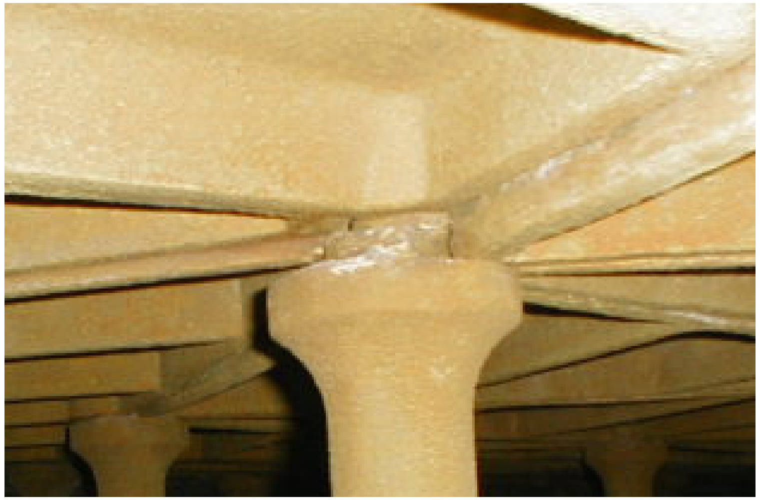
Carbon Steel Cast Iron Grids

- Bulging of shell
- Corrosion
- Collapsed posts and grids
- Failed brick lining
- Failed metallizing
- Gas leaks around nozzles

Stainless Steel

- Scaling
- Gas leaks
- Mechanical problems
- Weld Repairs
- Screen corrosion

Typical Problems



Typical Problems

Examples

Mosaic (Cargill) Florida	Original 1961 cast iron grid and post converter replaced in 1999 with a new stainless steel design. Service life of 38 years. The converter was replaced as part of a plant increase in capacity from 2200 to 3200 STPD.
Mosaic (Cargill) Florida	Original 1965 cast iron grid and post converter replaced in 2004 with a new stainless steel design. Service life of 39 years.
Lucite (Ineos) Memphis Site	Sulphuric acid regeneration plant converter, originally built in 1972 was replaced in 1996 after a service life of 24 years.
Agrium Redwater, Alberta	Original cast iron grid and post converter replaced in 2002 with a new stainless steel converter after a service life of 33 years.
J.R. Simplot Pocatello, Idaho	Original 35 year old cast iron grid and post converter replaced in 2001 with a new stainless steel converter
Sasol Agri Phalaborwa, South Africa	Plant built in 1975. Original converter replaced after a service life of 24 years with a stainless steel converter. Plant capacity also increased.
TeckCominco Trail, British Columbia	Original converter in No. 8 acid plant was installed in 1966. Converter will be replaced this year after a 40 year service life. Converter underwent many repairs over the years.

Typical Service Life

The typical service life of a cast iron post and grid carbon steel converter ranges from 30 to 40 years.

There have been no known cases of failures of stainless steel converters where there has been a requirement to replace the entire converter.

Extending the Life of Cast Iron Post and Grid Carbon Steel Converters

- Inspect converter regularly
- Upgrade material from Meehanite HR to Meehanite HS

  Tensile Strength – Type HR = 40,000 psi

  – Type HS = 60/100,000 psi
- Increase the diameter of support posts
- Increase the diameter of the support shoulder
- Increase the depth of the support grids
- Replace sections of the shell that have bulged

Replacement Options

The accepted replacement option for a cast iron post and grid carbon steel converter is a stainless steel converter.

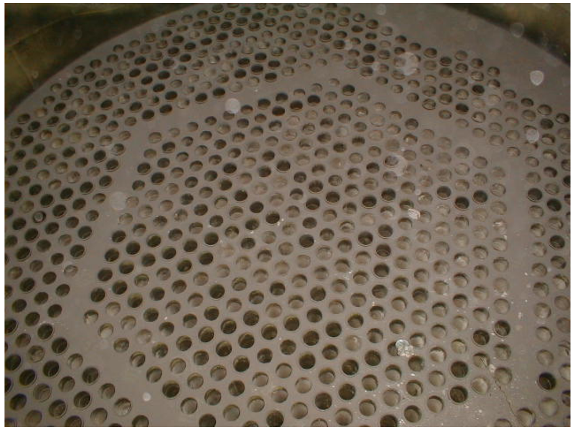
Gas-to-Gas Heat Exchangers

Typical Problems

- Corrosion due to acid condensation and sulphate formation
- Fouling of heat exchanger surface
- High pressure drop
- Tube leaks
- Insufficient or poor heat transfer
- Differential thermal expansion

Gas-to-Gas Heat Exchangers

Typical Problems



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Gas-to-Gas Heat Exchangers

Examples

J.R. Simplot Lathrop, California	Two 13 year-old exchangers replaced with Monplex units. Old units corroded, tubes plugged. High pressure drop low heat transfer
CODELCO El Teniente, Chile	SO_3 cooler originally installed in 1998. Exchanger re-tubed after 6 years in early 2004. Tube failures continue through 2004 and exchanger re-tubed at end of 2004.
INCO Coppercliff, Ontario	Plant built in 1991. Cold reheat exchangers replaced in 2004 after a service life of 13 years. The hot and hot reheat exchangers were replaced in 2005 after a service life of 14 years. The replacement of the heat exchangers was part of a plant expansion. The cold reheat exchangers were showing high pressure drops which necessitated their replacement.
Tessenderlo Chemie Belgium	Cold heat exchanger replaced in 1997 after a 7 year service life. During previous shutdowns corrosion was noted at the lower inlet tubesheet and some tubes were plugged. Although the unit was still serviceable, a decision was made to replace the unit to ensure reliable operation.
Sasol Agri Phalaborwa, South Africa	Plant built in 1975. Hot heat exchanger replaced after a service life of 24 years. Cold exchanger replaced after a service life of 26 years.

Gas-to-Gas Heat Exchangers

Examples

Bunge Fertilizantes Cubatão, Brazil	Replacement of heat exchanger E104 in 1995 after a service life of 17 years. Exchanger E104 is a hot exchanger in a sulphur burning plant.
Tesoro Refining Martinez, California	Original hot heat exchanger installed in 1962 was replaced in 1971, 1980 and 1991 with a similar design (carbon steel with alonized tubes). In 2003, the hot exchanger was replaced with a stainless steel design.

Typical Service Life

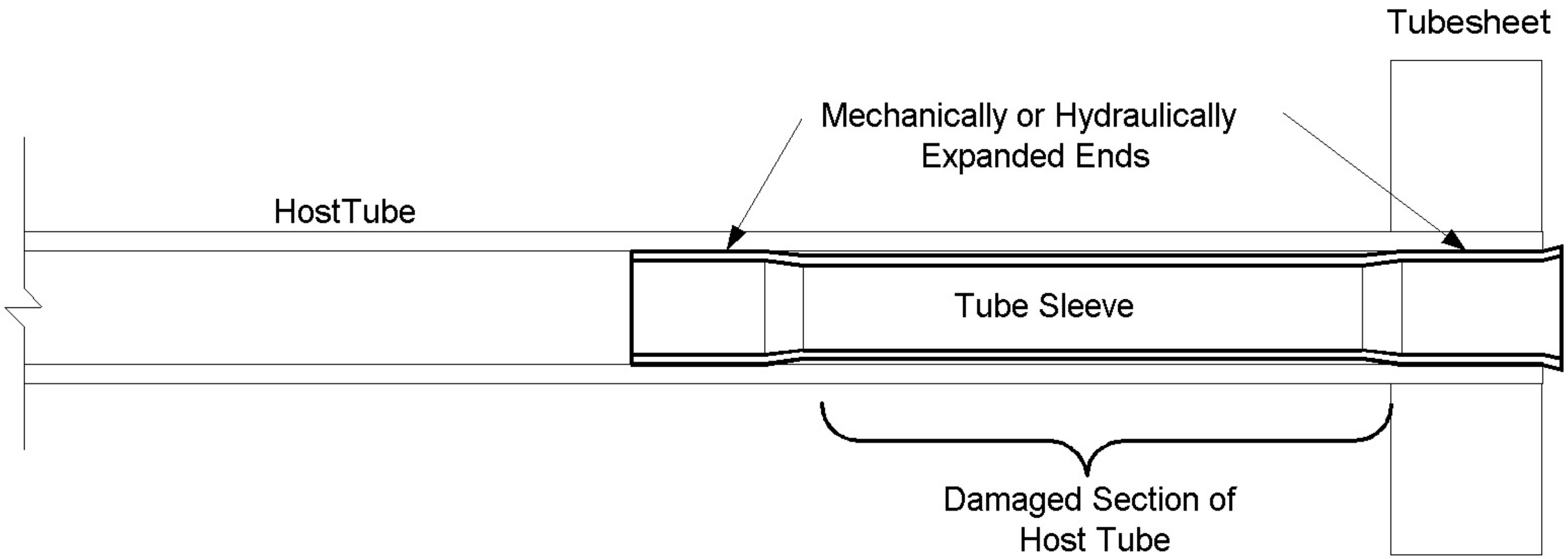
- Cold Exchanger: 5 to 12 years
- Hot Heat Exchanger: 12 to 20 years
- SO_3 Coolers: < 8 years

Extending the Life of Heat Exchangers

- Inspect heat exchangers regularly
- Drain heat exchangers regularly
- Leak detection techniques
- Plug leaking tubes
- Retubing
  - Tubes are discarded and tubesheets and shell are reused
- Changing operating conditions
  - Operate above dew point of gas
- Wash exchanger to remove sulphate build-up

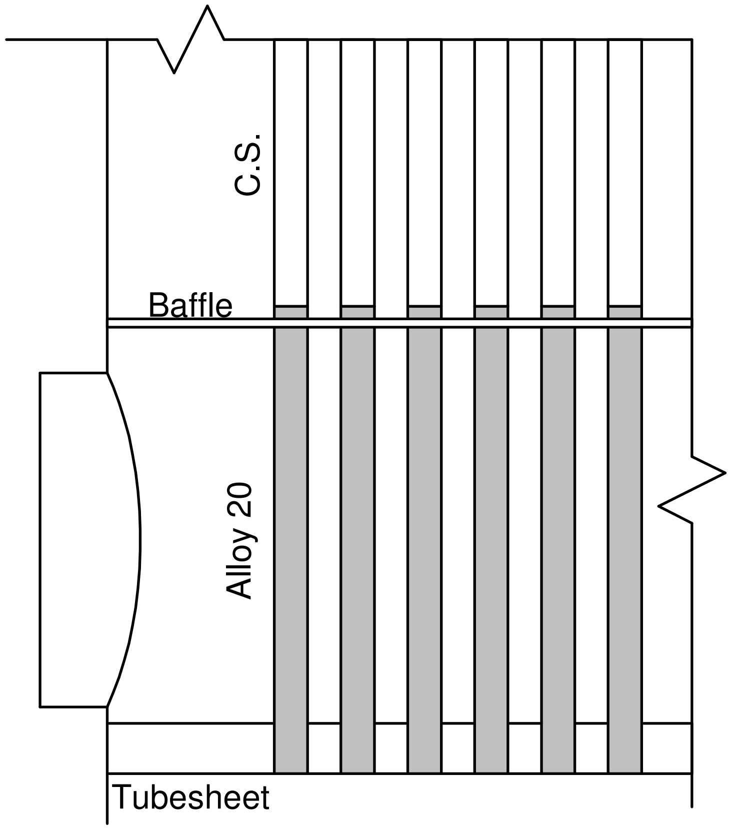
Extending the Life of Heat Exchangers

- Tube sleeving



Extending the Life of Heat Exchangers

- Bimetallic Tubes



Replacement Options

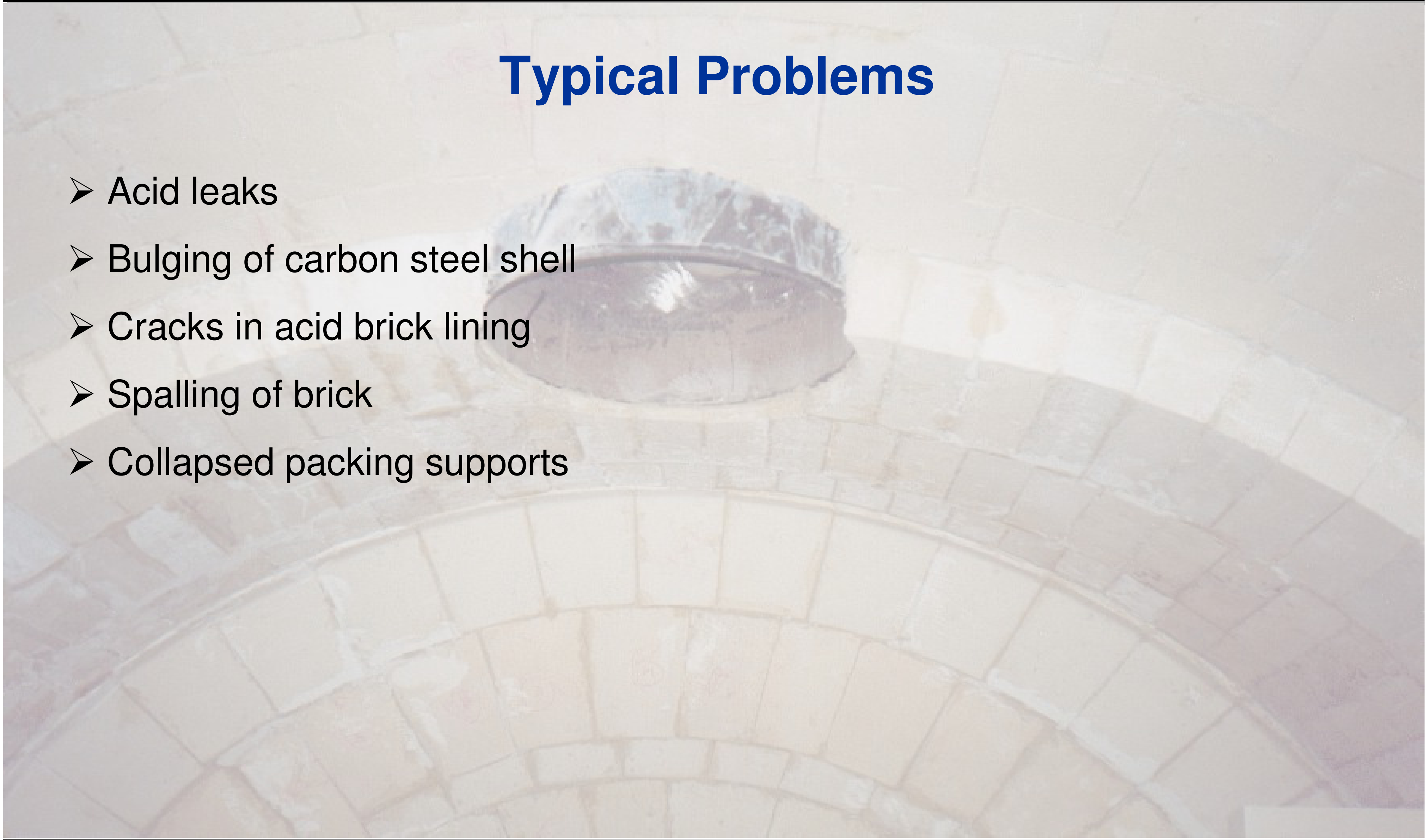
- Replacement 'In-Kind'
- New materials

  - C.S. or 'Alonized' tubes to stainless steel
- New design

  - sacrificial tube bundle

  - hot sweep design

Brick Lined Vessels



Typical Problems

- Acid leaks
- Bulging of carbon steel shell
- Cracks in acid brick lining
- Spalling of brick
- Collapsed packing supports

Typical Problems

Brick Lined Vessels

Typical Problems

Examples - Towers

DuPont Wurtland, KY	40 year old drying tower replaced. 37 year old absorber tower replaced.
Mosaic Co. Uncle Sam, LA	Absorber tower originally installed in 1968. The tower lasted 36 years but had been repaired numerous times. Approximately, 60 to 70% of the shell had been repaired or replaced.
Pasminco Zinc	Original venturi absorber was built in 1978. Over the years the tower developed bulges, leaks and degradation of the carbon steel shell. In 1998, the tower was replaced and capacity was increased (+15% flow). The tower had a life of 20 years.
Lucite (Ineos) Memphis Site, TN	Drying and absorbing towers were replaced as part of a plant upgrade to increase capacity by a factor of 2 times. The original 1972 drying tower was replaced in 1994 after a 22 year life. The original absorber tower was replaced in 2000 after a 28 year life.
CF Industries	Original 1965 drying tower was replaced in 1997 after a service life of 32 years. The original tower had a flat bottom design that was repaired numerous times. This was done in both the A and B plants.

Examples - Towers

Mosaic Co. South Pierce, FL	Original 1975 absorber tower in the No. 10 plant was replaced in 1992 after a service life of 17 years. Absorber tower in No. 11 plant was replaced in 1996 after a service life of 21 years.
PCS Phosphates Aurora, NC	Original final absorption tower on the No. 5 plant built in 1982 replaced in 1989 and again in 1995. In 2002, tower was replaced with an alloy design.
Falconbridge Timmins, Ontario	Original absorber tower built in 1972 replaced in 1993 after 21 years of service. The replacement tower experienced problems early in its life and was eventually replaced in 2005 after only 12 years of service.
Copebrás Limitada Cubatão, Brazil	Final absorption tower replaced in 2001 after a service life of 27 years.
Sasol Agri Phalaborwa, South Africa	Plant built in 1975. Original dry and absorber towers suffered from leaks and the integrity of the brick lining was in question. Both towers were replaced in 2001 with alloy towers after a 26 year life.
Climax Molybdenum Fort Madison, Iowa	Plant built in 1977. Original drying tower and pump tank replaced in 2005 after a service life of 28 years. New drying tower is an alloy design.

Examples – Pump Tanks

Chevron Hawaii, USA	Original 43 year old pump tanks were replaced in 2003 with ZeCor™ pump tank in new location
PCS Phosphates Aurora, NC	Original brick lined flat bottom interpass and final absorber pump tanks replaced with SX tanks in 1995. Original pump tanks had a service life of approximately 19 years.
Climax Molybdenum Fort Madison, Iowa	Original drying tower pump tank replaced in 2005 with an alloy design after a 28 year service life.

Typical Service Life

- Should get a minimum of 20 years of service

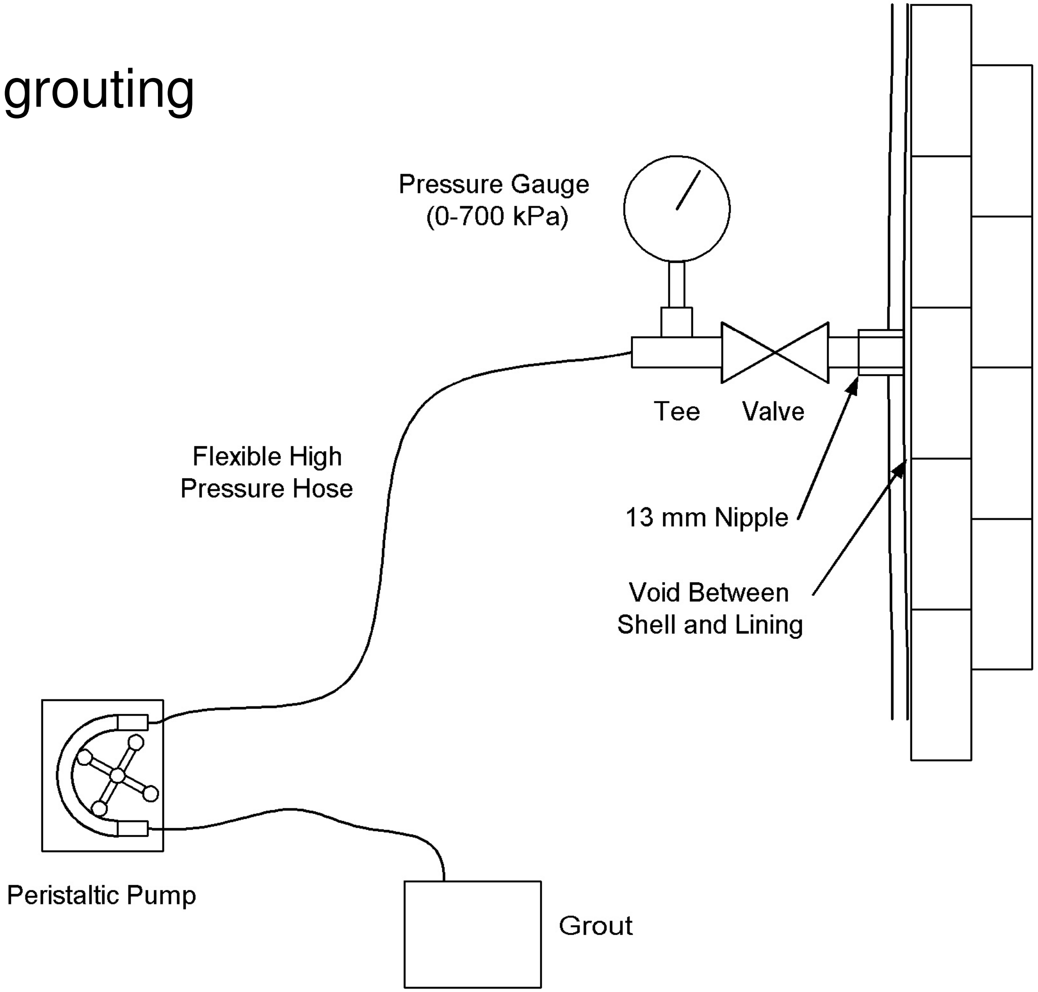
- Average 25 to 30 years

Extending the Life of Brick Lined Equipment

- Regular inspection
  - Shell thickness measurements around gas inlet nozzle
  - internal lining inspection
- Repair damaged brick work
- Polymer concrete jacket (technique pioneered by Sauereisen)
- Alloy metal liners (Edmeston)

Extending the Life of Brick Lined Equipment

- Repair leaks by pressure grouting



Extending the Life of Brick Lined Equipment

- Extensive repair of shell and re-bricking

Replacement Options

- Replacement 'In-Kind'

- Improve design

  - Flat bottom to dished bottom design

  - New lining design

- New materials

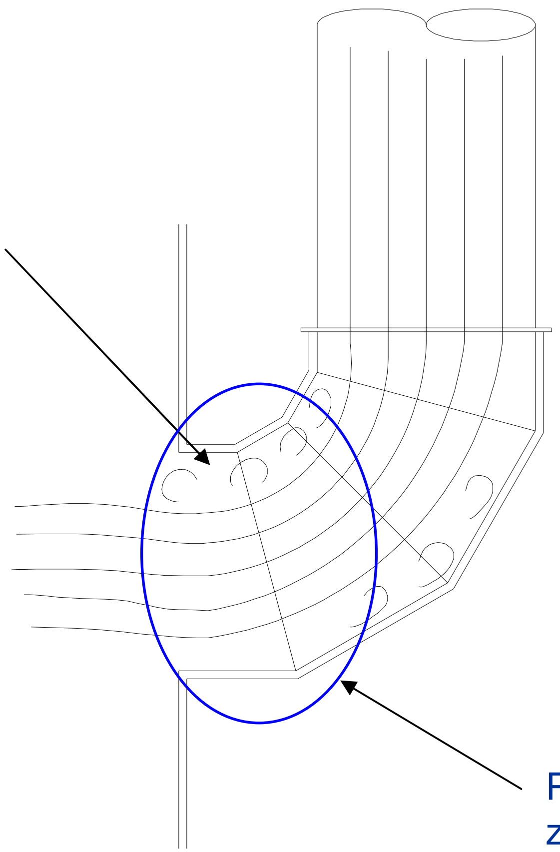
  - high silicon stainless steels

Typical Problems

- Acid leaks
- Corrosion of carbon steel shell
- Bulging of carbon steel shell
- Crack in acid brick lining

Typical Problems

Typical Problems



Quench/Humidifying Towers

Examples

Rhodia Hammond, Indiana	Original humidifying tower of plant built in 1958 replaced in 2005 after a service life of 47 years. The original tower shell was extensively patched and has been re-bricked several times.
Tesoro Refining Martinez, California	Humidifying tower install in 1980 as part of a plant revamp. Tower has been repaired many times over the years due to leaks. The tower has an operating life of approximately 26 years.
CEZinc Valleyfield, Quebec	The No. 1 acid plant was built in 1966. Humidifying tower was replaced in 2001 giving a service life of 35 years. New quench tower is a Swemco design.

Extending the Life of Quench Towers

- Regular inspection

  - Shell thickness measurements around gas inlet nozzle

  - Internal lining inspection

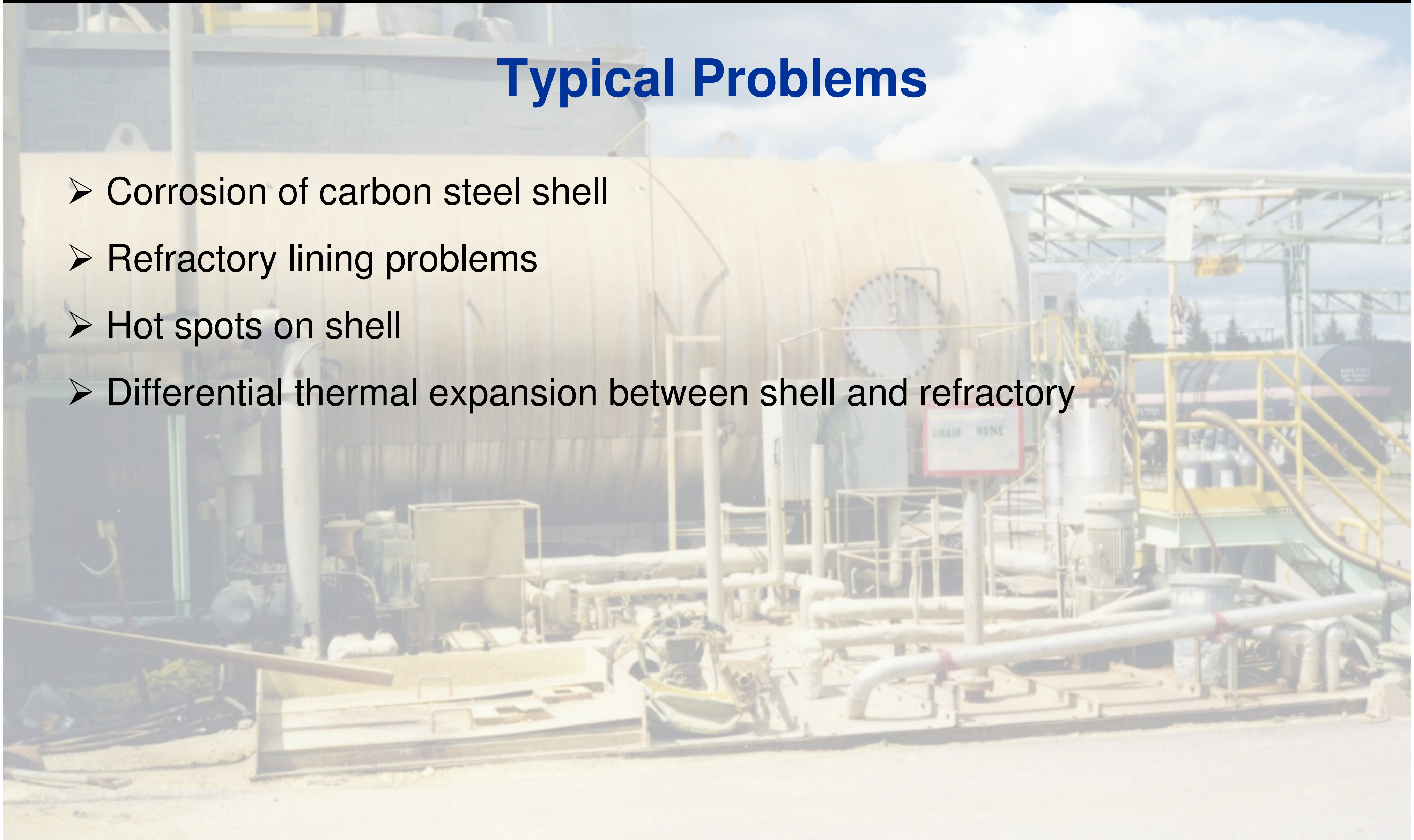
- Repair acid resistant lining
- Patch shell
- Ultimate solution – Replace tower with new design

Replacement Options

- Replace “In-Kind”
- Replace with a new design

  Co-Current quenching as an add-on unit or as a complete new tower

Refractory Lined Vessels



Typical Problems

- Corrosion of carbon steel shell
- Refractory lining problems
- Hot spots on shell
- Differential thermal expansion between shell and refractory

Refractory Lined Vessels

Typical Problems

Refractory Lined Vessels

Examples

Bunge Fertilizantes Cubatão, Brazil	After 18 years of operation the sulphur furnace was requiring frequent maintenance and repairs. The sulphur furnace and boiler were replaced and the plant capacity was increased at the same time.
Marsulex Prince George, BC	Plant originally built in 1966. Sulphur furnace replaced in 1989 as part of a plant expansion and addition of liquid SO_2 plant. Service life of 23 years.
Mosaic (Cargill) Florida	No. 8 acid plant originally built in 1966. Sulphur furnace replaced in 2003 after a service life of 37 years.

DuPont Burnside, Louisiana	20 year-old acid regeneration furnace replaced

Acid Piping

Typical Problems

- Corrosion leading to acid leaks
- Leaks at flanges due to gasket failures

Factors Affecting Life of Piping

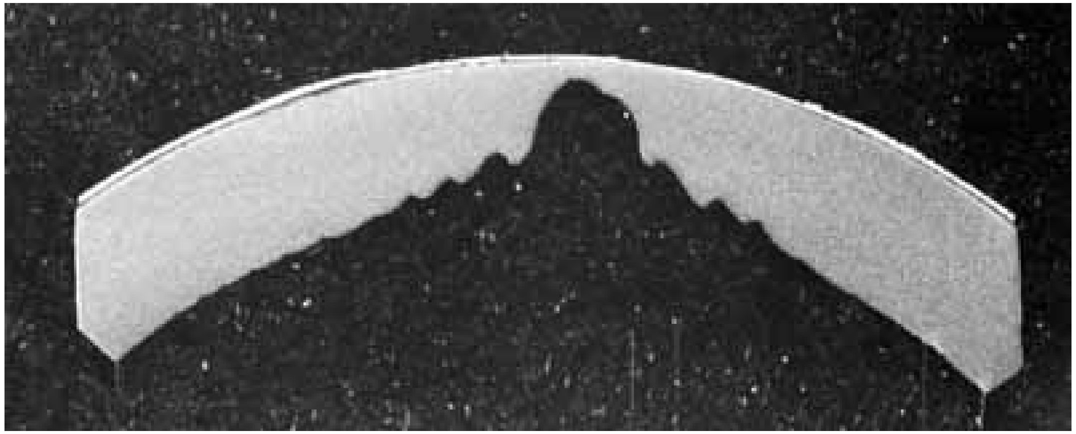
- Corrosion rate
  - Acid concentration
  - Acid temperature
  - Velocity and turbulence
  - Impurities
- Wall thickness
- Piping design and erection quality

Service Life

The expected service life of a pipe will simply be the ‘usable’ wall thickness divided by the corrosion rate. The usable wall thickness is the corrosion allowance plus the thickness of the wall that can be removed before the pipe can no longer contain the operating pressure in the pipe.

The above statement will be true if corrosion is uniform. However, if corrosion is not uniform, the service life may be considerably less.

Examples

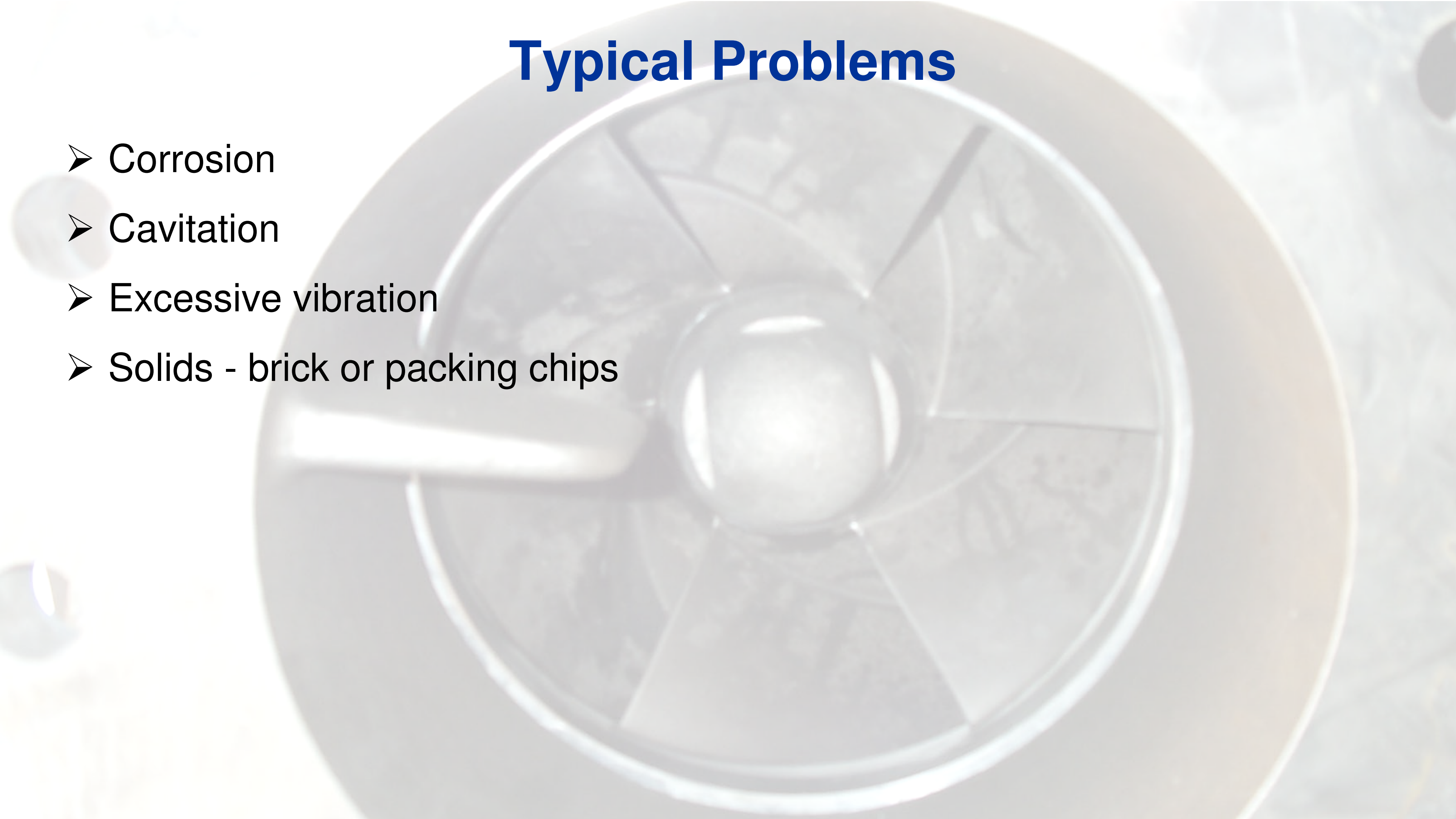


Extending the Life of Acid Piping

- Monitor pipe wall thickness concentrating on areas of high velocity or turbulence (i.e. elbows and tees)
- Alloy piping systems – Patch and repair
- Upgrade or change materials
- Keep velocities low
- Operate within the acceptable range of temperature and concentration
- Perform a piping stress analysis

Extending the Life of Acid Piping

- Temporary repair - Stop It® Pipe Repair System



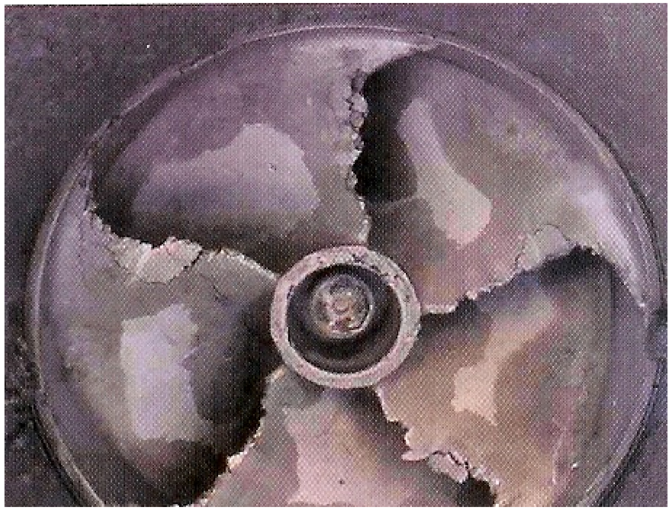
Typical Problems

- Corrosion
- Cavitation
- Excessive vibration
- Solids - brick or packing chips

Acid Pumps

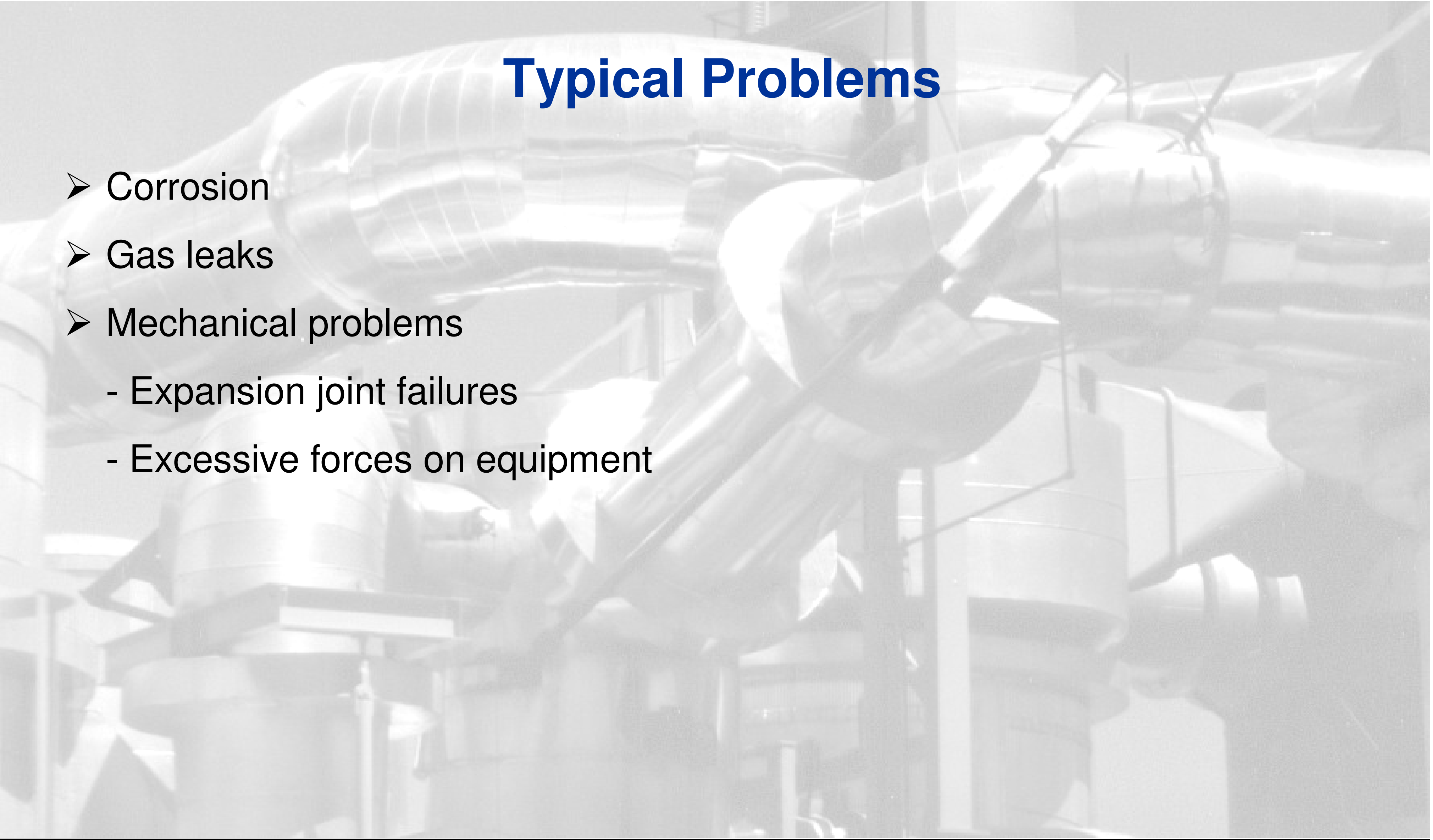
Typical Problems

Typical Problems



Extending the Life of Acid Pumps

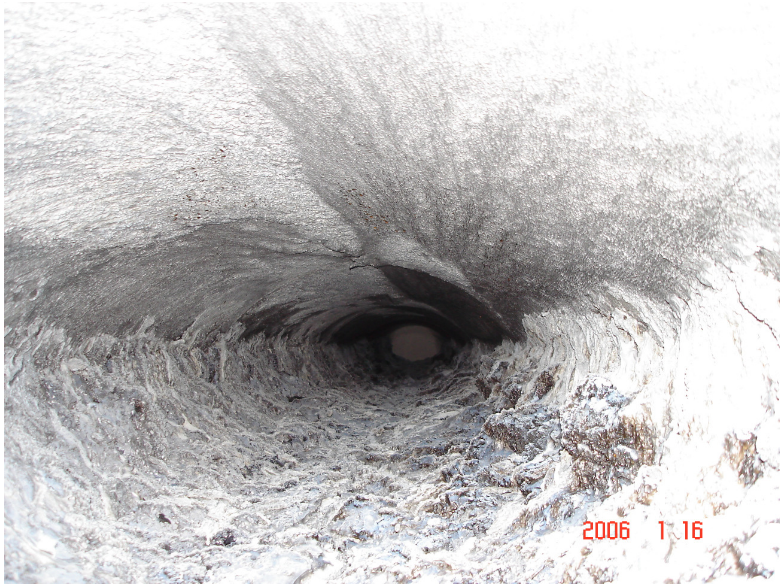
- Ensure acid in pump tank is of uniform concentration – poor acid dilution
- Increase operating level in pump tank to eliminate cavitation
- Eliminate excessive vibration
  - Review pump tank mechanical design
  - Ensure proper pump alignment
- Use suction basket or strainer
- Ensure proper lubrication



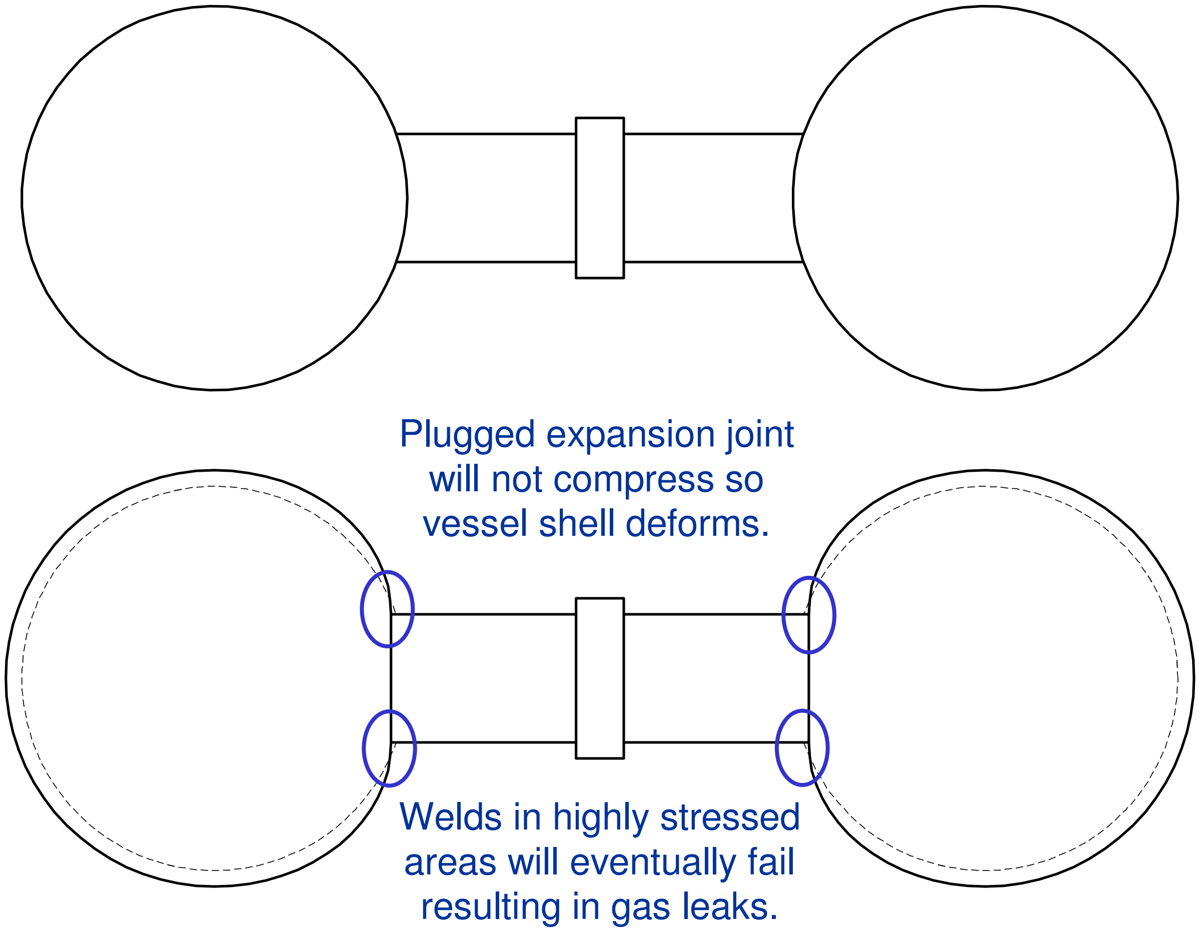
Typical Problems

- Corrosion
- Gas leaks
- Mechanical problems
  - Expansion joint failures
  - Excessive forces on equipment

Typical Problems



Typical Problems



Extending the Life of Gas Ducting

- Inspect ducting – thickness measurements
- Ensure thermal insulation is in good order
- Check low point drains on a regular basis
- Repair and patch
- Upgrade material
- Resolve process problems – mist elimination and carryover
- Ensure expansion joints are in good working order. Replace failed expansion joints.
- Ducting stress analysis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