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2014 Purdue Conferences
Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings

Design of Accelerated Fatigue Tests for Flame Free Refrigeration Fittings

Chad Bowers, Creative Thermal Solutions

Agenda

- Need for flame free fittings
- Design of a novel flame free fitting
- Test methods
  - » Pressure resistance test
  - » Leak integrity
  - » Freeze-thaw
  - » Combined pressure and temperature cycling
  - » Vibration
- Results from testing
- Q&A

Limitation of Brazing

- State of the art is to braze components together using a silver based alloy and flame
  - » Fire hazard with open flame - some insurance companies require 45 minutes wait time after the torch is turned off
  - » Cost variability of precious metal content
- Brazing is an art form, and varies between operators
  - » Supermarket systems are known to leak 20% or more of total refrigerant a year
  - » Supermarket Executive – “systems are only as leak tight as our worst pipefitter”
- Precautions must be taken when brazing in ancillary equipment (valves, filter driers, etc.)
- For on-site contractors brazing requires moving heavy/ cumbersome equipment
- Creation of oxides can clog filters, cap tubes, etc.

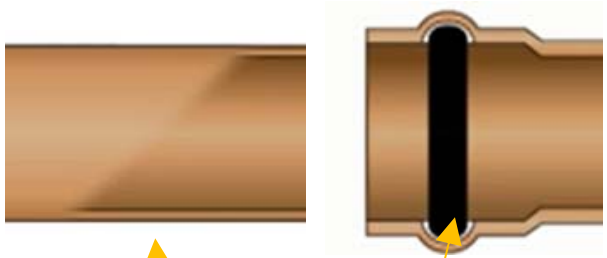
Existing Flame Free Fittings

- Flare fittings are used in refrigeration applications.
  - » Affordable, and only require wrenches for installation
  - » Many instruction manuals required the fitting to be retightened after a specified service interval

- Other commercial styles are available
  - » Expensive
  - » Complicated assembly requiring a special tool
  - » One style requires the use of an adhesive to ensure leak tight joint

Existing Press Fittings for Water

Bell & Spigot Fitting Design

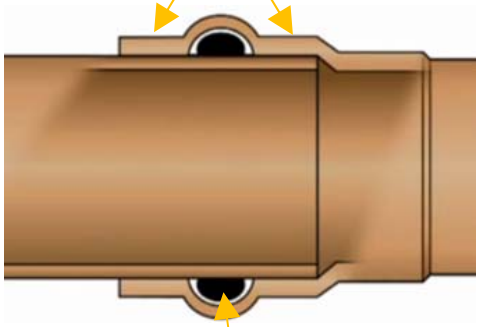


Adjoining Tube

EPDM O-ring for Water

Jaw for Crimping

Fitting Compressed for Pressure Resistance

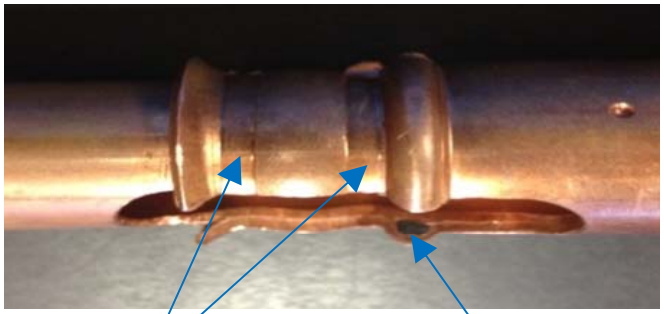


O-ring Compressed to Seal Fluid

Flame Free Fitting for HVAC&R

- Differences
  - » Designed for higher pressure operation
  - » Designed for use with gasses (helium leak tight)
  - » O-ring selection compatible with refrigerants
  - » 8 sizes will be available in January of 2015 ranging from ¼” to 1 1/8”

Patent Pending



Dual crimp outboard of O-ring for higher pressure resistance

Elastomer compatible with most refrigerants

Burst Pressure Testing

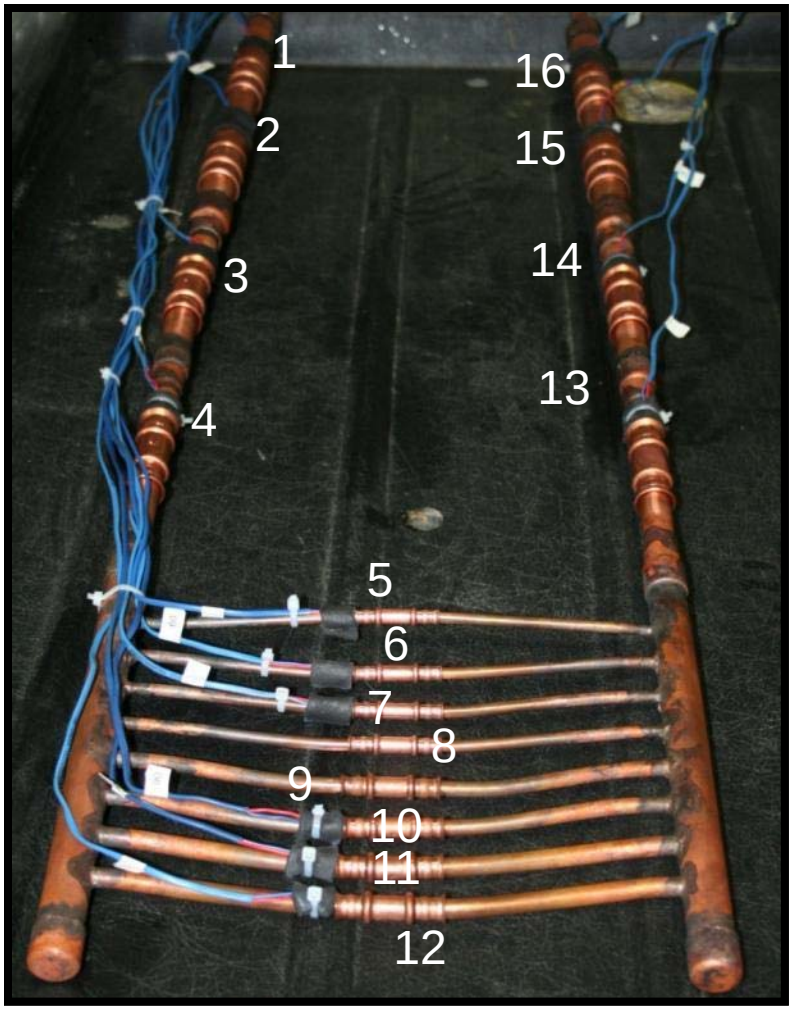
- Fitting is designed for operating pressure of 700 psi
- UL 109 specifies the fitting must withstand
  - » Either 3500 psi of pressure without a leak
  - » Or 2100 psi of pressure without a leak
    - – Including 250,000 pressure cycles
- Conclusions
  - » Tubing sizes below ½” – burst in fitting well above 3500 psi
  - » Tubing sizes above ½” – burst in tubing above 2100 psi

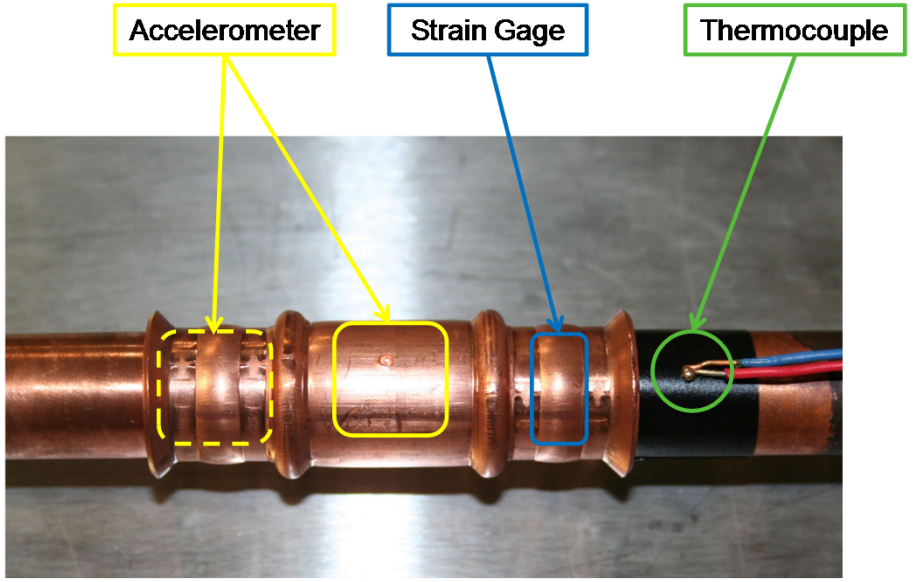
Leak Integrity

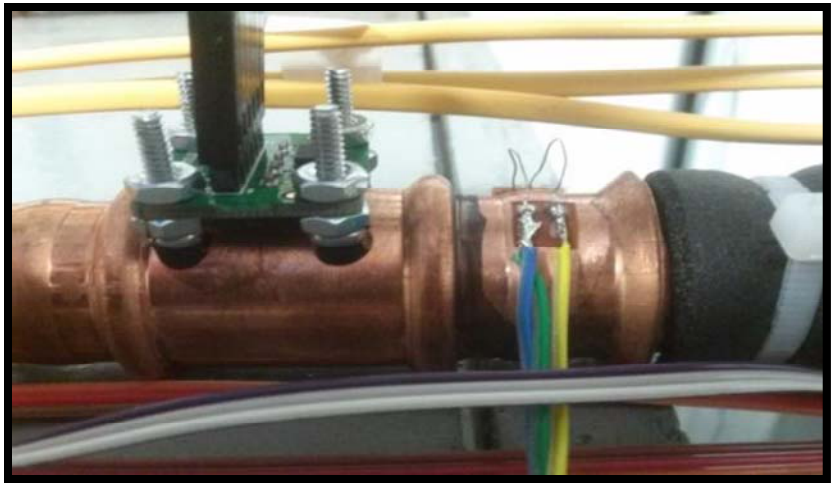
- Helium leak test on six fitting sizes
- Test performed by drawing vacuum on a sealed tube and spraying helium on the joint

- Used 30 fittings for each size – each fitting had two crimps
- All sizes had helium leak rates below 5 x 10^{-9} std cc/sec

Sensor Locations for Both Freeze/Thaw and Pressure/Temperature Cyclic Testing







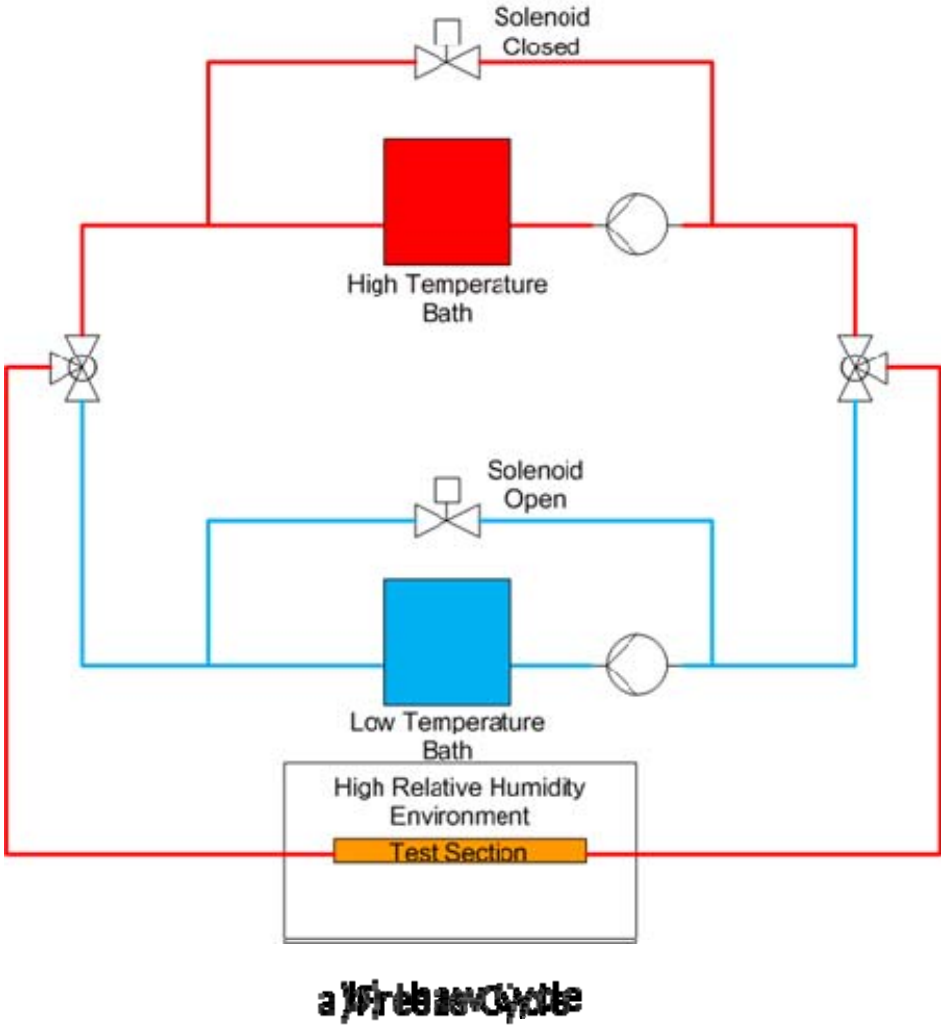
Freeze Thaw Cyclic Testing

- Concern – during freezing and thawing in heat pump mode could water migrate into the fitting, freeze, and repetitively expand the joint until failure occurs

- Goal is to design a test that can simulate 5 years of frost-de frost, which is estimated at 5,000 cycles based on estimated heat pump operating conditions

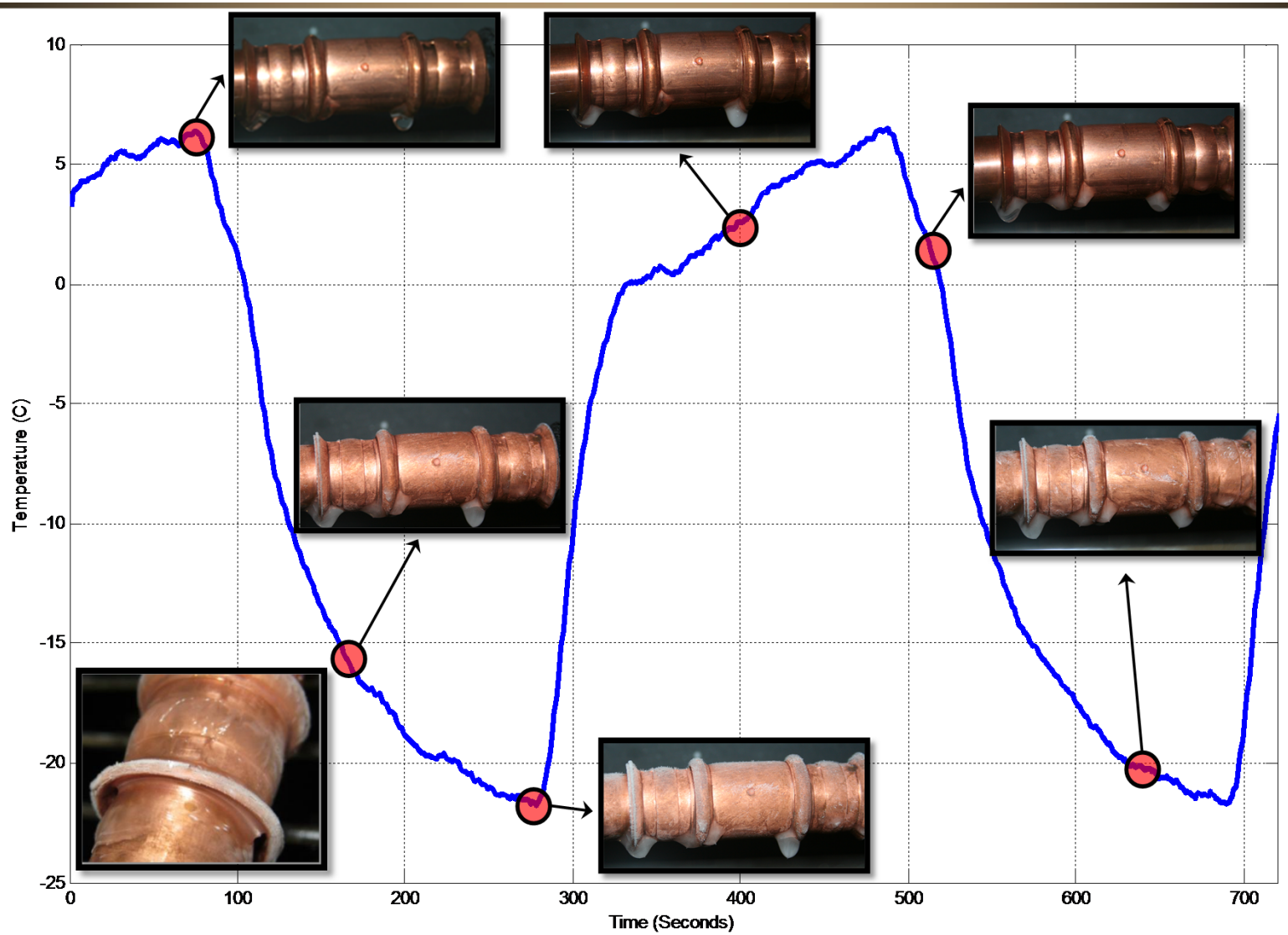
- 5,000+ cycles achieved for all 16 fittings tested without any detectable leakage

Freeze Thaw Testing Facility

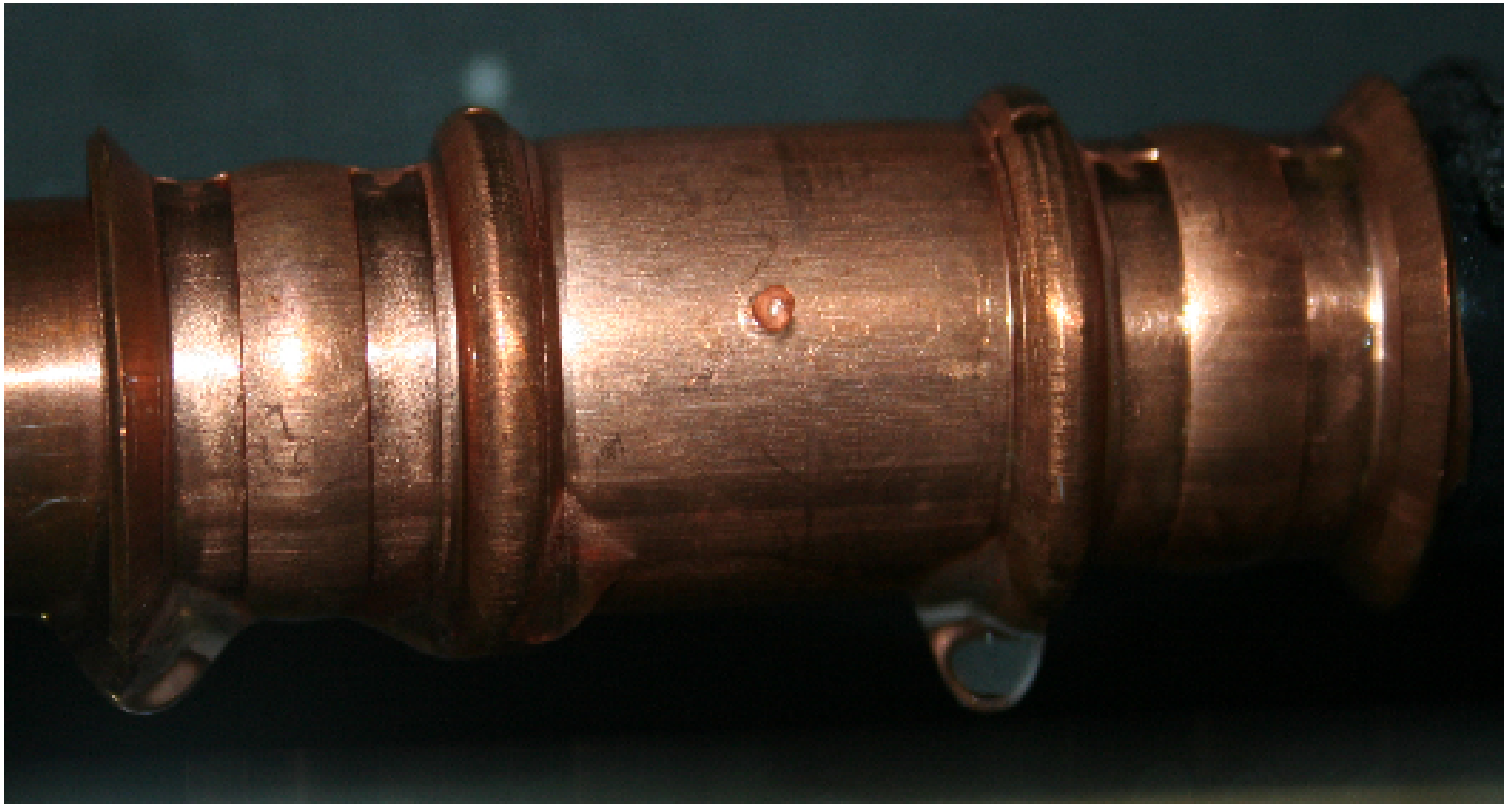


a) Freeze Thaw Cycle

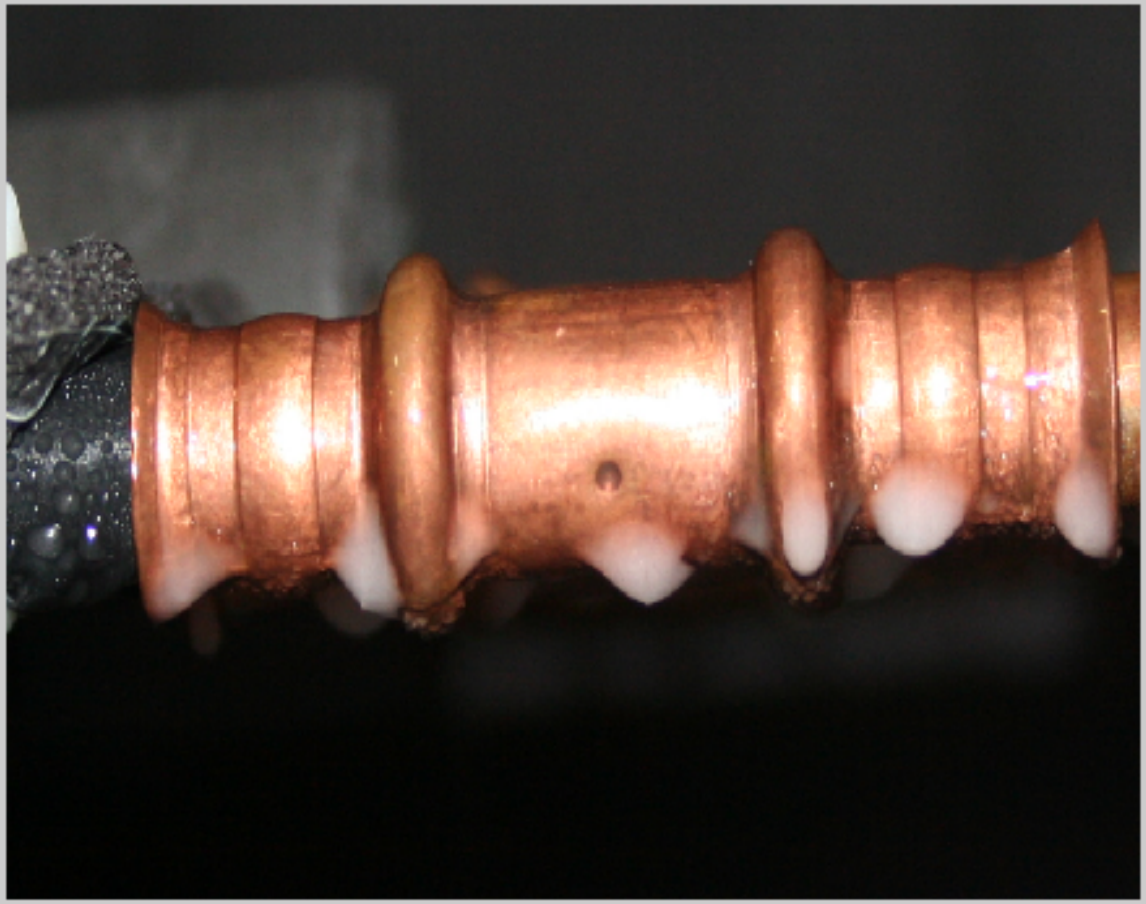
Typical Freeze/Thaw Cycles



Typical Freeze/Thaw Cycles



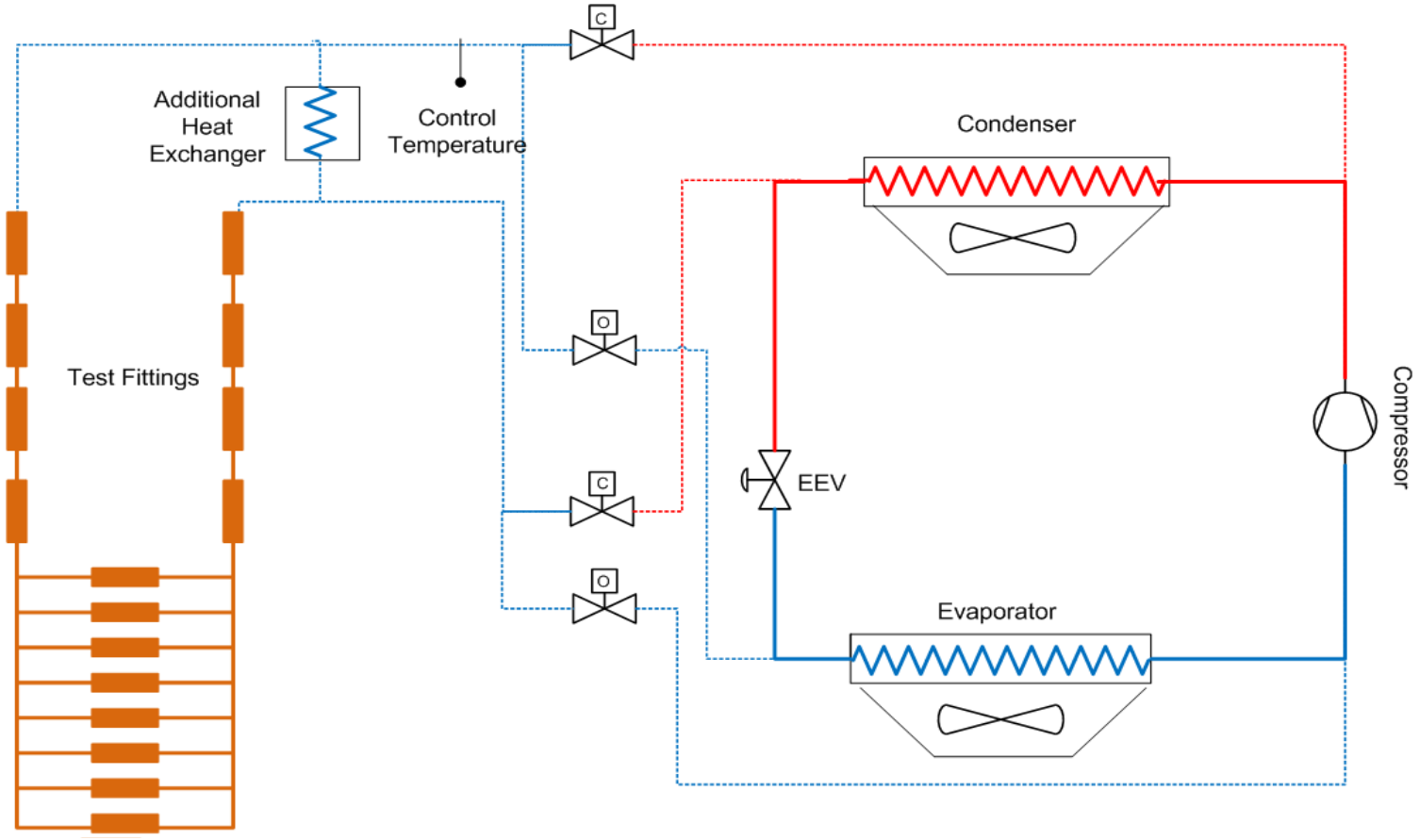
Typical Freeze/Thaw Cycles



Combined Pressure Temperature Cycle

- Added the complexity of temperature cycling along with pressure cycling using R410A and POE lubricant
- Simulates on/off compressor cycling as well as switching to defrost mode
- High temperature/pressure = 90 C / 3000 kPa
- Low temperature/pressure = 10 C / 1000 kPa
- Cycle time = 20 seconds hot, 10 second cold
- Target # of cycles = 80,000

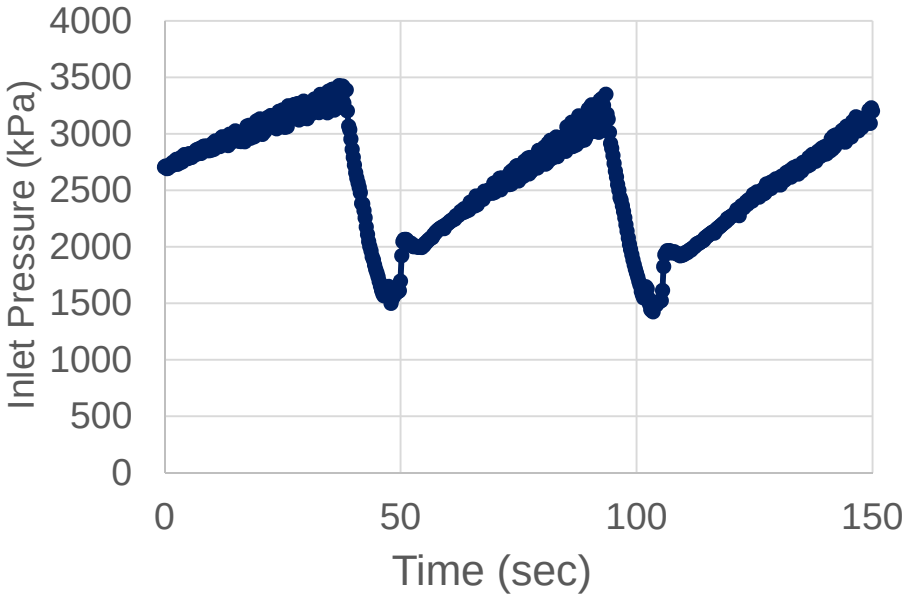
Pressure/Temperature Cycling Test Apparatus



High Pressure/High Temperature Mode
Ran until control temperature reached 90 C

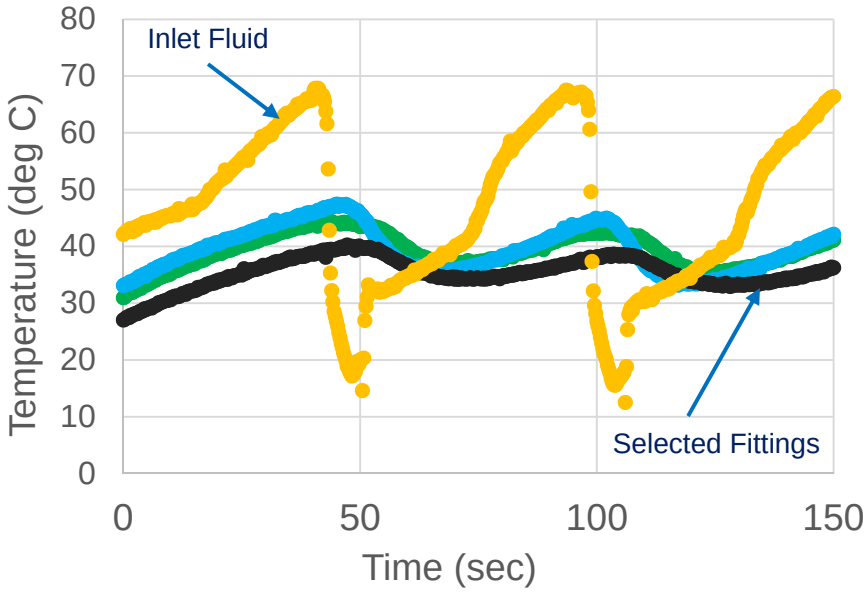
Fitting Loads During Pressure/Temperature Cycles

Internal Pressure Trace



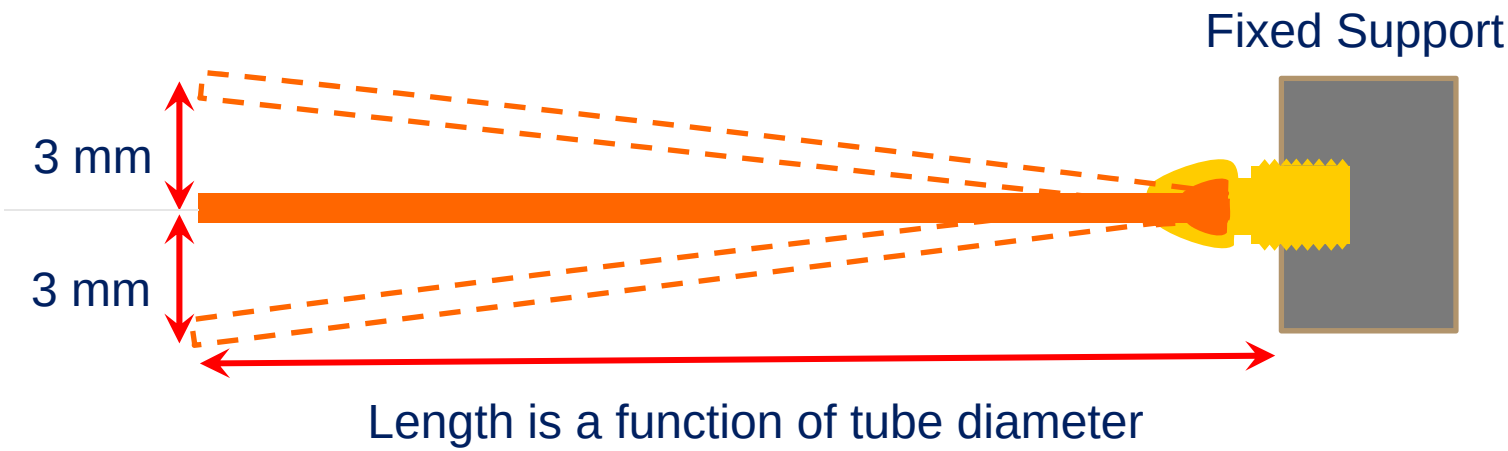
Similar cycling was performed for a total of 80,000 cycles. Weekly leak check s were performed, with no leaks detected during or after testing.

Temperature Trace

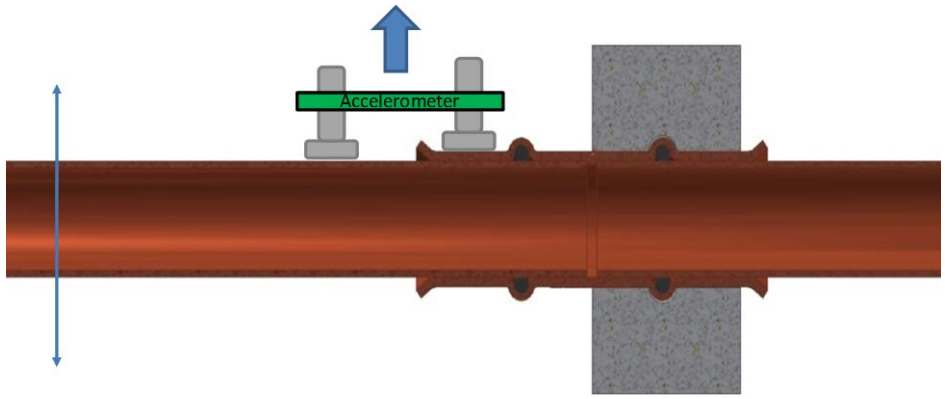


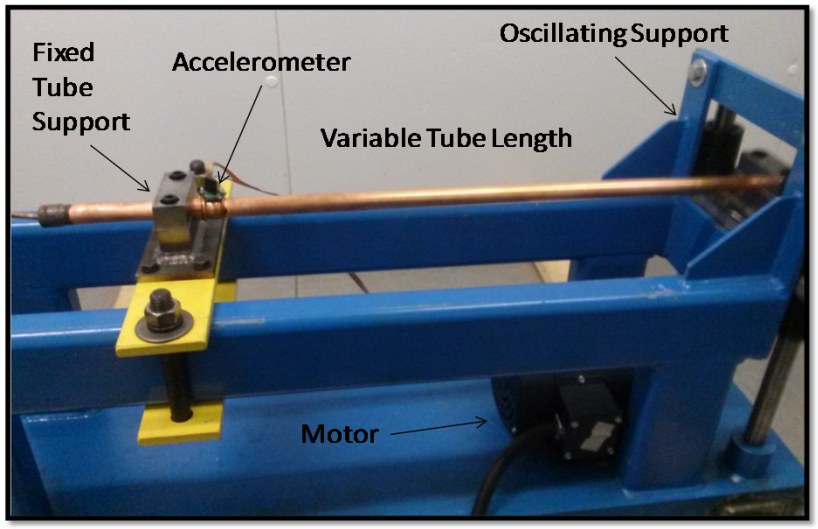
Vibration Fatigue

- Always a concern near rotating machinery
- Vibration absorber tubing is commonly used at the compressor
- UL 207 for fluid fitting specifies a vibration test for flare type fittings
- Below is a rendition of UL 207 vibration test set



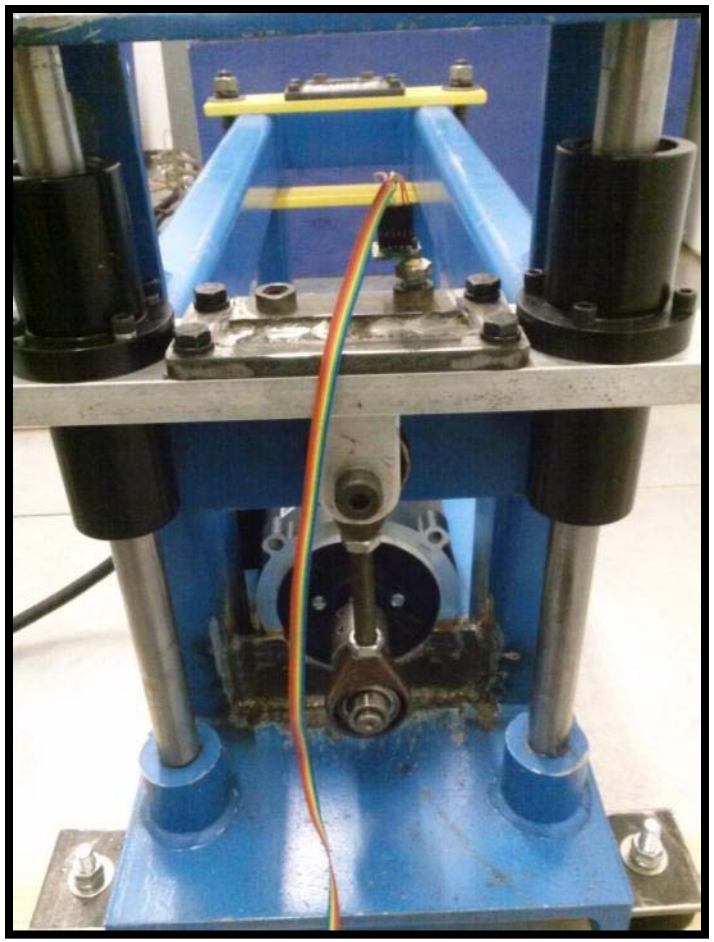
Test Apparatus

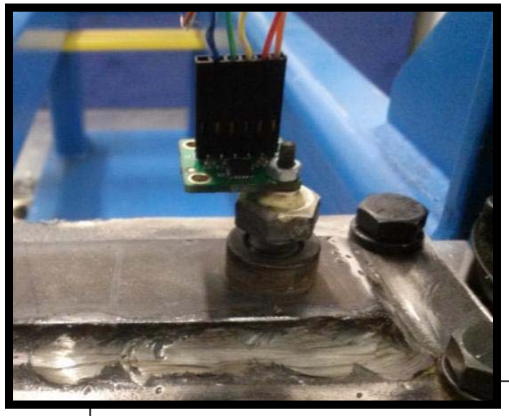




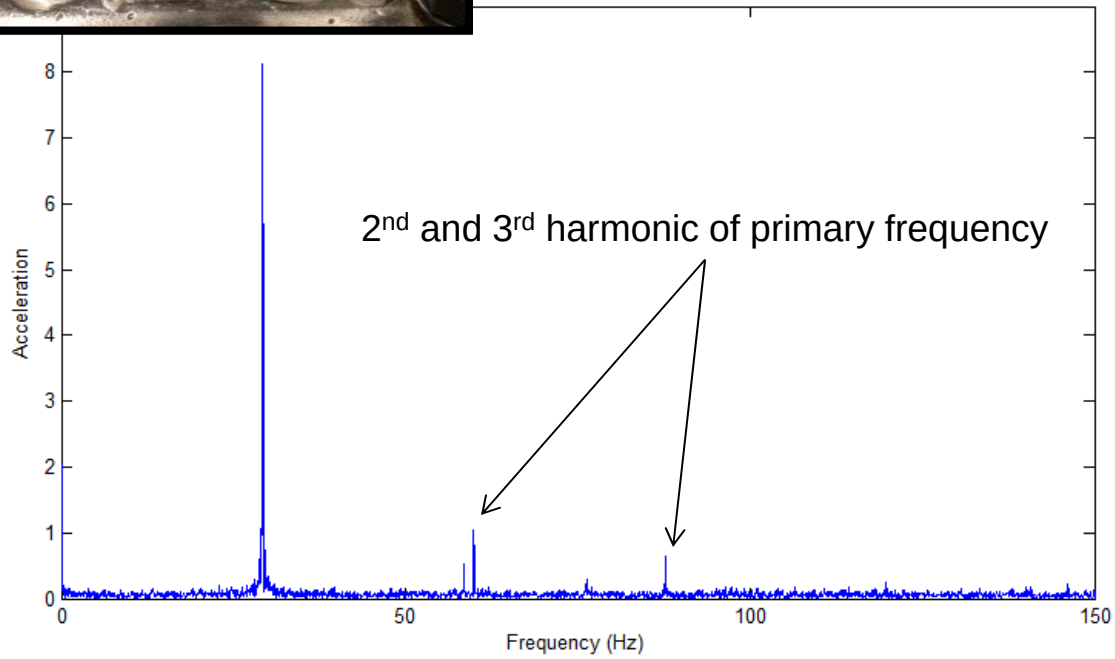
Testing performed in this configuration as well as with the fitting in the center of the clamped tube.

The Primary Frequency for The Facility around 29Hz



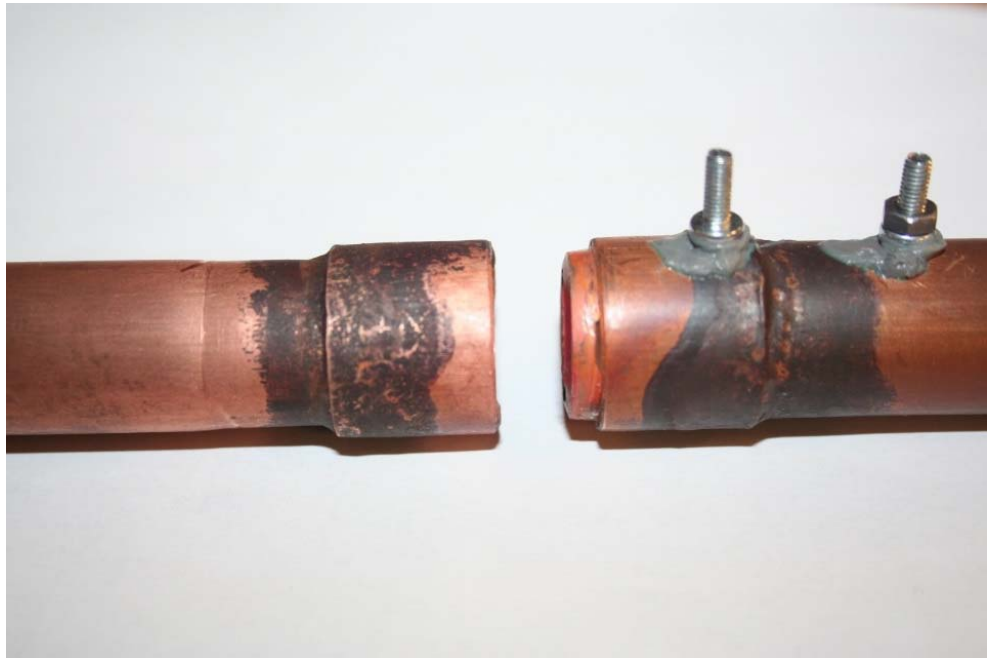


For initial testing, accelerometer mounted on clamp mounts. Displacement characteristics should be higher here than any other place on the test section



Testing on a 7/8″ Brazed Fitting

Similar style of clamp
Tested at 30 Hz



Failed between 1 million and 2 million cycles

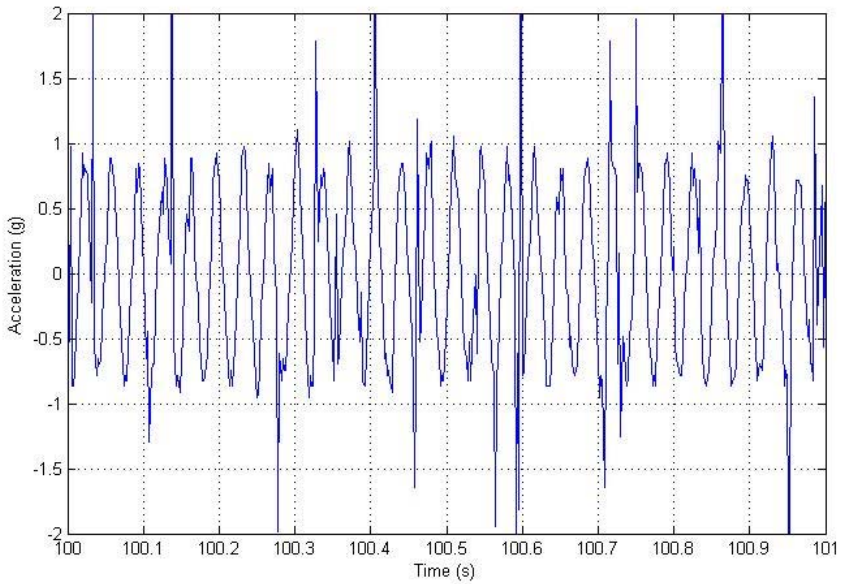
Vibrational Fatigue Results

Test was set up for 30 Hz and 1 million cycles

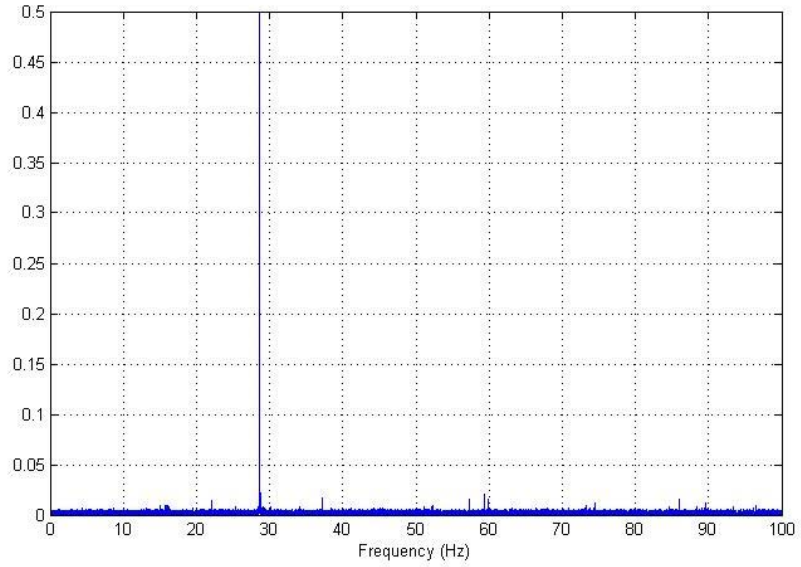
- All samples were leak free

Next steps

- More cycles (3 million or 5 million)*
- Testing at 60 Hz



Time Domain Shows +/- 1g Acceleration



Frequency Domain ~30 Hz Acceleration

Summary

- Introduced a novel flame free fitting for HVAC&R applications
- Established durability tests
  - » Pressure resistance test
  - » Leak integrity
  - » Freeze-thaw
  - » Combined pressure and temperature cycling
  - » Vibration
- Reviewed test results

- Questions??