SEISMIC CAPACITY OF THREADED, BRAZED AND GROOVED PIPE JOINTS

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Motivation

- Understand the behavior and failure mode of common joints under extreme lateral loads
- Static and shake table tests conducted of pressurized
  - Threaded,
  - Brazed,
  - Mechanical joints

Static Testing

- Pressurized spool to 150 psi
- Steady downward force applied while recording deflections
- Grooved clamped mech. joints
  - 16 tests performed
- Threaded joints
  - 4 tests
- Brazed (copper)
  - 4 tests

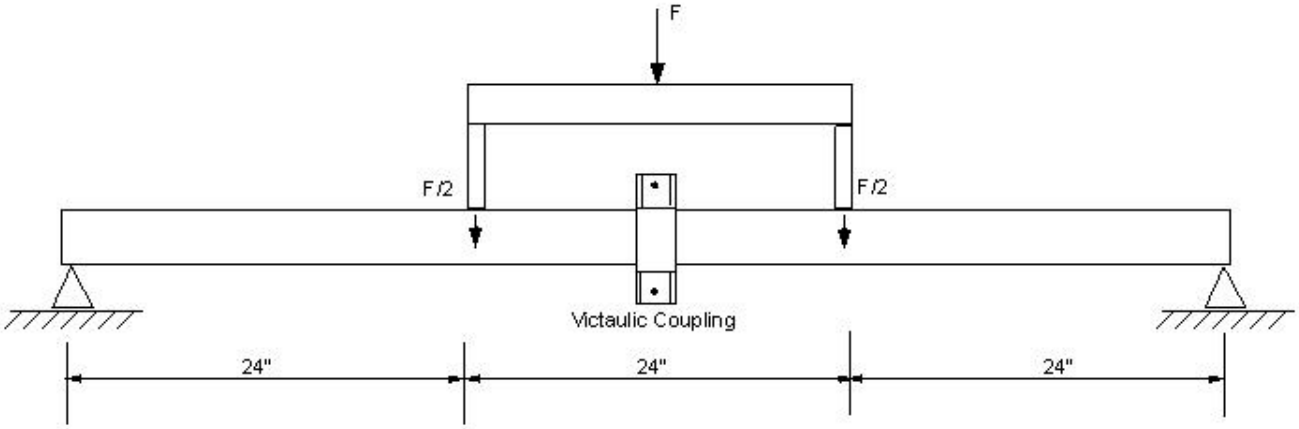
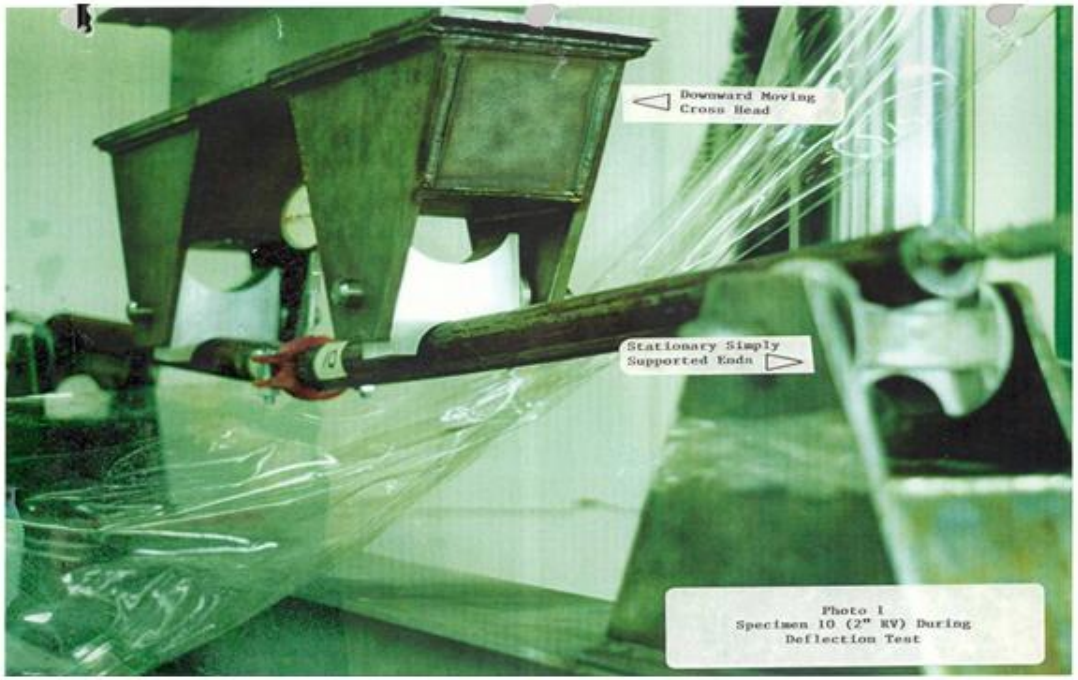


Figure 1 – Static Test Arrangement Four-Point Bend Test



Grooved Couplings

- Catalog items
- ASTM A106 Grade B piping
- ASTM A 536 couplings
- Lateral deflections imposed well above manufacturer's angular installation tolerance

Type & Size	2"	4"
Rigid	4	4
Flexible	4	2

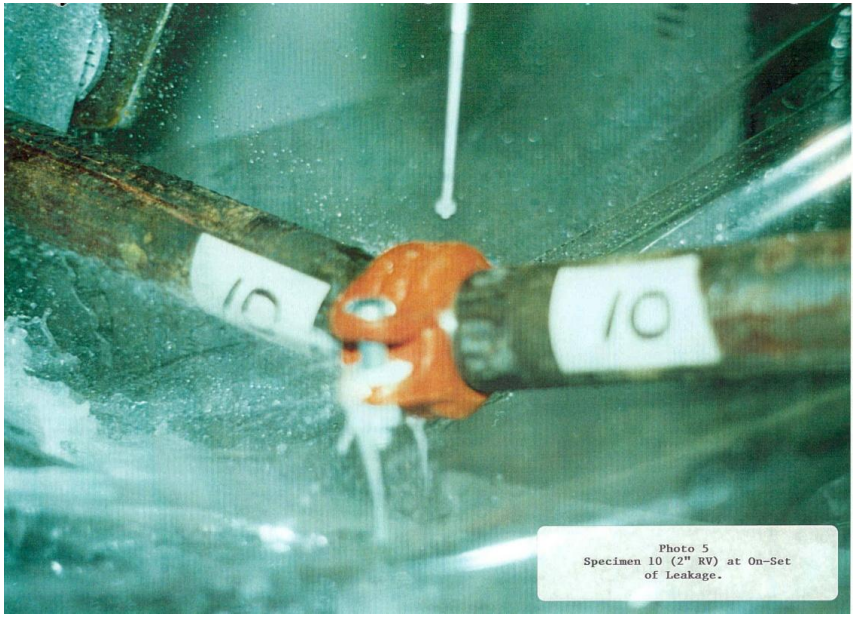
4” Dia. Grooved Couplings

Rupture of coupling followed by leakage

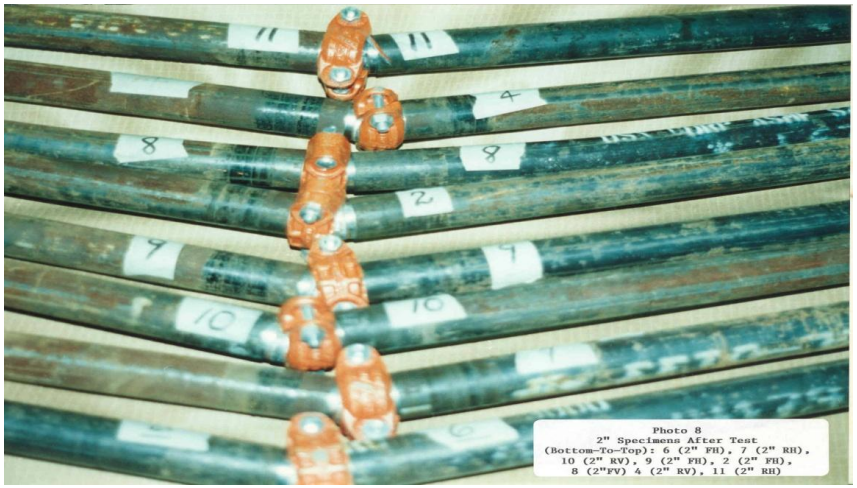
All specimens exhibited same failure mode; cracked housing followed by loss of gasket preload and leakage

2” Dia. Grooved Couplings

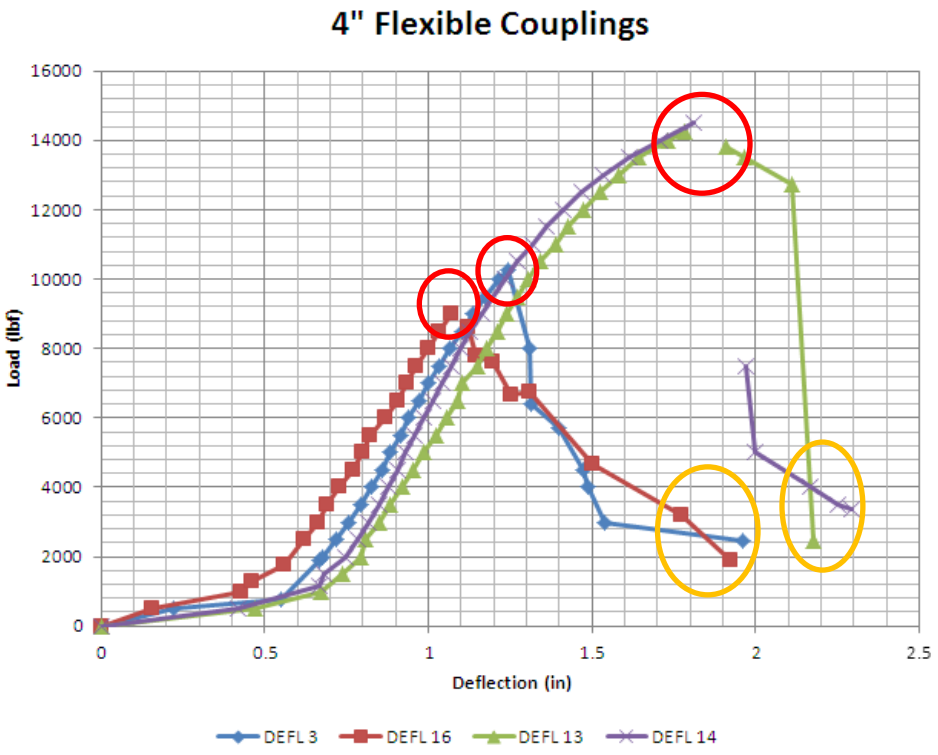
Typical failure mode

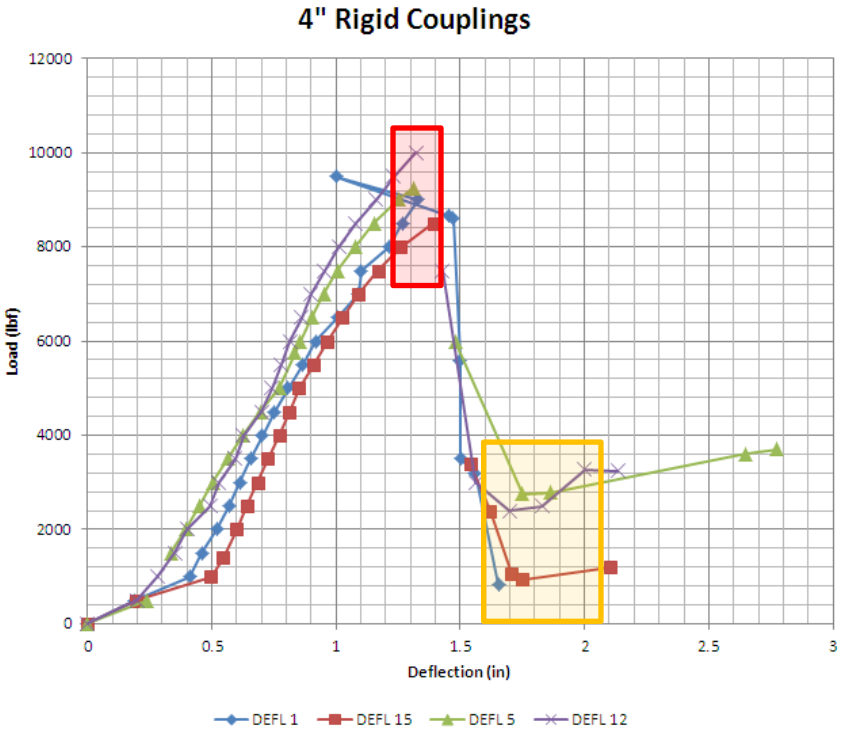


All but two failed by cracked housing, loss of gasket preload followed by leakage



4” Dia. Couplings Load – Deflection Curves

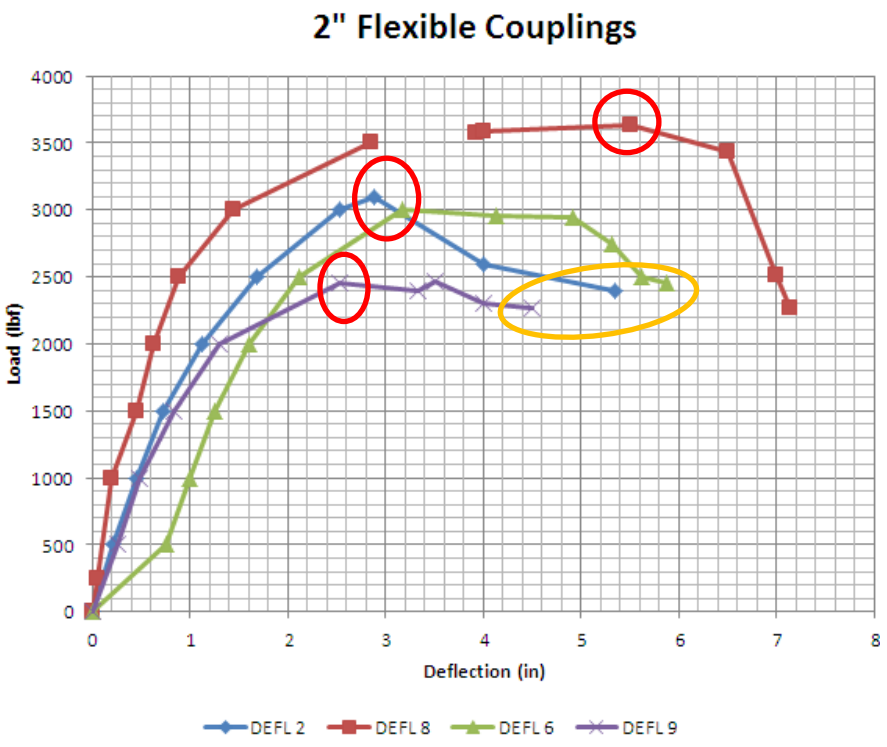


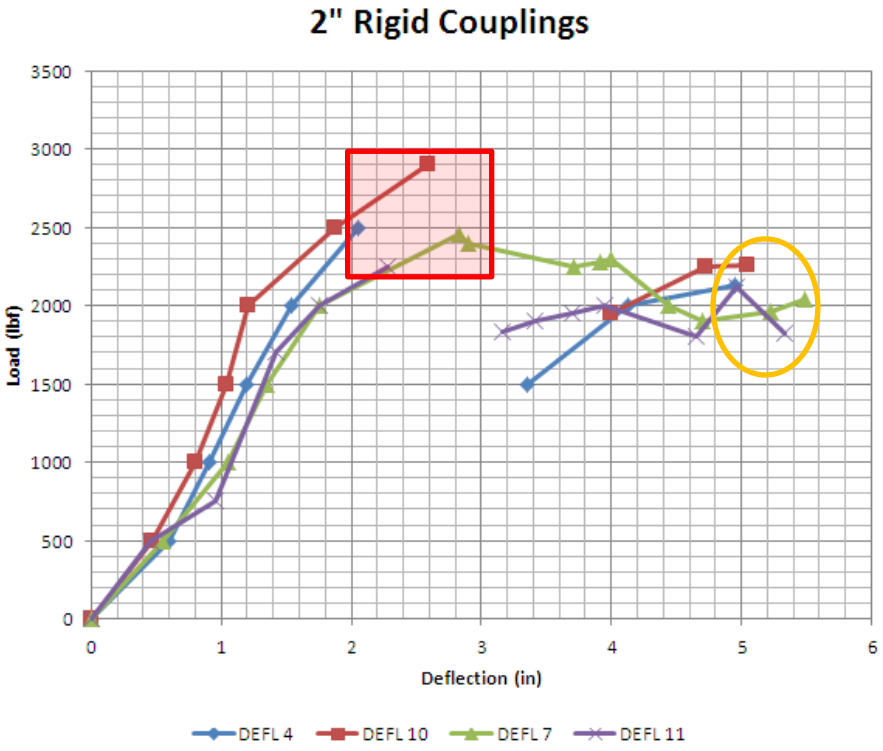


Loss of stiffness regions

Onset of leakage regions

2” Dia. Couplings Load – Deflection Curves



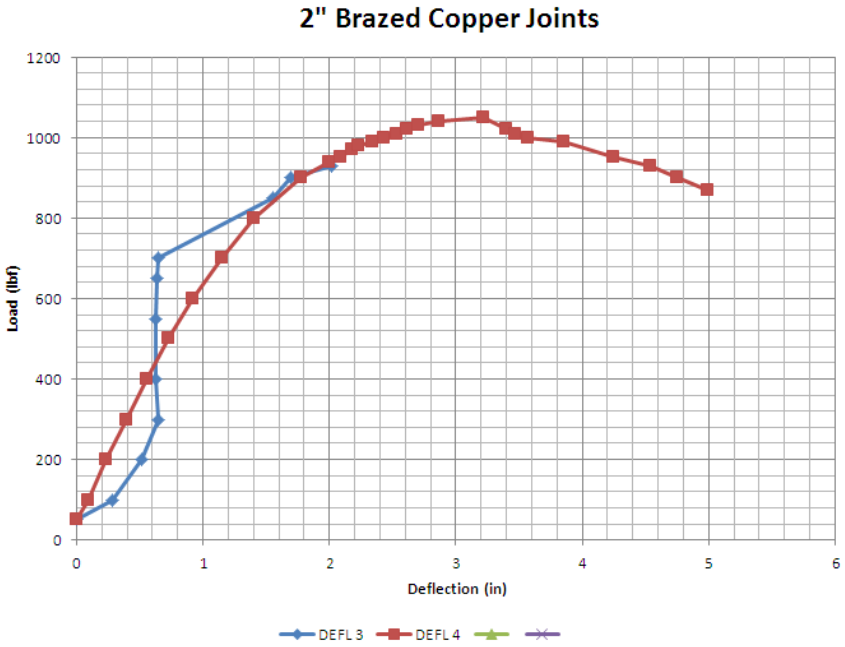


Loss of stiffness regions

Onset of leakage regions

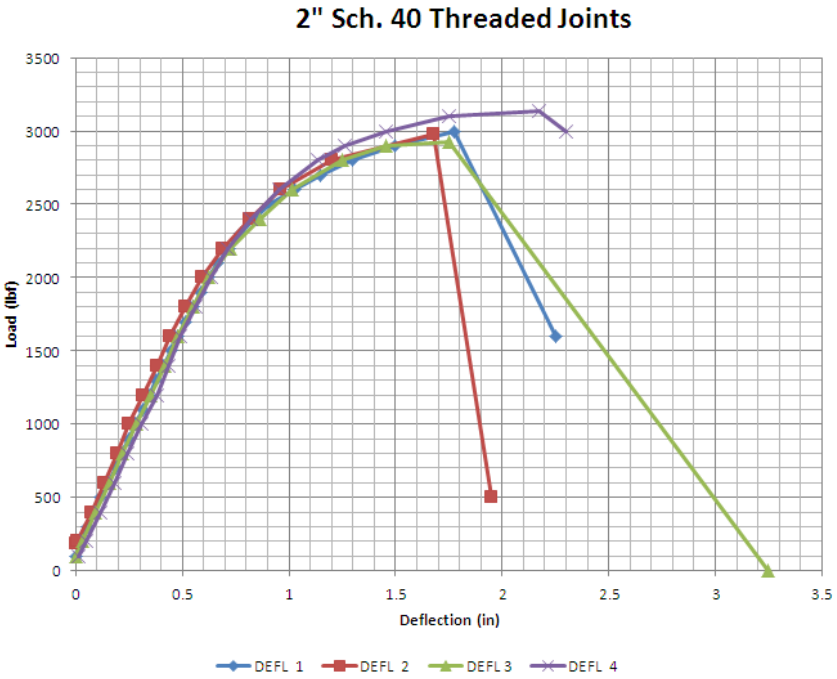
Brazed and Threaded Joints

The brazed fittings joint 2” ASTM B 88 type L seamless tubing (0.061 inch wall).



Brazed couplings have a slight inward depression all around their circumference which serves as an abutment to the two pipe ends. Three specimen failed by rupture of the brazed fitting at the coupling’s centerline, where the inward depression is located. One specimen crimped (buckled) at the bearing point between the machine’s cross head and the pipe (The two points of load application F/2 in Figure 1), with the 24” long center section remaining straight, causing practically no bending at the joint

The threaded fittings were ASME B16.3 malleable iron fittings, joining two 2 inch schedule 40 ASTM A 53 Grade B carbon steel pipes.



Three specimen failed by rupture of the first exposed pipe thread, and one specimen failed by stripping of the engaged threads.

Dynamic Testing

- Dynamic (shake table) testing performed through SRS SQUIRTS membership
- SQUIRTS standard test spectra – envelopes all utility membership
  - Table max. capacity
    - 5% damped spectra
    - 7.5g peak
    - ZPA of 3.5g
- Two series of tests
  - Threaded couplings (4)
  - Grooved couplings (16)

Test	Max FB (g)	Max SS (g)	Max Vert. (g)
4” Rigid	35.96	21.4	6.5
4” Flex	31.38	29.2	7.68
2” Rigid	4.19	7.4	5.4
2” Flex	21.35	23.47	7.0
Table	5.53	4.25	4.68

Test	Rigid (Hz)	Flex (Hz)
4” FB	12.59	12.30
4” SS	11.48	9.886
4” Vert	rigid	rigid
2” FB	7.762	7.161
2” SS	7.328	5.129
2” Vert	Rigid	rigid

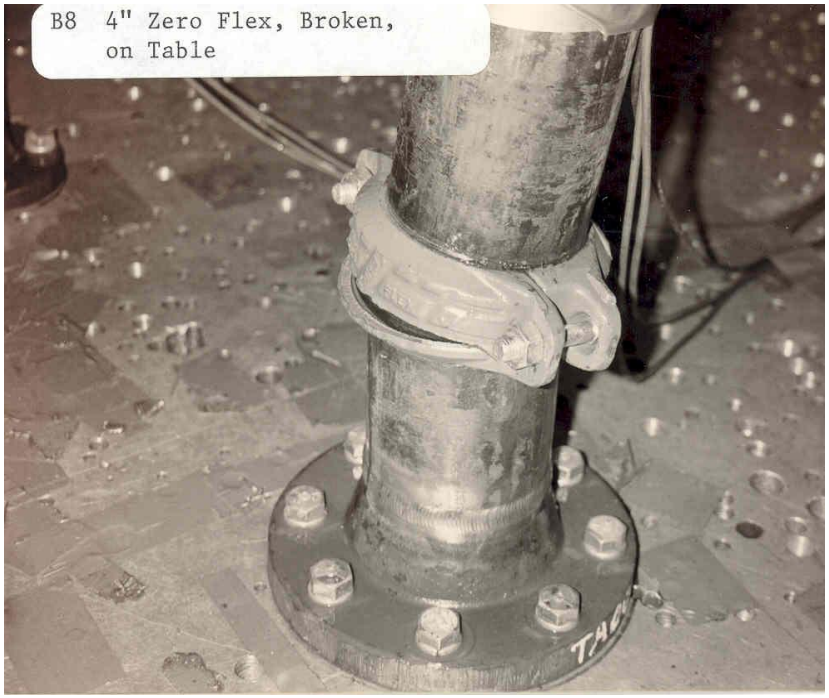
Dynamic Testing

- 6’ long pipe joined to 4” long spool welded to flange mounted on table
- Weight mounted on top of 6’ long pipe to simulate moment loads of similar magnitude to bending moments in static tests
- Pressurized specimens to 150 psi

Dynamic Testing

Threaded Specimen Mounted on Shake Table

Threads Do Not Exhibit Damage After Dynamic Test to Leak



Failed Mechanical Coupling during Dynamic Test

Rigid and flex grooved couplings tested leaked at 70% of table capacity.
Threaded joints leaked at 25% and 50% of table capacity (at onset of shaking).

Conclusions

- Joints performed beyond manufacturer's installation recommendations
- Dynamic failure mode of grooved couplings same as static failure mode
  - Failure moment consistent with static
- Threaded couplings did not perform as expected
  - Leakage at onset of shaking but no visible damage to threads