

# Testing Services



design • analysis • testing



## Stress Engineering Services

Stress Engineering Services a leader in providing proven engineering services and solutions for a broad range of industries worldwide. Always at technology's leading edge, we set the standard in technical excellence by providing clients with the right answers - on time.

This commitment to excellence is the cornerstone of our business. It stems from our belief that there's more to providing quality service than just producing results. It's about having the most advanced technology and equipment along with a team of highly qualified engineering experts with years of applied industry experience and a wide array of engineering disciplinary skills. More importantly, it's about really listening to the client's needs to effectively assess their problem, and combining the right skills and resources to solve their problem in the time they need it.

Since 1972, we have been servicing the needs of clients who require special, in-depth technical knowledge in the areas of testing, materials engineering, metallurgy, floating systems, pipeline engineering, fitness for service, risk assessment, mechanical design, fluid and fracture mechanics, process technology, instrumentation, product design and development, subsea engineering, finite element analysis, and more.

Aerospace

Automotive

Chemical & Refinery

Consumer Products

Electronics

Manufacturing

Medical & Surgical

Oil & Gas

Pharmaceutical

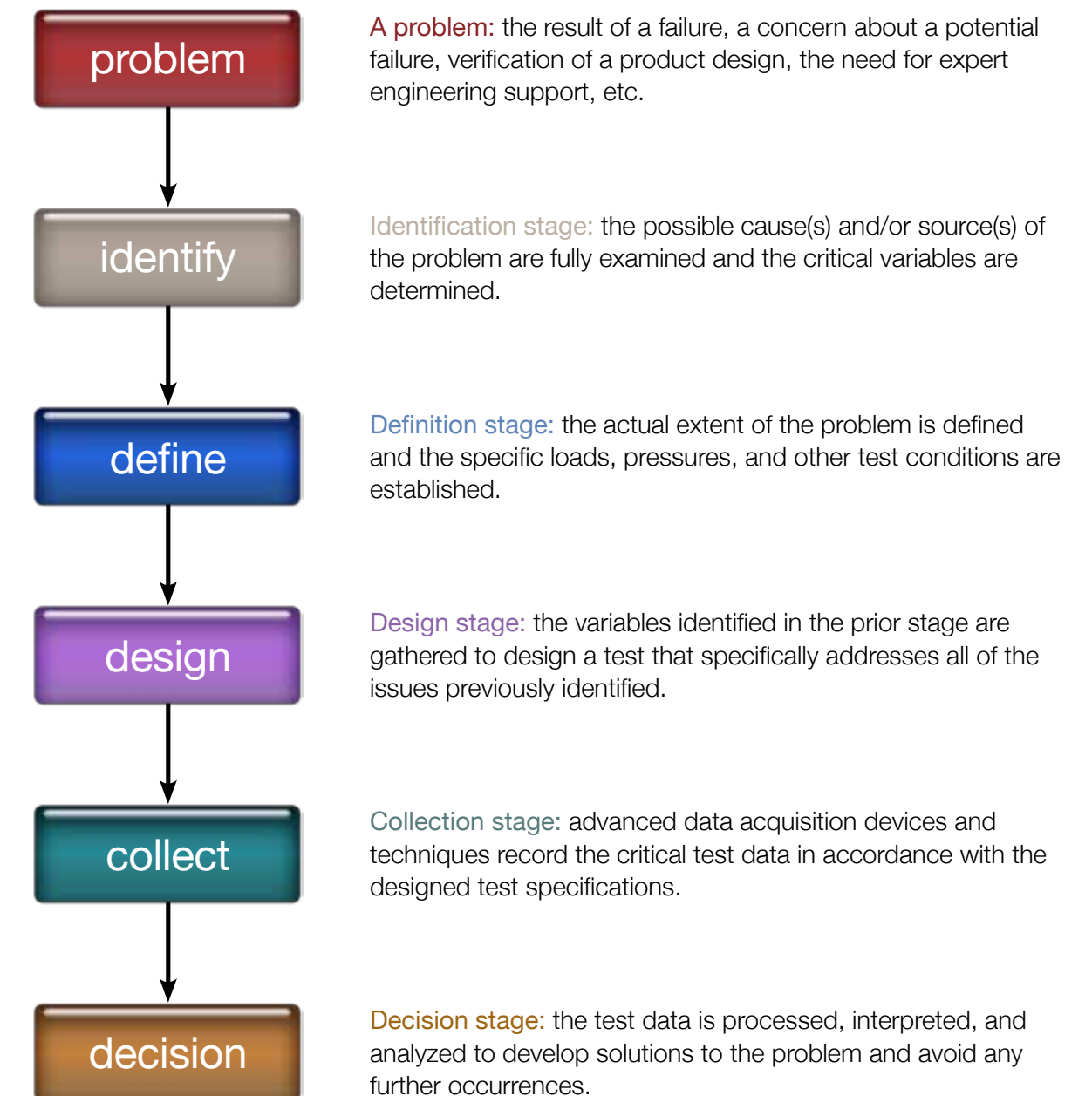
Pipelines

Power & Utilities

Science & Research



## Testing Services







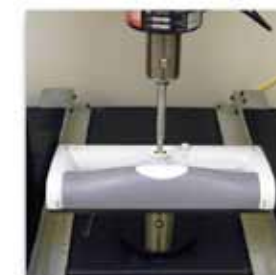
## Force / Load

From over six million pounds to a fraction of a gram, Stress Engineering Services supplies a full range of standard and customized tensile / compressive load testing services to assess all aspects of equipment, components, products, devices, and material behaviors.

Our engineers and technicians use their comprehensive knowledge and experience, together with an extensive array of static and dynamic load frames of various sizes, orientations, and load capacities, to support the high precision and diverse load test programs we provide.

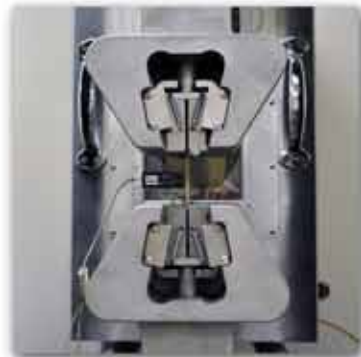
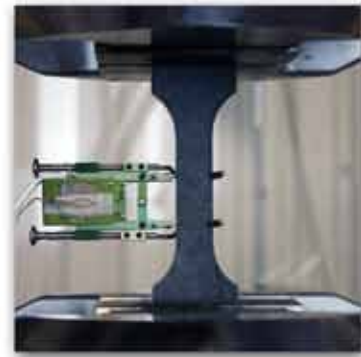
When more diverse test conditions or specifications are required, our load / force testing may be performed in conjunction with thermal and pressure loading, bending and torque, as well as exposure to fluids, corrosive, harsh, or other environmental factors. Applied loads may also be cycled to support fatigue analysis.

- **Combined Load Testing:**
  - Tension: up to 6 million lbs (26.7 MN)
  - Compression: up to 4.5 million lbs (20.9 MN)
  - Bending: up to 1,000,000 ft-lbs (1356 KN-m)
  - Internal (Gas) Pressure: up to 32,000 psi (220 MPa)
  - Internal (Liquid) Pressure: up to 60,000 psi (345 MPa)
  - External (Liquid) Pressure: up to 30,000 psi (138 MPa)
  - Temperature: -75°F to 700°F (-59°C to 371°C)
- **Material Coupon Testing:**
  - Tension and Compression: up to 150,000 lbs (667 kN)
  - Temperatures: from Cryogenic to 2000°F (1093°C)
  - Fatigue, Fracture, and Component Testing
  - Saturated or Fully-Immersed Environments
  - Impact Testing: up to 12.7 ft/sec velocity and 223 ft-lbs energy



*See page 22 for a complete listing of our load frames and specifications.*





# Fatigue

We offer a variety of cyclic testing services for examining equipment, products, devices, and components. Our load testing capabilities may be applied in a cyclic manner to assess fatigue behavior, vibration loading, fracture mechanics, damage tolerance and failure mechanisms. We also have the capacity to combine fatigue with other factors, such as bending, internal pressure, temperature, and chemical exposure to assess their combined effects.

- Full-Scale Component, Small-Scale Component, and Material Coupon
- Resonant Fatigue Testing
- Complex and Mixed Loading Scenarios
- Induced Cracking and Crack Growth Assessment
- Corrosion Effects
- Elevated Temperature and Chemical Exposure
- Four-Point Rotational Bending Testing
- Drill String Friction Testing
- Casing and Riser Wear Testing

## RESONANT BENDING FATIGUE TESTING

Stress Engineering Services is a renowned leader in high-speed fatigue testing of full-scale pipe samples to verify fatigue resistance of connectors, girth welds, and more. These tests involve applying sinusoidal alternating bending stresses around the entire pipe circumference to stimulate the pipe specimen near its resonant bending frequency. By internally pressurizing the test sample, a mean axial stress can also be supplied.

- Resistance Fatigue Machines:
  - 7 machines - 3" to 24" (76 to 610 mm) diameter samples
  - 1 machine - 20" to 36" (508 to 914 mm) diameter samples
  - 8 machines - 0.59" to 3" (15 to 76 mm) diameter samples
- Stress Ranges: typically 5 ksi to 50 ksi (35 to 350 MPa)
- Cyclic Rates: about 2.5 million cycles per day
- 24 hour / 7 day Operation with Automatic Shut-Downs
- Continuous Monitoring of Alternating Fatigue Stresses
- Post-Mortem Dimensional and Metallurgical Evaluations







## Pressure

Understanding operational pressure limits can be essential, which is why we utilize specialized pressure and collapse testing methods to solve our clients' most complex environmental challenges.

Our testing laboratories are equipped with a variety of pressure vessels, chambers, and enclosures to accommodate a broad range of pressure specifications, sample sizes, and industry-specific testing requirements.

Internal and external pressures may be combined with fluids and temperatures to simulate fluid flow and various environmental conditions. In these cases, we can also apply wet or dry strain gages in order to accurately monitor and record critical sample activity as it occurs.

High pressure / high temperature (HPHT) testing can be conducted in both gaseous and liquid environments, and also combined with numerous load and bending configurations. More information on our HPHT testing capabilities can be found in the *Temperature* section.

- Internal and External Hydrostatic Tests:
  - Internal pressurization up to 60,000 psi (414 MPa)
  - External pressurization up to 30,000 psi (207 MPa)
- Internal and External Fluid Heating: up to 1500°F (816°C) as well as other ranges for specialty liquid applications
- Large Diameter Pipe Collapse and Burst Tests
- Product Containers and Packaging Tests
- Continuous Monitoring of Alternating Fatigue Stresses
- Testing of Seals, Wellscreens, Umbilical Cables, Subsea Connectors, Instrumentation, Chambers, and Vessels



*See page 22 for a complete listing of our pressure vessels and specifications.*





## Temperature

Testing at elevated or extremely low temperatures includes the challenge of quantifying and characterizing the material properties of the sample. This data is critical to understanding the operational limits and reliability of the product or equipment under evaluation.

At Stress Engineering Services, we have the ability to support unique and extreme temperature situations including fire exposure, controlled thermal cycling up to 1200°F (650°C), and a wide range of cold and cryogenic tests. Examples of the range of cold testing we perform include:

- Testing of tensile coupons and full-scale pipe sections with temperatures as low as -320°F (-196°C)
- Full-scale testing of compressed gas transportation tanks at temperatures as low as -69°F (-56°C)
- Circulating fluid at -40°F (-40°C) to quantify the impact on the inner pipe structure

### HIGH PRESSURE / HIGH TEMPERATURE

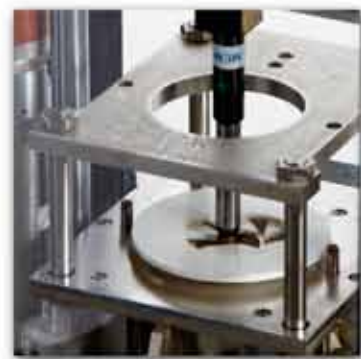
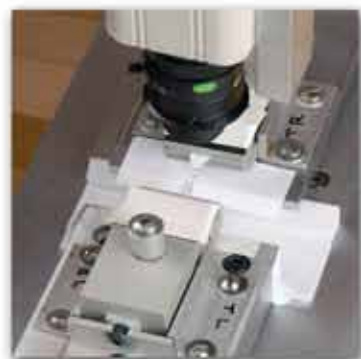
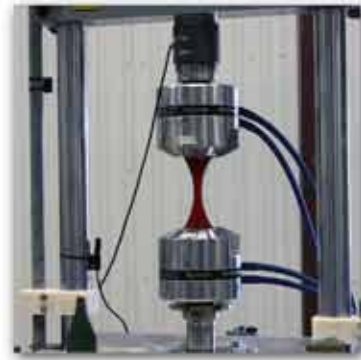
Oil and gas operators, equipment manufacturers, and drilling contractors are continually faced with the challenge of ensuring that the equipment used in the drilling and production of high pressure / high temperature (HPHT) wells is safe and reliable for operation under extreme conditions.

To simulate these in-situ or near in-situ conditions, we offer a variety of HPHT engineering and testing solutions including verification testing under combined loads of pressure, temperature, bending, torque, fatigue, and fluids. In addition, we provide a wide range of material testing services to characterize the performance of the materials when exposed to HPHT and sour service environments.

- Tension: up to 6 million lbs (26.7 MN)
- Compression: up to 4.5 million lbs (20.9 MN)
- Bending: up to 1,000,000 ft-lbs (1356 kN-m)
- Internal (Gas) Pressure: up to 32,000 psi (220 MPa)
- Internal (Liquid) Pressure: up to 60,000 psi (345 MPa)
- External (Liquid) Pressure: up to 30,000 psi (138 MPa)
- Temperature: -75°F to 700°F (-59°C to 371°C)







## Materials

### HARSH ENVIRONMENT TESTING

Our materials testing facilities host a full-service fatigue and fracture lab for materials testing in ambient  $H_2S$ , high pressure / high temperature,  $CO_2$ , nitrogen, methane, and other extreme and toxic environments. In addition, we provide materials characterization and selection assistance for equipment used in harsh environments, as well as full-scale equipment assessments. The labs feature digitally controlled servo-hydraulic material test frames with capabilities ranging from 22 kip to 150 kip (98 kN to 667 kN) for:

- Fatigue, Fracture and Sour Service Testing
- Tensile and Compression Testing
- Fracture Toughness Testing: KIC, JIC and CTOD
- Fatigue Crack Growth Analysis
- Small-Scale Component / Assembly Characterization
- S-N Testing

### NON-METALLIC MATERIALS

Stress Engineering Services provides a range of non-metallic materials (polymers, elastomers, composites) testing methods including tensile, fatigue, chemistry, climate, creep and relaxation testing, as well as characterization of rheological properties. We also provide customized testing for less-traditional analyses such as impact, high strain rate, multi-axial tensile, environmental stress cracking, accelerated life, coefficient of friction, and gas/water vapor permeability.

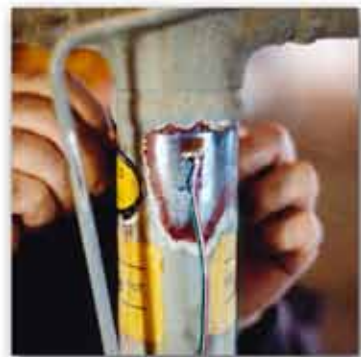
### HIGH TEMPERATURE CREEP TESTING

Our creep laboratories provide high temperature creep testing across a full range of engineering applications – from ambient to 2000°F (1093°C) on materials of virtually any description.

The creep testing facilities provide a viable resource to support areas such as risk and remaining life assessment, fitness-for-service evaluations, vessel re-rates, and experimental verification of design procedures. They also serve as a center for exploring and developing innovative methods for creep evaluation of service-exposed components.

- 50 Conventional Tensile Creep Machines
- Electro-Hydraulic Test Rigs for Subcomponent and Cyclic Testing
- Two 100,000 lb (445 kN) Creep Machines for Testing of Weldments





## Measurement & Monitoring

Comprehensive testing abilities, advanced software, and exceptional electrical engineering skills are the foundation of our measurement and monitoring capabilities. Our labs are equipped with the most advanced instrumentation, monitoring and data-acquisition systems available.

Undertaking unique and complex data acquisition requirements is our specialty. Our projects have been as intricate as measuring and controlling electrical impulses in a human muscle, as extensive as measuring loads on a 40 foot (12.2 m) pipe sample, or as challenging as monitoring structural vibrations at 10,000 feet (3038 m) below the ocean's surface. We are renowned experts in the installation and use of strain gages and in the development of state-of-the-art instrumentation monitoring and data acquisition systems.

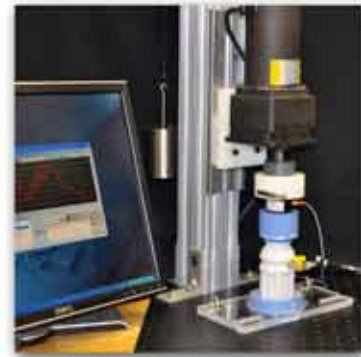
### REMOTE MONITORING

Our measurement and monitoring expertise extends well beyond the laboratory. In the field, our engineers and technicians use the most advanced data acquisition systems and installation techniques to accurately monitor and collect data related to a variety of equipment, components, devices, and processes. We also provide a wide range of remote monitoring and measurement solutions including cellular phone / satellite monitoring and real-time posting of data on a secured website, for those who need reliable equipment monitoring data to be accessible from anywhere and at anytime.

### CUSTOM BUILT SYSTEMS

Recognizing that a large number of test programs require some type of customized data acquisition capabilities, we have designed and built a wide range of measurement and monitoring systems to provide signal conditioning for strain gages and various other sensor types. Examples of our proprietary measurement and monitoring systems include:

- Subsea Vibration Data Logger – Tool for measuring vibration on equipment up to ultra-deepwater depths; designed to collect high-quality vibration data for extended periods in stringent subsea environments.
- StrainDAQ, VxiDAQ – Data acquisition software for acquisition and processing of virtually every signal variable that is used in stress testing and analysis.
- MiniDAQ, MicroDAQ, BottleDAQ and PalletDAQ – Data acquisition tools measuring variables during manufacturing, transportation, and product usage. Designed for monitoring consumer products, packaging, devices, and more.



## Products and Packaging

For over three decades Stress Engineering Services has been measuring and assessing the performance of many different types of products and packaging. Our focus is on developing test procedures that will accurately assess the behavior of a product or packaging, determine possible modifications, and provide highly efficient solutions.

We specialize in measuring a variety of factors that can significantly affect the functionality of products and packaging, including rapid loading rates, varying temperatures, extreme forces, displacement, deflection, acceleration, vibration, cyclic events, and others.

- Functional Verification
- Human Factors and Ergonomic Evaluation
- Force and Displacement Input / Output
- Fluid / Flow Measurements
- Aging, Life Assessment, and Reliability Testing
- Materials Characterization and Certification
- Electronics Performance
- Thermal and Impact Performance

## Medical / Surgical Devices

Testing of new medical/surgical products and sub-systems often involves aging studies, multiple firing or clamping operations, along with measuring the effect of harsh environmental exposures such as those experienced in the sterilization process. The objective of this testing is to develop reliability data for components, sub-systems, or full-scale devices in order to address product requirements and support warranty specifications.

Generating test data for new medical/surgical products and systems often requires custom test development and integration. Our engineers are experts in developing custom test protocols and systems that can effectively measure data in a variety of applications.

- Instrumented Drop Impact Testing
- Noise & Vibration Testing of Medical Products
- Verification Testing for Functional Performance
- Custom Strain Gaging and Instrumentation
- Concept Model and Prototype Proof Testing
- Fluid Flow Characterization
- Reliability Testing





## Field Testing

Real-world problems can't always be examined in a laboratory – that is why we offer an array of field testing services in a number of industry sectors. Our engineers and technicians are widely experienced in conducting field tests and assessments in a variety of extreme and challenging site conditions around the world.

By using the most advanced field testing methods, we are able to effectively determine the operating conditions of equipment and structures. We use this information to diagnose problems, evaluate operating performance, determine compliance, and recommend improvements.

- Field Metallurgical Replication
- Weld Testing and Evaluation
- Equipment Monitoring for Structural Stability
- Manufacturing and Processing Equipment Testing
- Acoustic Emission Testing
- Ultrasonic Flaw Detection
- Crane Testing
- Metallography

## Noise and Vibration

Stress Engineering Services has a long history of providing noise and vibration solutions as they apply to structures, equipment, machinery, consumer products, medical devices, systems, pipelines, vessels and more. We specialize in noise and vibration problems that are complex and require in-depth assessment approaches—ones that involve combinations of computer simulations, specialty field measurements, and/or advanced data analysis techniques.

Both in the field and in the laboratory, we are fully equipped to perform a variety of noise and vibrating testing services including sound pressure levels or experimental modal analysis, as well as flow-induced, vortex-induced, and force response vibration. We integrate our broad range of experience and extensive measurement, testing, and analysis capabilities to quickly identify sources of problems and provide the most efficient and practical solutions.

- Sound Pressure Levels
- Force Response Vibration
- Experimental Modal Analysis
- Flow-Induced Vibration
- Vortex-Induced Vibration
- Turbulence-Induced Vibration

tensile / compression frames

| Frame          | Max Tensile Capacity (lbs) | Max Compression Capacity (lbs) | Max Bending (ft-lbs) | Max Stroke (in) | Max Sample Length (ft) |
|----------------|----------------------------|--------------------------------|----------------------|-----------------|------------------------|
| 6000K          | 6,000,000                  | 4,500,000                      | 1,000,000            | 72              | 44                     |
| 4000K          | 4,000,000                  | 3,000,000                      | 500,000              | 36              | 27                     |
| 3300K          | 3,300,000                  | 2,700,000                      | 400,000              | 36              | 11                     |
| 3250K          | 3,250,000                  | 3,500,000                      | 400,000              | 15              | 30                     |
| Vertical 3000K | 3,000,000                  | 2,250,000                      | -                    | 60              | variable               |
| 2500K          | 2,500,000                  | 1,400,000                      | 200,000              | 12              | 7                      |
| Vertical 2000K | 2,000,000                  | 1,500,000                      | -                    | 60              | variable               |
| L 2000         | 2,000,000                  | 2,000,000                      | 120,000              | 60              | 50                     |
| Vertical 1500K | 1,500,000                  | 1,500,000                      | -                    | 60              | variable               |
| 1100K          | 1,100,000                  | 1,100,000                      | 200,000              | 30              | 45                     |
| 1000K          | 1,000,000                  | 750,000                        | 120,000              | 60              | 14                     |
| N 1000         | 1,000,000                  | 1,000,000                      | 120,000              | 24              | 10                     |
| V 1000         | 1,000,000                  | 1,000,000                      | 120,000              | 24              | 10                     |
| 200K           | 200,000                    | 200,000                        | -                    | 18              | 50                     |
| Baldwin        | 120,000                    | 120,000                        | 120,000              | 8               | 586                    |

| Frame                      | Variables                       | Max Load Capacity (lbs) | Additional Capabilities                    | Temperature Range | Opening                        |
|----------------------------|---------------------------------|-------------------------|--|-------------------|--------------------------------|
| MTS 220 kip Load Frame     | Tensile and Compression         | 110,000                 | Max Frequency: 2 Hz @ .100"                | -100°C to 93°C    |                                |
| MTS Alliance RT/100        | Tensile and Compression         | 22,500                  | Max Crosshead Speed: 20 in/min             | -100°C to 260°C   | 16.75" vertical                |
| MTS Elastomer 858          | Tensile and Compression         | 3,300                   | Max Frequency: 85 Hz                       | -100°C to 93°C    | 16.75" vertical                |
| MTS Elastomer RT/10        | Tensile and Compression         | 2,225                   | Max Crosshead Speed: 40 in/min             | -100°C to 93°C    | 16.75" vertical                |
| Pallet Load Frame          | Tensile and Compression         | 50,000                  | Floating upper platen                      | -                 | 72" vertical<br>56" horizontal |
| Instron 1321 Biaxial Frame | Tensile, Compression and Torque | 10,000                  | Torque: 88 ft-lbs.<br>Rotary stroke: -280° | -100°C to 93°C    |                                |

pressure vessels / chambers

| Vessel | Max Pressure (psi) | Max Inside Diameter (in) | Max Sample Length (ft) |
|--------|--------------------|--------------------------|------------------------|
| 1      | 30,000             | 4,700,000                | 15.5                   |
| 2      | 30,000             | 5                        | 15.5                   |
| 3      | 30,000             | 10                       | 14                     |
| 4      | 30,000             | 10                       | 10                     |
| 5      | 20,000             | 6                        | 1.5                    |
| 6      | 20,000             | 5.75                     | 21                     |
| 7      | 20,000             | 4                        | 12                     |

| Vessel | Max Pressure (psi) | Max Inside Diameter (in) | Max Sample Length (ft) |
|--------|--------------------|--------------------------|------------------------|
| 8      | 20,000             | 4                        | 3                      |
| 9      | 15,000             | 11                       | 6.5                    |
| 10     | 15,000             | 5.75                     | 24                     |
| 11     | 6,000              | 14                       | 4                      |
| 12     | 5,900              | 42                       | 22                     |
| 13     | 4,750              | 26                       | 11                     |
| 14     | 3,700              | 22                       | 20                     |



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