# Development of a Deadweight Tester into a Pressure Testing Station at the STAR Facility

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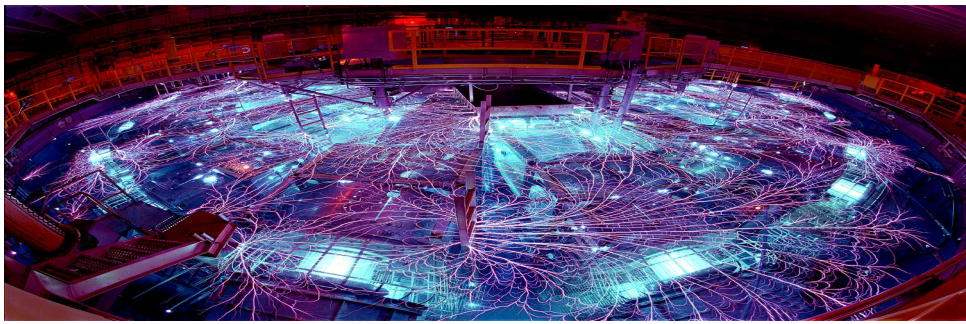

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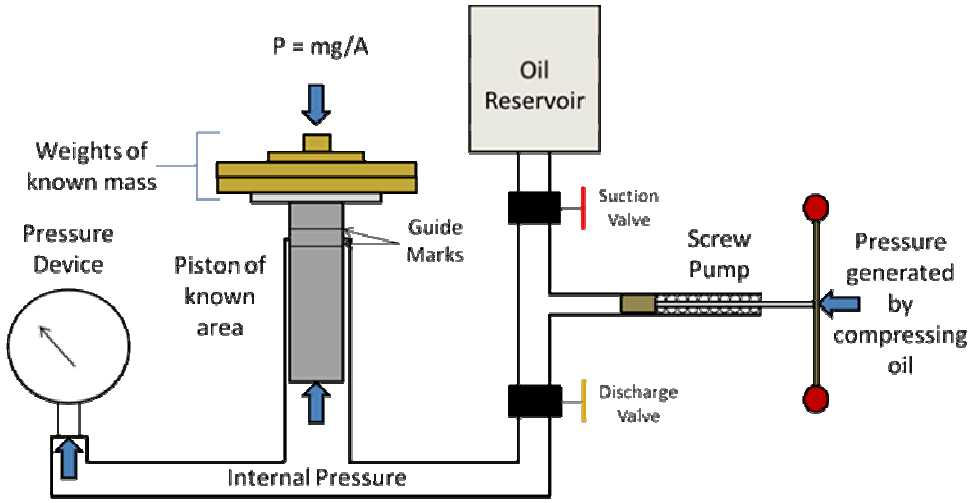
# Deadweight Tester

- Generates a known pressure based on fundamental units
  - Mass (kg, lb)
  - Area ($m^2$, $in^2$)
    - P = Mg/A
- Weights of known mass are placed on a piston of known area




- Pressure generated by compressing oil with a hand pump
  - Pressure is known when force of the internal pressure makes the piston rise to equilibrium position

# Theory of Operation

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## Pascal's Law

- Static pressure exerted on an internal fluid is distributed evenly through the fluid
  - Only changes in pressure come from internal effects
    - Hydrostatic Pressure
    - $\Delta P = \rho g \Delta h$
  - Since $\Delta h$ is very small, hydrostatic effects are considered to be negligible

## System Accuracy

- Using correcting equations, can be accurate up to 0.02% of the indicated pressure.

$$F_{buoyancy} = 1 - \frac{D_{air}}{D_{mass}}$$

$$P_{head} = D_{oil}(H - H_{ref})$$

$$F_{press} = \frac{1}{1 + bP}$$

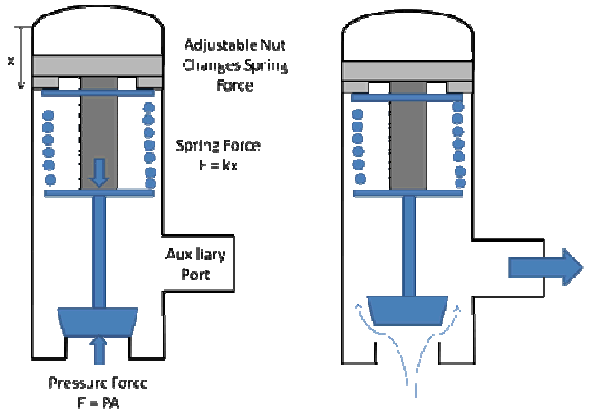
$$F_{temp} = \frac{1}{1 + (a_{cyl} + a_{piston})(T - T_{ref})}$$

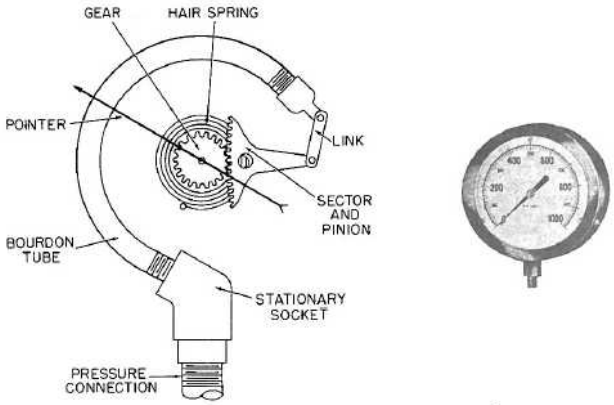
$$F_{gravity} = \frac{G}{G_s}$$

$$P_{corr} = \frac{1}{1000}\left(\frac{M_{app}}{A_{cyl}} F_{gravity} F_{buoyancy} F_{temp} F_{press}\right) \pm P_{head}$$

$D_{air}$ = Density of Air at test pressure and temperature
$D_{mass}$ = Density of the weights (8.39 g/cm$^3$)
$D_{oil}$ = Density of hydraulic oil (1.11 g/cm$^3$)
$H$ = Height above base of device being tested
$H_{ref}$ = Height of extended piston above base (6.4 cm)
$b$ = Pressure Coefficient of the Effective Area (9.39x10$^{-7}$ cm$^2$/kg)
$P$ = Nominal Pressure listed on weights
$a_{cyl} + a_{piston}$ = Thermal Expansion Coefficient of Piston and Cylinder ($a_{cyl} + a_{piston}$ = 2.59x10$^{-5}$ 1/°C)
$T$ = Ambient Temperature during testing (°C)
$T_{ref}$ = Temperature at time of calibrating (25°C)
$G$ = Local Gravity (978.468 cm/s$^2$ in Albuquerque)
$G_s$ = Standard Gravity (980.665 cm/s$^2$)
$M_{app}$ = Mass of the weights applied
$A_{cyl}$ = Area of the Piston used

# Project Motivation






http://enginemechanics.tpub.com/14037/css/14037_58.htm

- Pressure Relief Valves
  - Overpressure protection for pressure systems
    - Valve opens when certain pressure in system is reached
- Pressure Gauges
  - Uses a mechanical means of indicating the pressure inside of a system
- Pressure Transducers
  - Converts pressure to an electrical signal
  - Signal can be read in order to determine internal pressure

# Project Motivation

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## Testing Intervals

- Pressure Relief Valves
  - Corrosive Environments
    - Once a year
  - High Pressure (>3,000 psi)
    - Every other year
  - All Other Valves
    - Every three years maximum
- Pressure Gauges and Transducers
  - Dependent on operators needs
    - Frequent inspection ensures accuracy

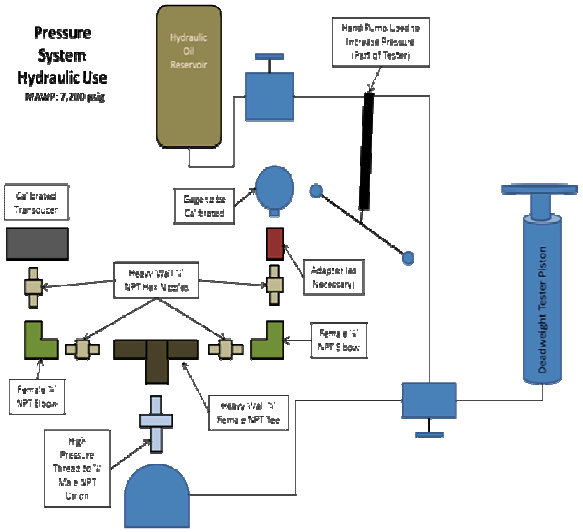
## Testing Requirements

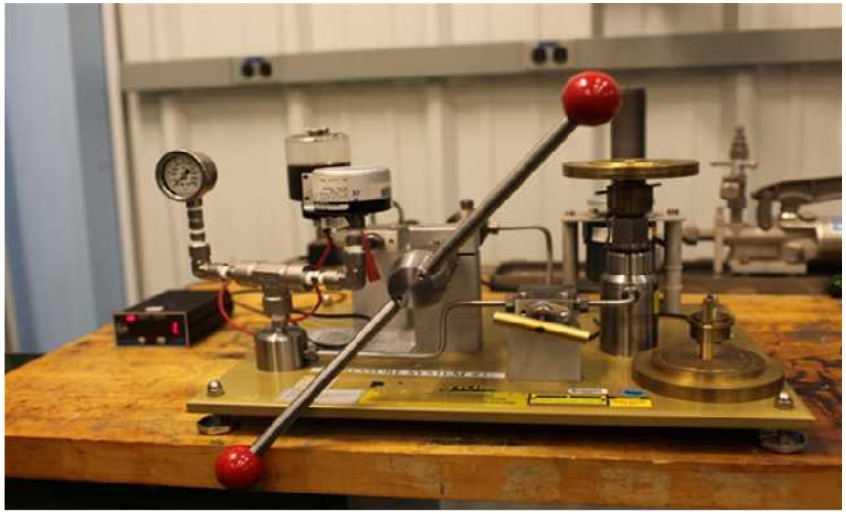
- Inspect Devices for Damage
  - Corrosion
  - Leakage
- Have a way of knowing the pressure in the tester
  - Needs to be a level of accuracy higher than the device being tested
- Be able to accept, repair, or replace the device being tested

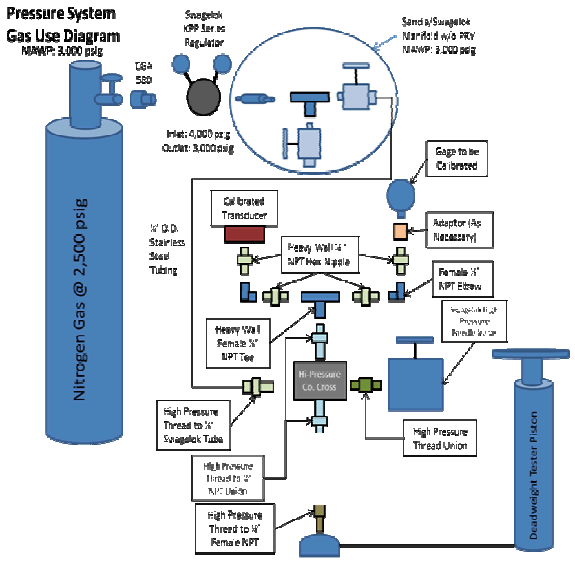
# Project Requirements

- Meet all Sandia Requirements as a test station
  - Be able to perform same operations as the Maintenance and Calibration Department
- Have a second port for a reference transducer
  - Would not be possible to know pressure at which PRV opens and closes using the weight measurement approach
- Able to accommodate all devices in the facility
  - Large range of pressures (10-10,000 psig)
  - Various inlet/outlet sizes
- Can test devices without the use of hydraulic oil
  - Some devices cannot be contaminated with anything other than a gas
  - Compressed Nitrogen Gas would need to be used as the working fluid

# System Design






# Results

- Currently, the device has been certified by Sandia for use
- To this point, only pressure relief valves have been tested
  - With the range of valves tested, both the hydraulic oil and nitrogen gas configurations were used
- All valves were tested according to Sandia requirements
  - A total of 18 valves from the facility were able to be tested
  - All valves were able to be reinstalled within the day
    - The majority of valves were within tolerances
      - Those that were not within tolerance were able to be repaired at the station
      - One valve required replacement, and one was found and tested

# Conclusions

- System has been operating as intended
  - Seems to be reading pressure accurately
    - Valves that were out of tolerance were so by a significant factor
      - System issues do not seem to be the cause of test failure
- Minor improvements could be made to the system
  - A flow meter could be used when testing pressure relief valves
    - Depending on the valve, it may be hard to determine if it is opened based on visual or audio cues
  - The weights and piston should be re-measured
    - Would allow for more accurate calculations of the internal pressure
      - Dimensions could have changed since last measured
    - Could be used instead of reference transducer for gauge and transducer calibrations
      - More accurate over full range
      - Less complicated

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# QUESTIONS ?