



University  
of Idaho

# AUTOCLAVE UPGRADE FOR CORROSION FATIGUE TESTING

DESIGN REVIEW

# THE PROJECT



## EXPANDING THE UNIVERSITY OF IDAHO'S CURRENT FATIGUE TESTING CAPABILITIES

- I Load Frame/Autoclave combo will be a unique addition to U of I's research equipment
- I Project will expand Dr. Stephen's ability to test fatigue of experimental materials
- I Similar product previously quoted by Cortest at \$100,000+

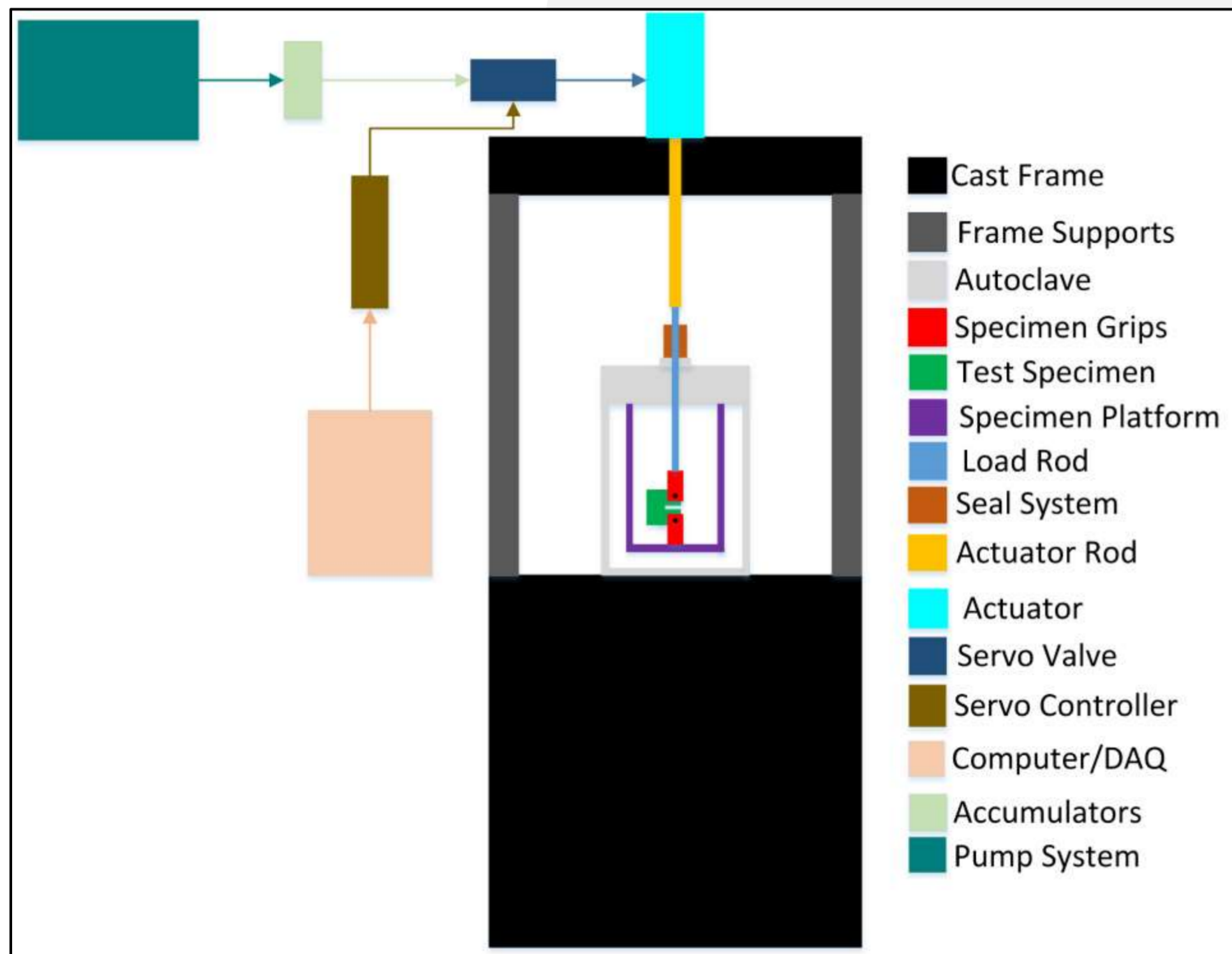


The Autoclave to be Modified

# SCOPE OF PROJECT



## EXPANDING THE UNIVERSITY OF IDAHO'S CURRENT FATIGUE TESTING CAPABILITIES



Block Diagram of Planned Work

- I Design and build load frame system that conforms to the product requirements of Dr. Stephens and fits budget of \$40,000
- I Design and build specimen platform and gripper arms for testing
- I Design and code LabView user interface (UI) that is similar in form and function to current UI used by other load frames in fatigue & fracture lab
- I Validate system in time for use after Fall Senior Design class ends

# HYDRAULIC VS ELECTRIC ACTUATION

Load Frame Actuation System Decision Matrix											
Criteria	Cost	Explanation	Complexity	Explanation	Meets Specifications	Explanation	Footprint	Explanation	Maintenance	Explanation	Total Value
Weight	7		5		10		2		6		
Hydraulic System	8	Actuator ≈ \$100-2000 Pump ≈ \$0-1000 Servo Valve ≈ \$1000 Accumulators ≈ \$900	6	Nick and member of team have relevant experience with hydraulic	10	Full cost range will meet ideal specifications.	7	May need a new pump.	7	Pump and actuator needs occasional maintenance.	38
Weighted Values	56	Total = \$2200-5100	30		60		14		42		202
Electric System	5	Servo Motor ≈ \$400-3000 Actuator/Screw ≈ \$250-13,000 Controller ≈ \$500	4	Team has little-to-no experience with large servo motor systems.	7	Meets minimum specifications.	8	Other than pump, is approximately the same size as hydraulic system.	6	Actual maintenance is unknown and could include replacement of ball screw or servo, which would be a	30
Weighted Values	35	Total = \$1350-13,700	20		42		16		36		149

# ACTUATION SYSTEM

The actuation system provides the force needed to fatigue test materials.

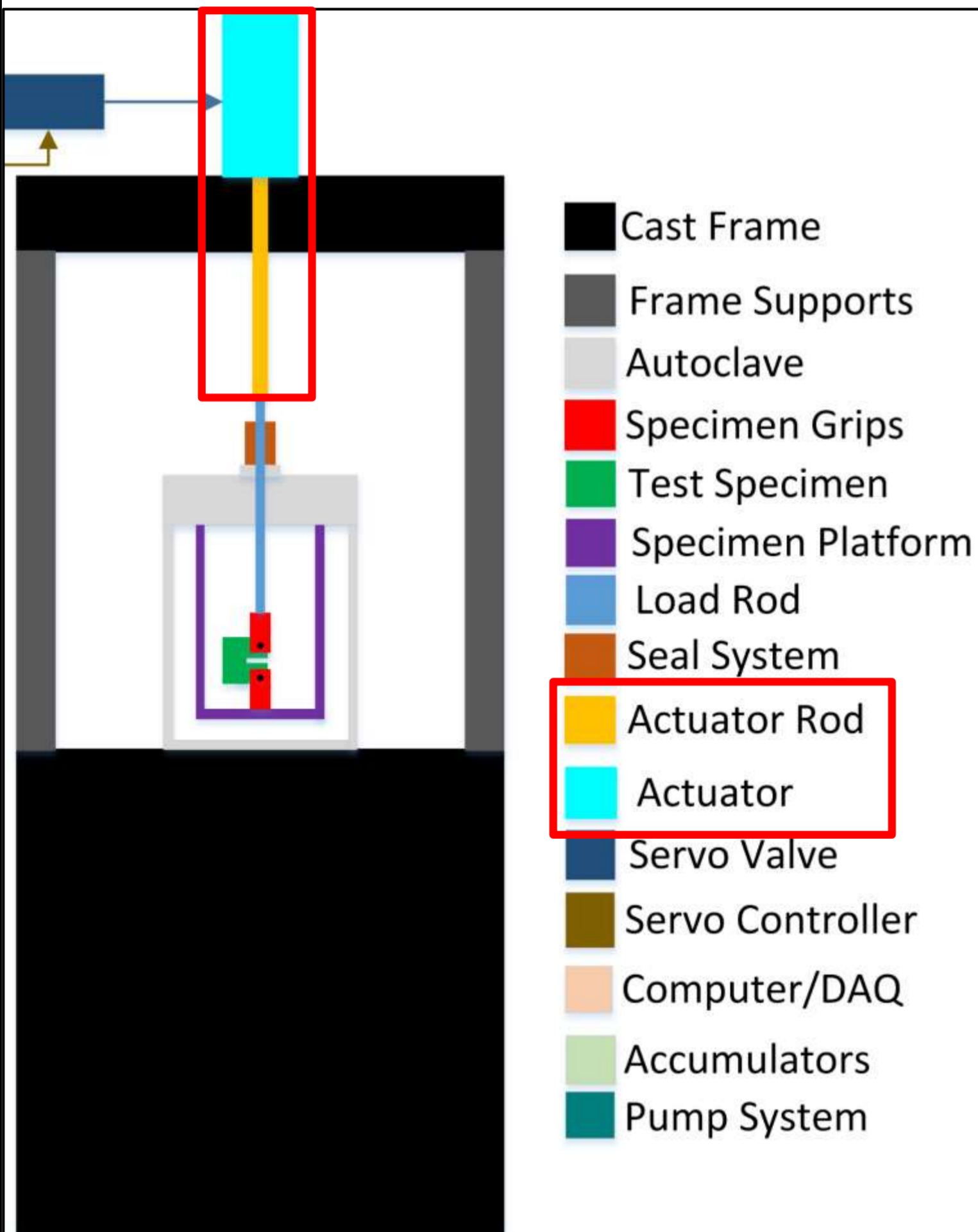
## COMPONENTS

- Actuator
- Pump
- Servo Valve & Controller
- Accumulators



# ACTUATOR

The hydraulic actuator will provide the force and movement of the load rod.



## BEST OPTION

The 2.50CJ2HKNFU139AC12.00 model hydraulic actuator from Parker was chosen as our best candidate for this project.



Cost: \$1567.72

- Rated at 10,000 lbf
- Cushioned head and cap
- Rod is female threaded
- Able to cycle at over 15hz

✓ Exceeds ideal product specifications

## SECONDARY

Max TC tie rod cylinder 2.5borx10stroke-125 rod from Bailey Hydraulic.



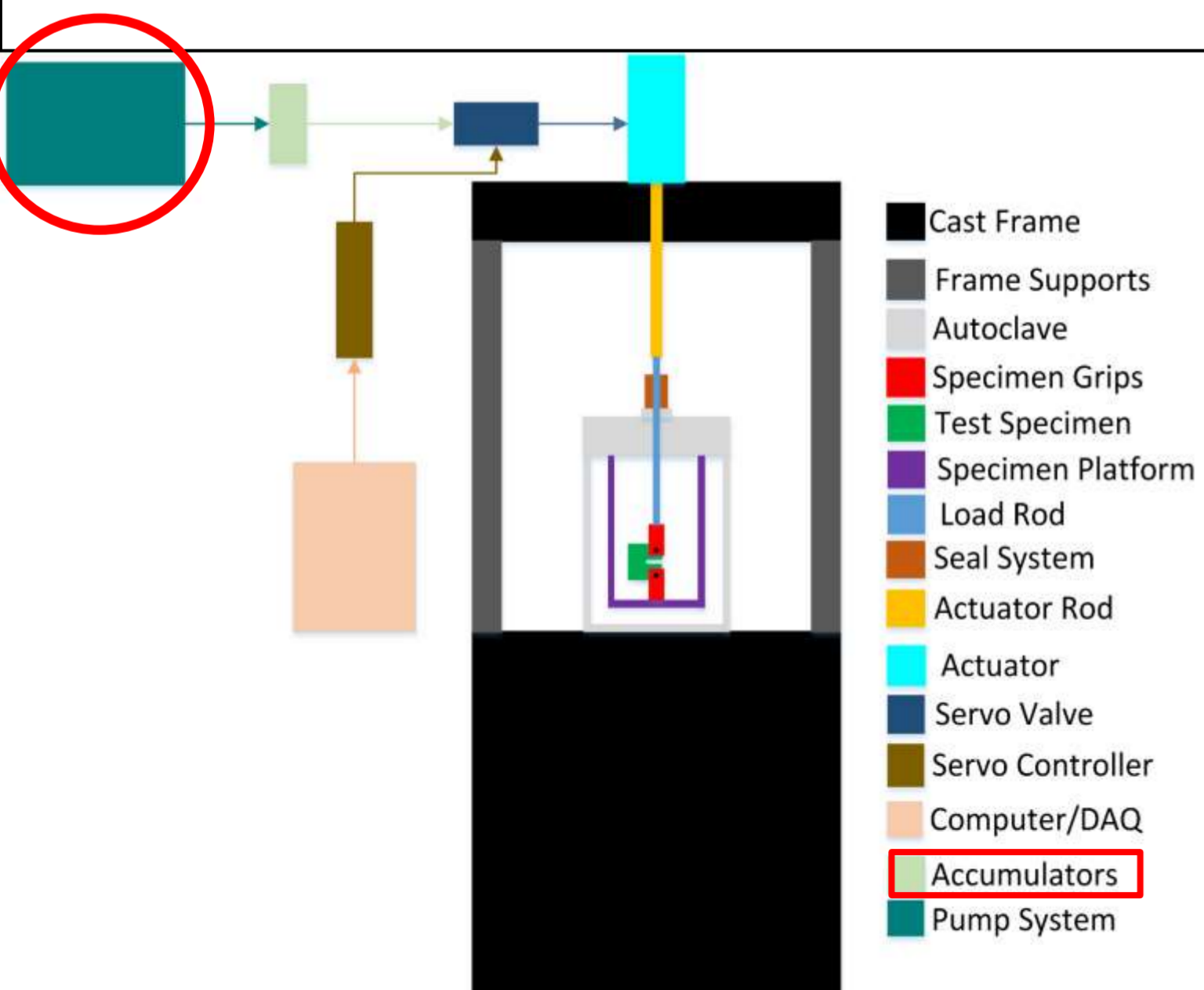
Cost: \$104.87

- Wrong Connector, would require adaptor
- Can handle max load

Only meets minimum product specifications

# PUMP

The pump will provide the pressure for the hydraulic fluid.



## BEST OPTION

The 50-1-1.5E model is the one we will be going with from Fosters.

- Filter
- Relief valve
- Pressure Gauge
- Does 28.76 mm/s



Cost: \$1170.00

✓ Exceeds ideal product specifications

## SECONDARY

The Pump is in lab.

- will cover what is needed but shared



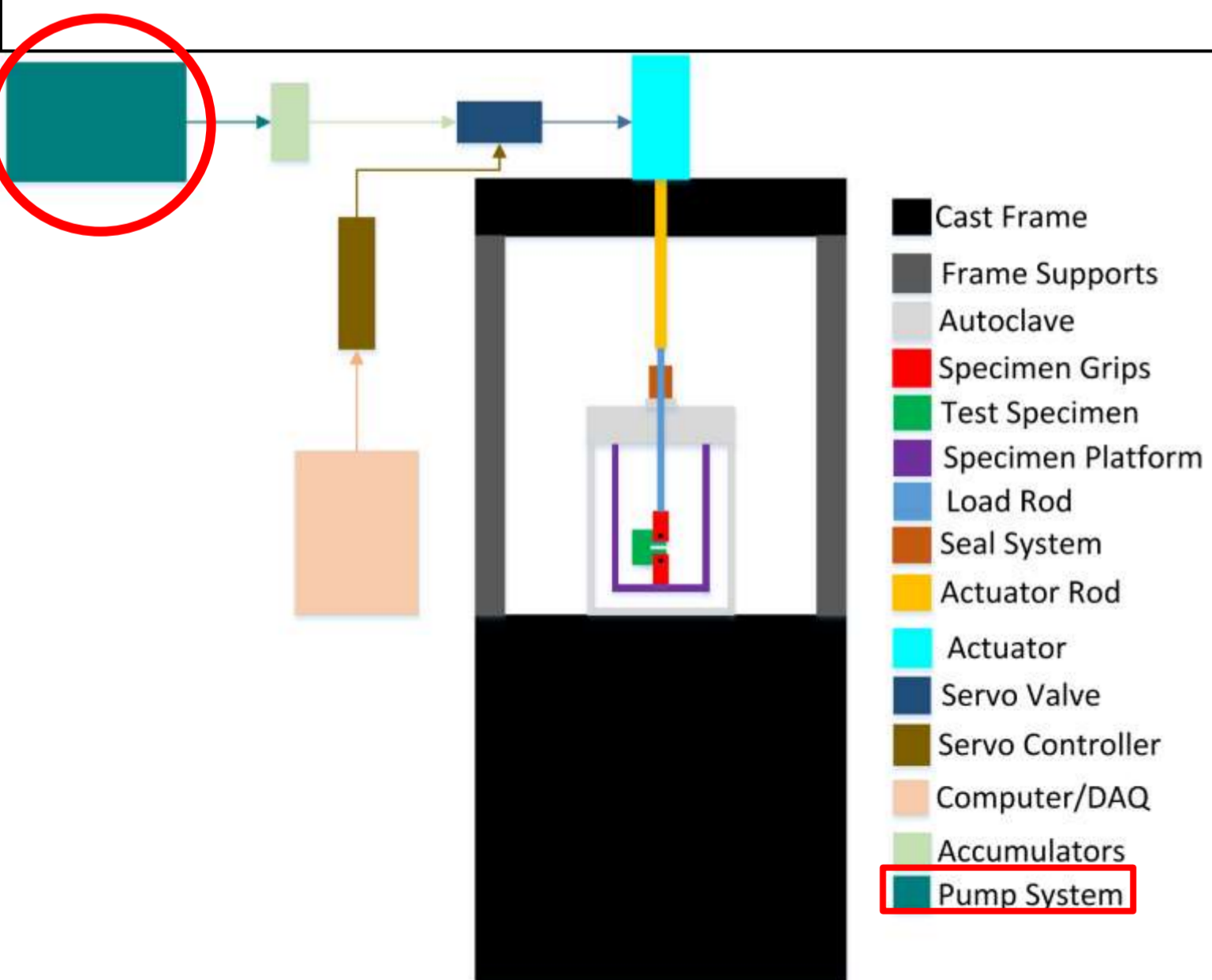
Cost: \$0

Meets ideal product specifications



# HEAT EXCHANGER

The heat exchanger will cool the hydraulic fluid.



## BEST OPTION

The EKS-508-T model is the one we will be going with from Southwest Thermal Technology Inc.

- Handles 80 gpm
- Only 10.38 in long
- Tube size 3/16 in



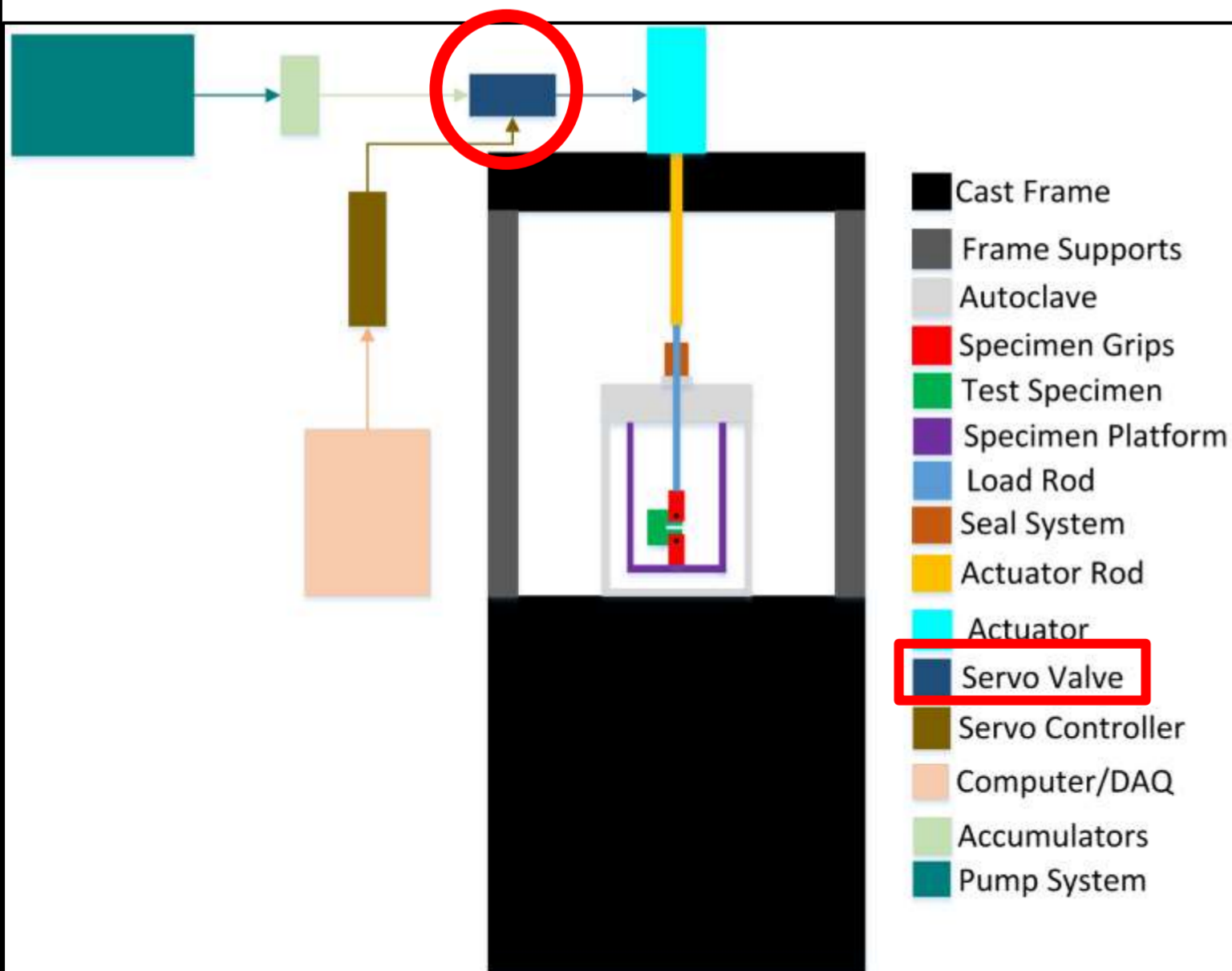
Cost: \$198.79

✓ Exceeds ideal product specifications



# SERVO VALVE

The servo valve, signaled by the controller, controls the flow/pressure of the hydraulic fluid entering the actuator.



## BEST OPTION

The 30 series Moog servo valve

- Flow controller
- Operating at maximum pressure of 4000 psi
- Flow rate of 0.125-1.85 gpm
- Rated signal options on  $\pm 10$ ,  $\pm 20$ ,  $\pm 40$  mA



Cost: In progress

✓ Exceeds ideal product specifications

## SECONDARY

The 760 series Moog servo valve

- Operate at maximum pressure of 3,000 psi
- Flow rate of 1-15 gpm
- Rated signal options on  $\pm 15$ ,  $\pm 30$ ,  $\pm 40$ ,  $\pm 50$ ,  $\pm 200$  mA

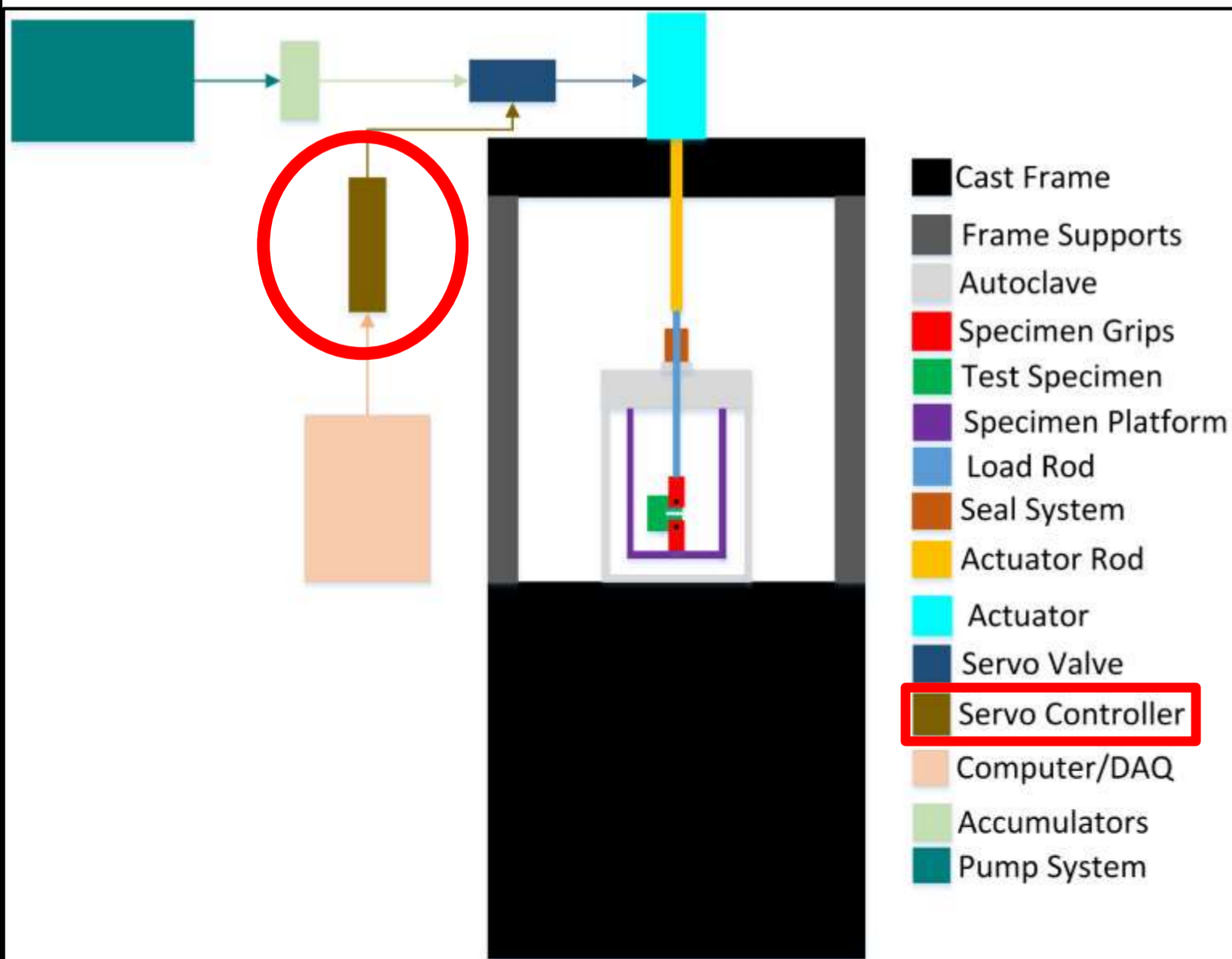


Cost: \$8000

✓ Exceeds ideal product specifications

# SERVO CONTROLLER

The servo valve controller, signaled by the DAQ, controls the servo valve.



## BEST OPTION

The Modular Test Controller for servo valve

- Converts voltage to current
- All connectors accessible from the same interface panel
- Perform tasks from PC application and mobile devices
- Can connect easily to the existing software



Cost: In Progress

✓ Exceeds ideal product specifications but it could be difficult to integrate.

## SECONDARY

A C-DAQ has been built on National Instruments website:

- Easy to integrate
- Highly priced



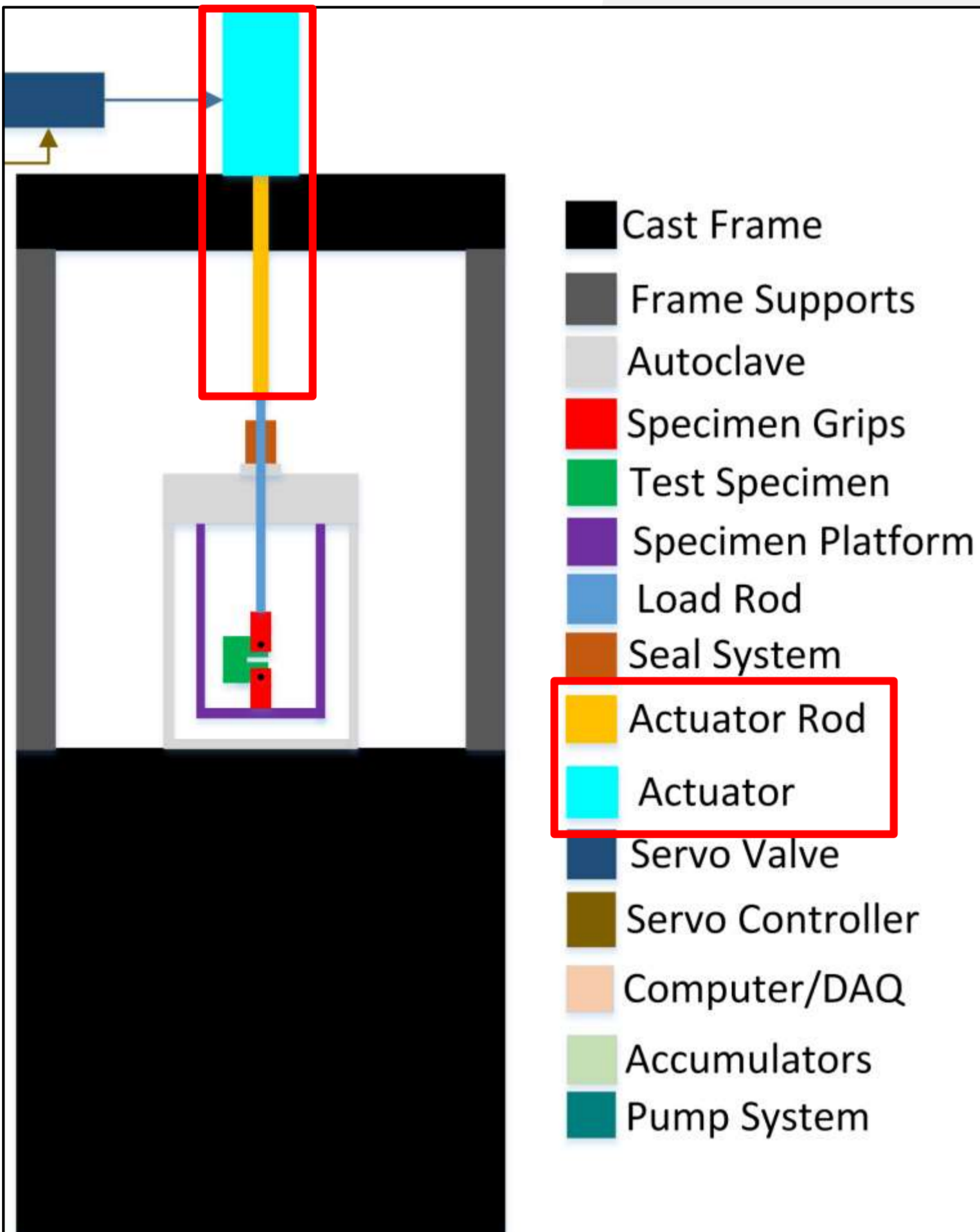
Cost: \$5803.52

✓ This package device is meeting the design specs



# LVDT

The linear variable differential transformer is a position measurement device for linear reciprocation.



## BEST OPTION

The OMEGA LDI-128-350-A010A

- Accommodates 12" Stroke length
- Contactless measurement
- Accurately measures linear displacement

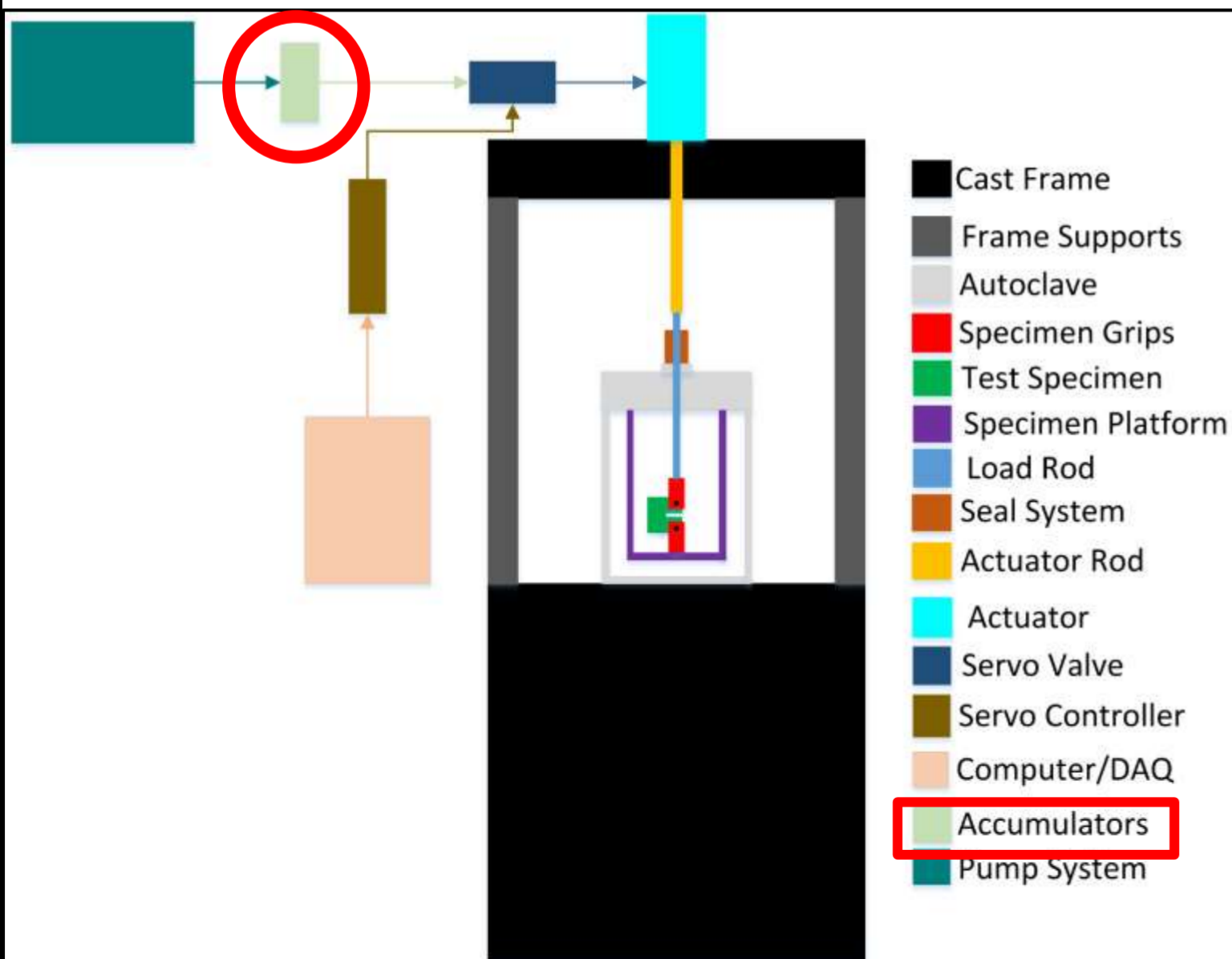


Cost: \$1,230.00

✓ Meets ideal product specifications

# ACCUMULATORS

The accumulators provide a buffer in the hydraulic fluid line. They are designed to absorb pressure fluctuations.



## BEST OPTION

Parker steel piston accumulator:

- Least expensive option
- Rated to 3000 psi
- Supports flow rates up to 100 gal/min
- Can handle oil temperatures from -20 °F to 165 °F

Cost: \$250.00 (1 pint)  
 \$277.50 (1 quart)  
 ✓ Meets product specifications



## SECONDARY

Parker steel bladder accumulator

- Supports a higher range (-20 °F - 200 °F) of oil temperatures
- Same as the system currently in use

Cost: \$729.00  
 ✓ Meets product specifications





# AUTOCLAVE COMPONENTS

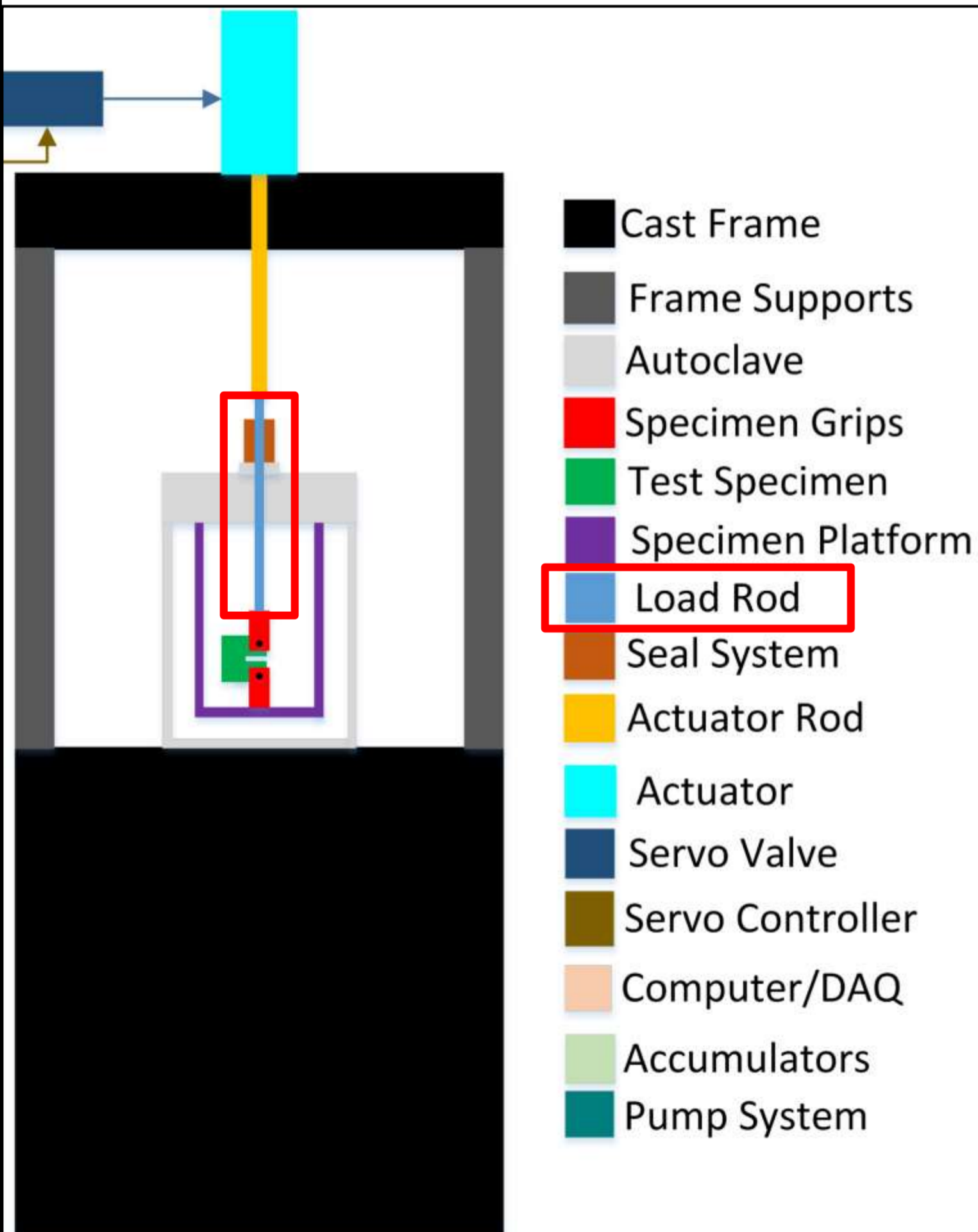
## COMPONENTS

- Load Rod
- Autoclave Seal
- Specimen Platform
- Specimen Grips

These parts mount directly on or inside of the autoclave. They are all going to be manufactured in house.

# LOAD ROD

The load rod transmits the force from the actuator, through the seal into the autoclave, to the specimen. It must be made to survive the harsh environment inside the autoclave.



# BEST OPTION

The Inconel 718 load rod

- $5/8$  inch diameter
- ~12 inches long
- Male thread both ends

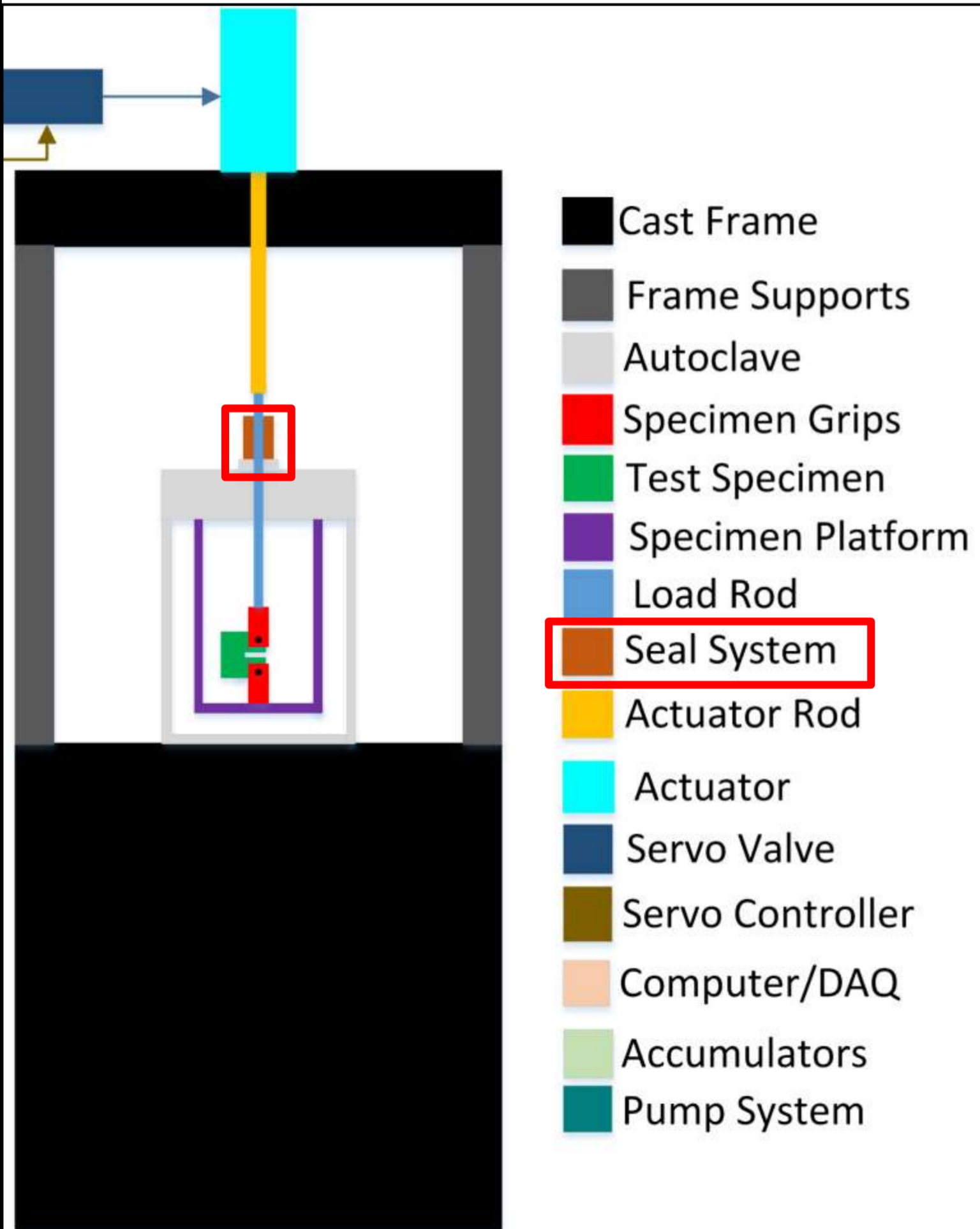


Cost: \$130.00

✓ Meets ideal product specifications

# AUTOCLAVE SEAL

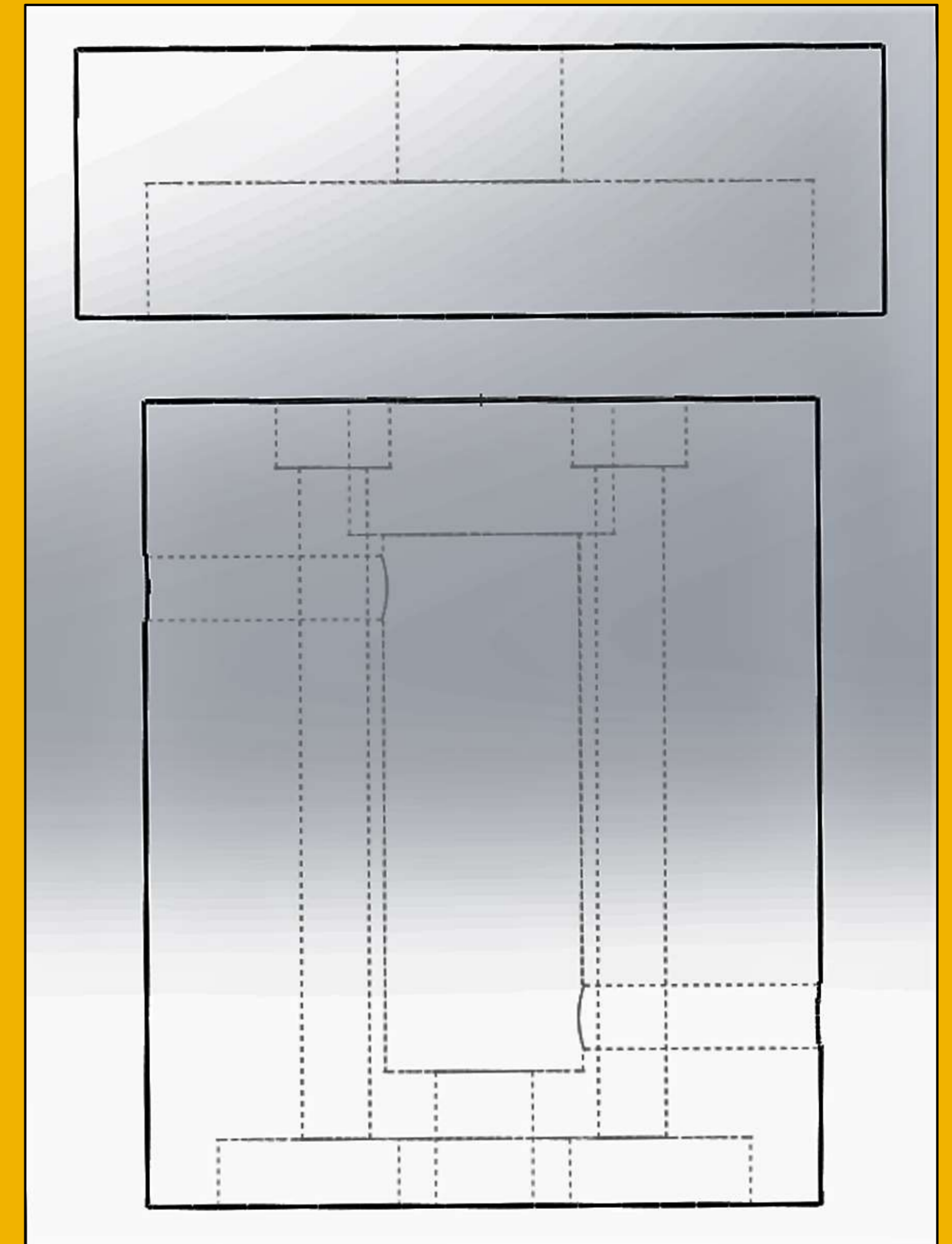
The dynamic seal on the top of the autoclave will allow the load rod to move while containing the environment inside.



## BEST OPTION

The autoclave seal will:

- Allow reciprocating movement
- Contain gas at 4000 psi
- Withstand temperatures of 300°C
- Have integrated cooling system



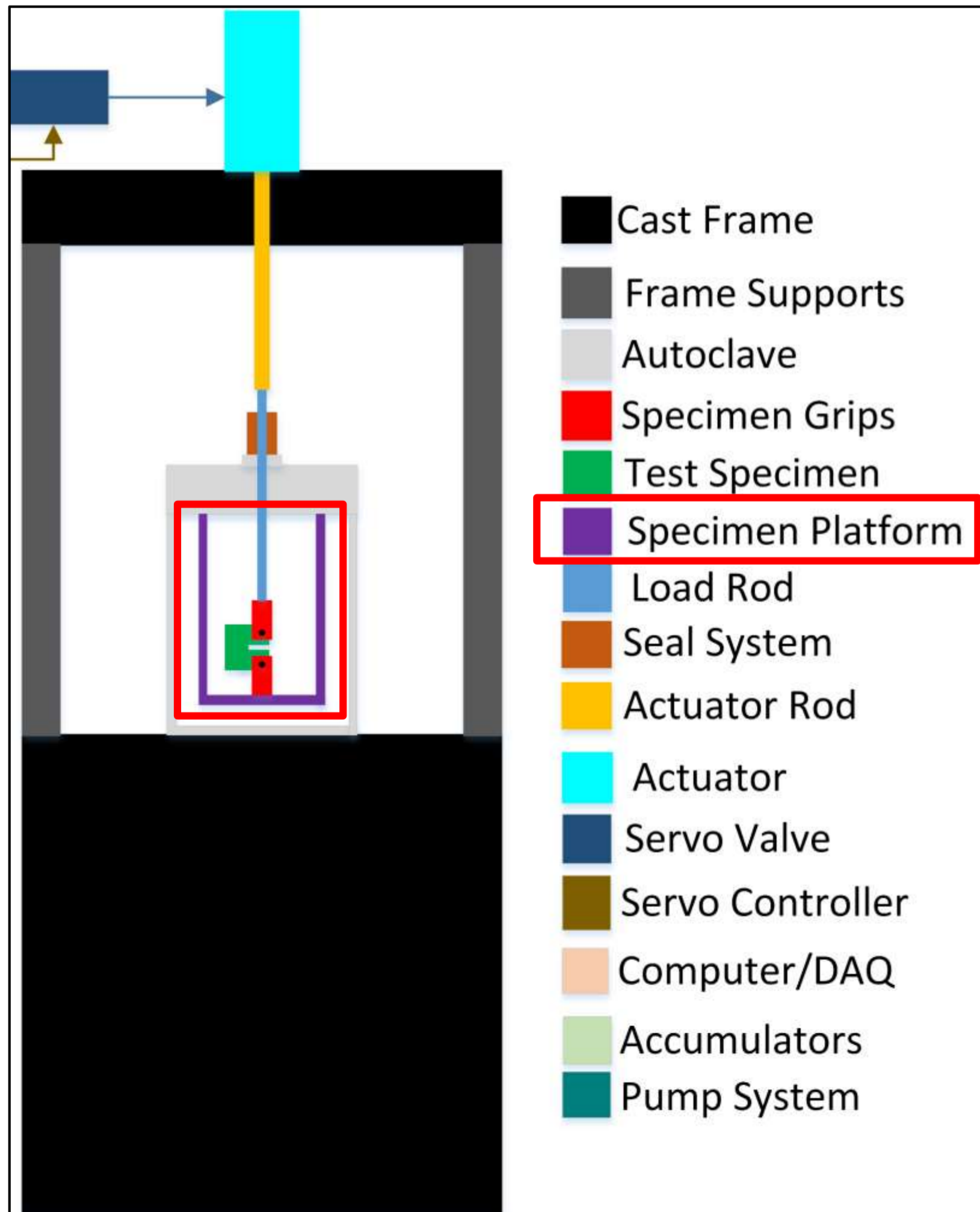
Cost: \$125.00

✓ Meets ideal product specifications



# SPECIMEN PLATFORM

The specimen platform will mount to the bottom of the autoclave lid. It will support the test specimen, and needs to be sturdy enough to handle the test loads.



## BEST OPTION

The specimen platform will consist of:

- Three  $\frac{3}{4}$  inch diameter 316ss rods 7.5 inches long
- One 4 inch X .5 inch circular flat plate
- Total length 8 inch long



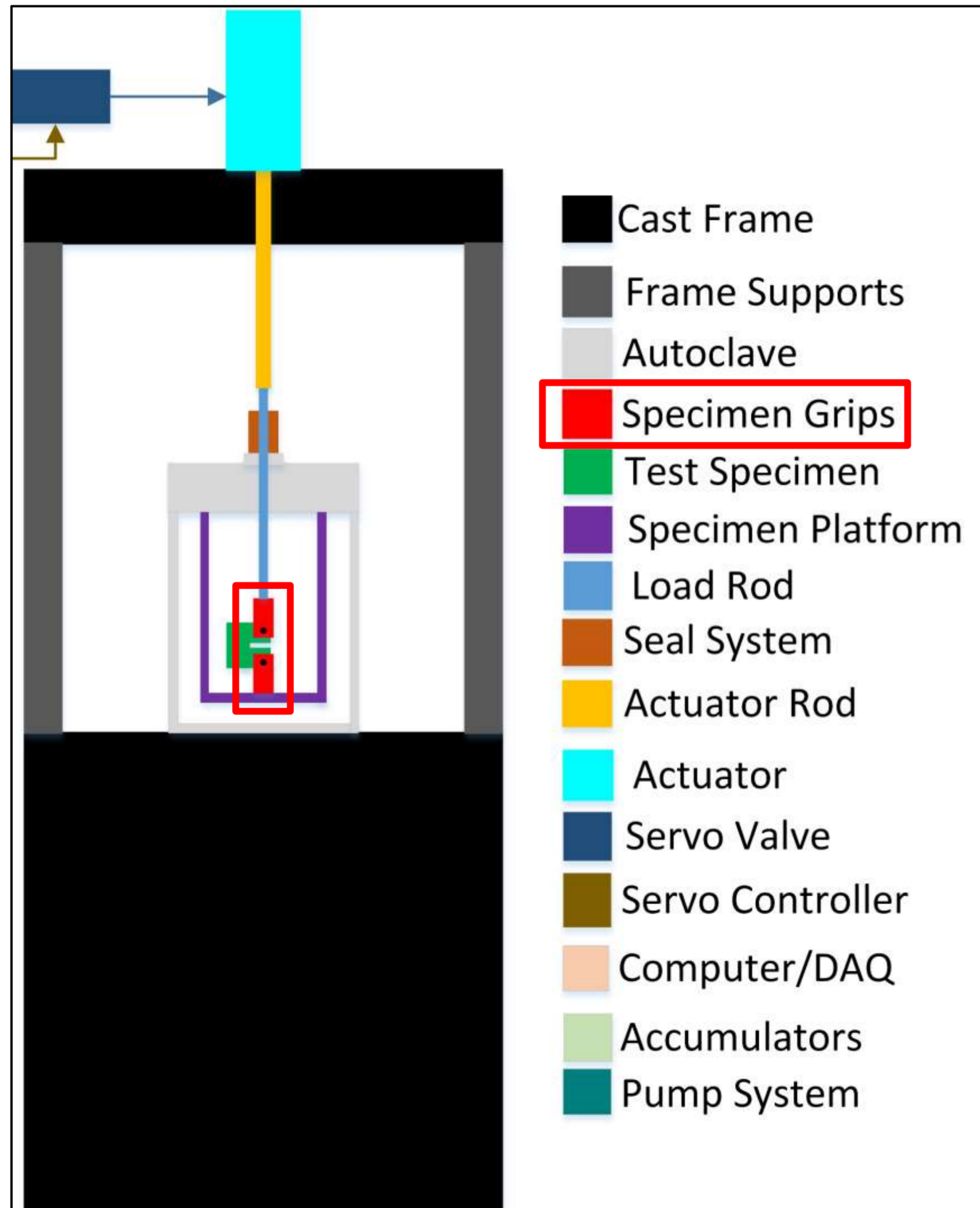
Cost: \$150.00

✓ Meets ideal product specifications



# SPECIMEN GRIPS

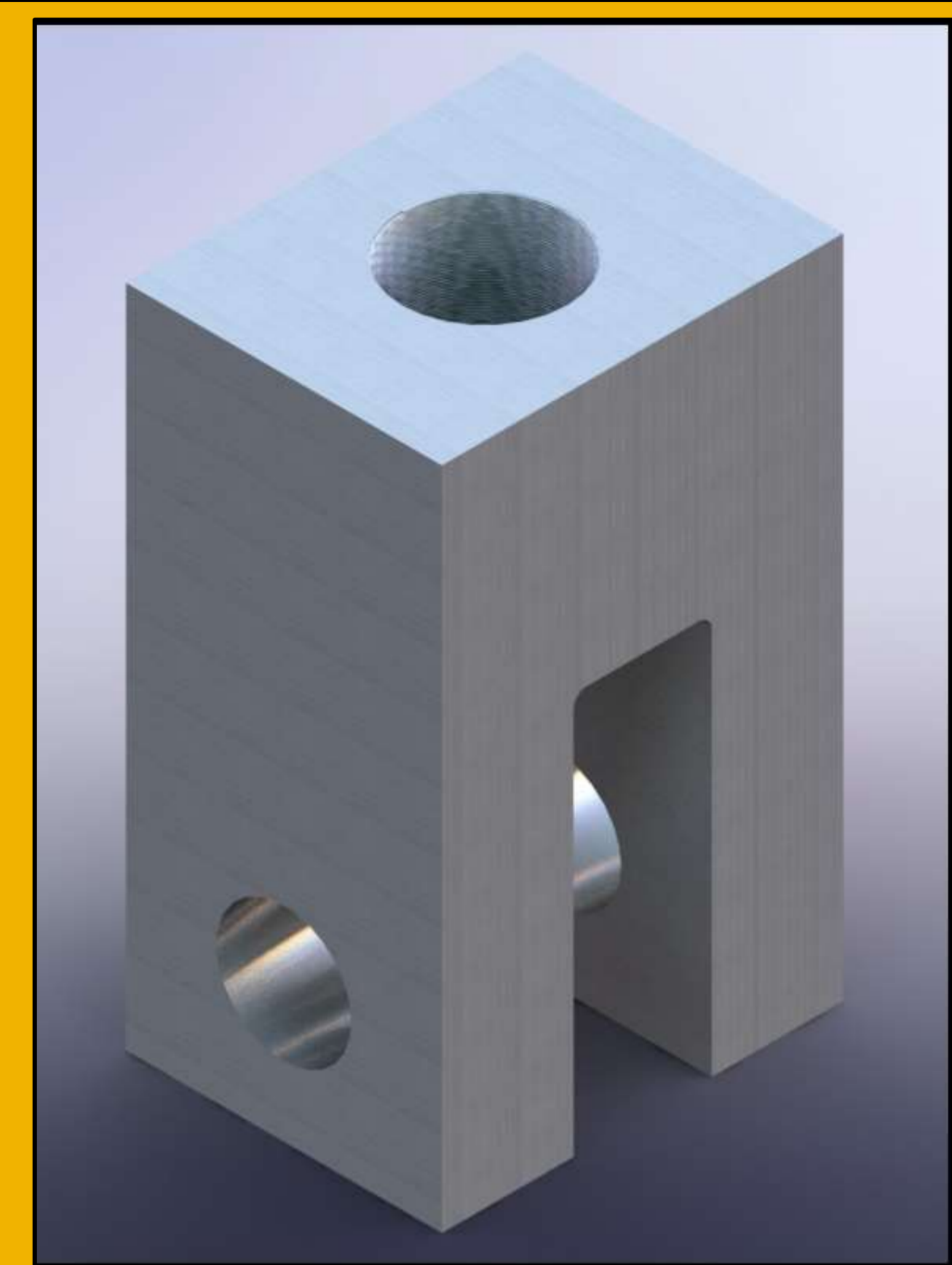
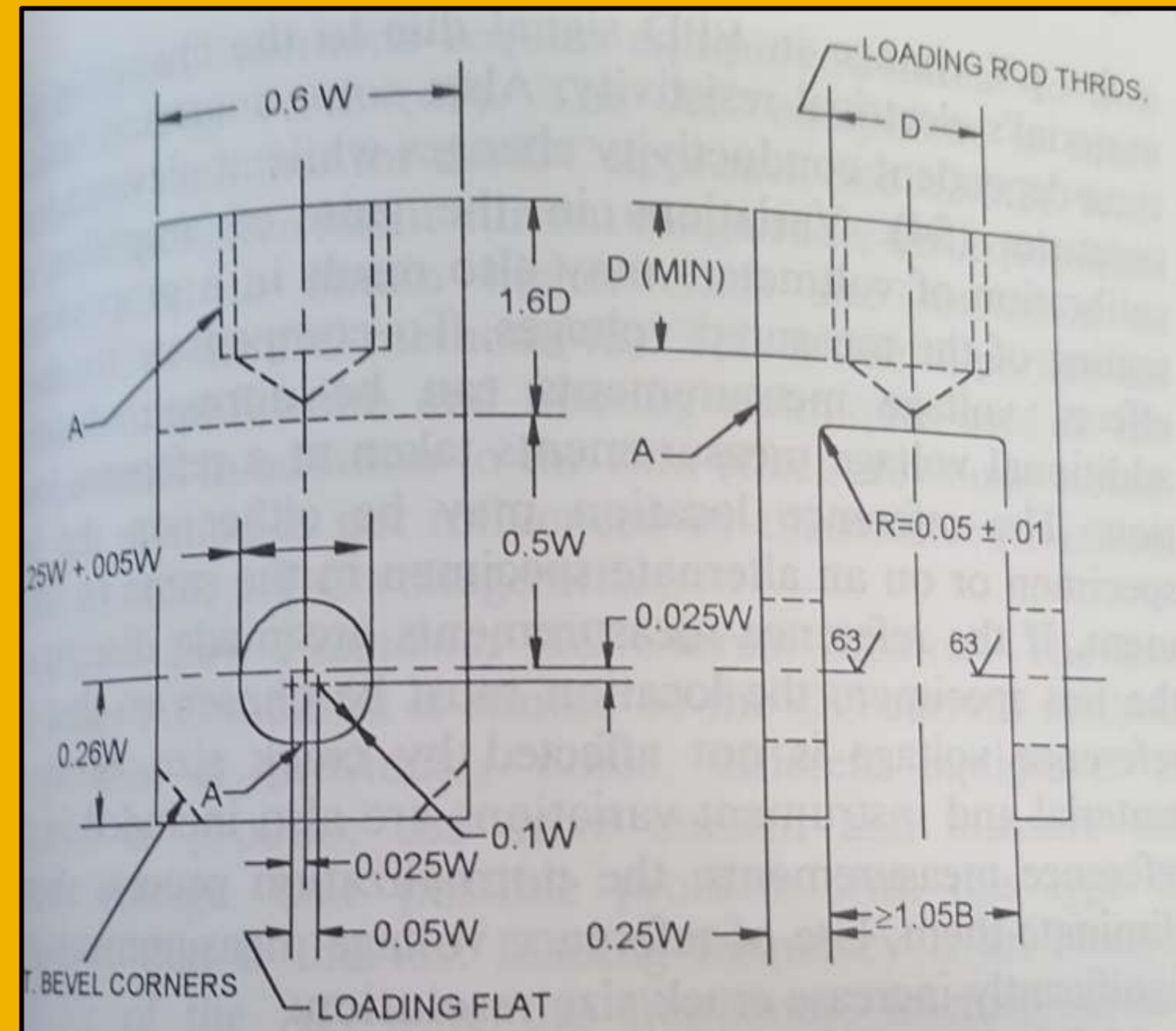
The grips will mount to the specimen platform and the load rod to hold the test specimen.



# BEST OPTION

The grips will be:

- Machined in-house
- Designed for infinite life
- Resistant to corrosion
- Withstand temperatures of 300°C
- ASTM E647 compliant



Cost: \$200.00

✓ Exceeds ideal product specifications

# CONTROL SYSTEM

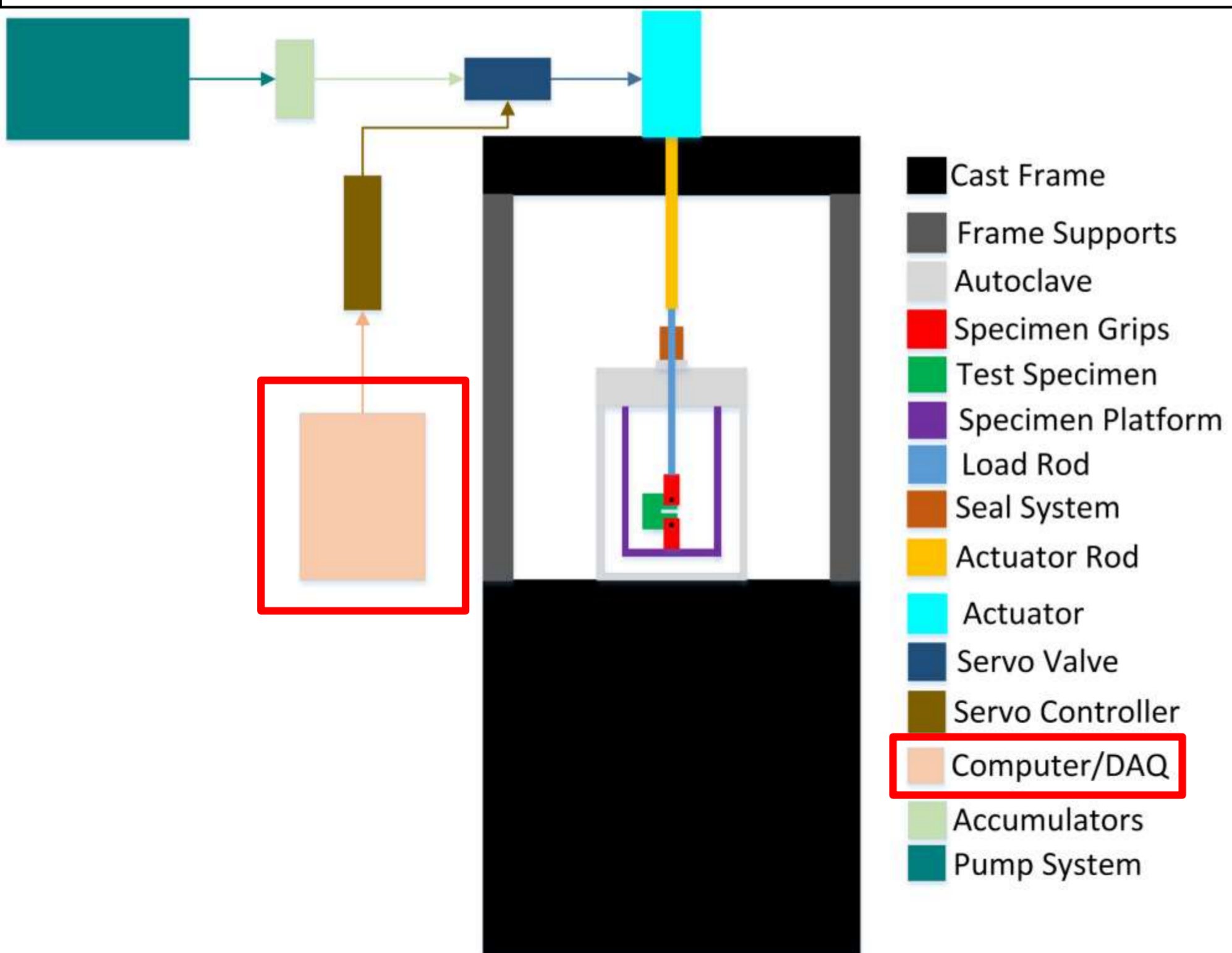
The control system is composed of the electronic inputs and outputs needed to run the load frame and collect test data.

## COMPONENTS

- Computer
- DAQ

# COMPUTER

The computer will be using LabView to control the DAQ. The virtual interface will allow the test operator to control the waveform, and provide monitoring and warnings of excess temperature, pressure, and load.



# BEST OPTION

Dell XPS Tower

- i5-8400, 4.0 GHz, 6 Core Processor
- 8GB, 2666MHz, DDR4 RAM
- 1TB 7200 rpm Hard Drive
- PCI-e expansion slots available



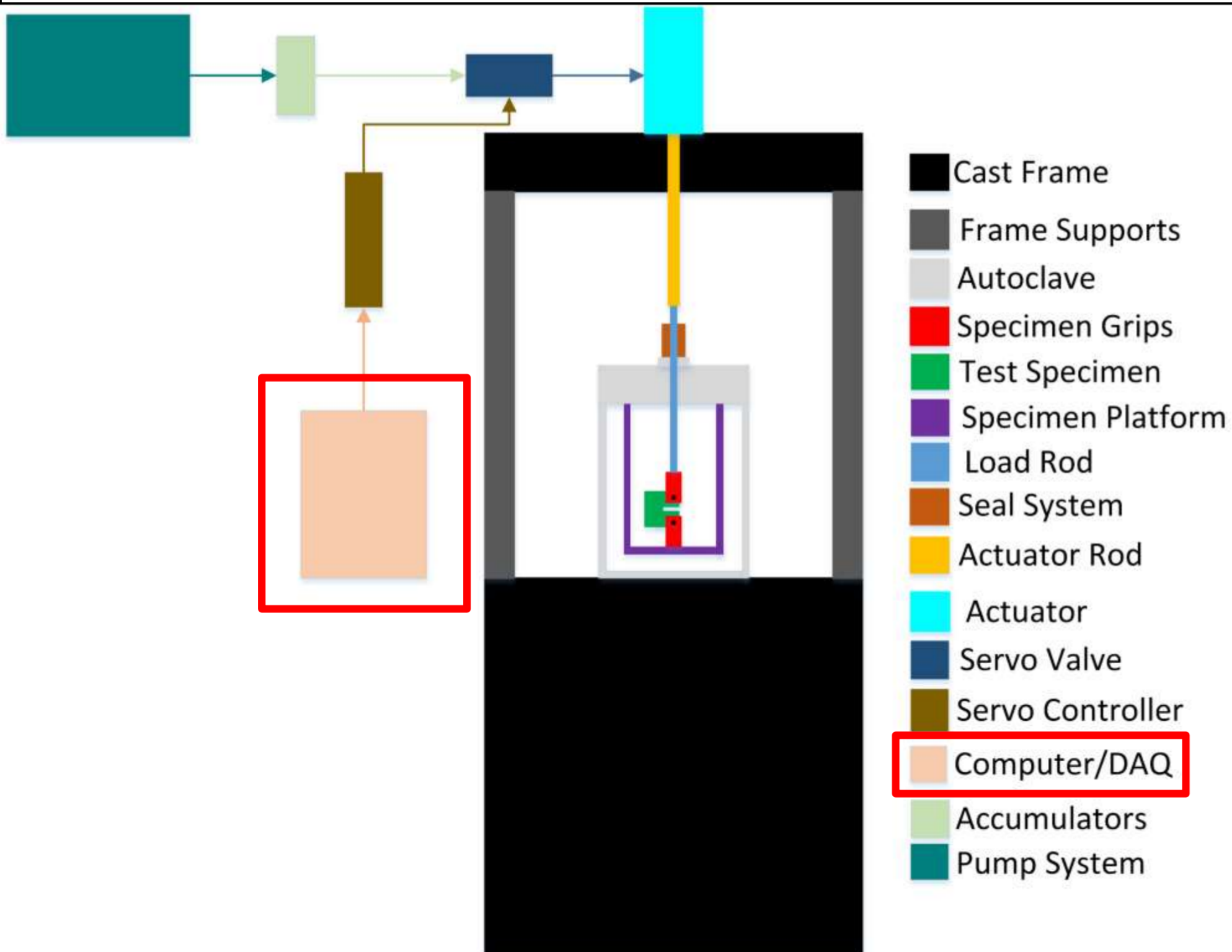
Cost: \$699.99

✓ Exceeds ideal product specifications



# DAQ

The DAQ is the bridge between the computer, mechanical components, and sensors. It takes measurement inputs from the various devices and control outputs from the computer.



## BEST OPTION

### NI PCI-6143 DAQ

- 8 AI, 8 DIO
- 16 bit resolution
- 250 kS/s/ch
- Simultaneous sampling
- Requires separate analog output card (\$400)



Cost: \$400.00

✓ Meets product specifications

## SECONDARY

### NI PCIe-6376 DAQ

- 8 AI, 2 AO, 8 DIO
- 3.57 MS/s/ch

Cost: \$4000.00

✓ Exceeds product specifications





# Gantt chart

<\\files.uidaho.edu\shared\Engineering\SeniorDesign\Senior Design\2018 Summer & Fall\Autoclave Experts\Portfolio\Gantt Chart R3.xlsx>

# Budget Summary

Budget	
Parts	Prices
Actuator	\$1,567.72
Hydraulic Pump	\$1,170.00
Heat Exchanger	\$198.79
Servo Valve	\$1,000.00
Servo Controller	\$40.00
Accumulators(1 Pint)	\$250.00
Accumulators(1 Quart)	\$277.50
Inconel	\$130.00
Autoclave Seal	\$125.00
Specimen Platform	\$150.00
Specimen Grips	\$200.00
Computer	\$699.99
DAQ	\$1,000.00
LVDT	\$1,230.00
Total Cost	\$8,039.00
Available Budget	\$40,000
Budget Remaining	\$31,961



# FUTURE WORK AND CHALLENGES

- Finish pricing and sourcing servo valve & servo controller
- Machining components
- Verify seal design and integrity
- Begin work on LabView UI
- Assemble system and test design integration
- Complete design validation