

# Mechanical Design Process

Transformer Concepts & Applications Seminar  
Goldsboro, NC  
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Brian Brinson  
Senior Mechanical Design Manager

Brian joined Prolec GE Waukesha in April 1999, holding several mechanical design positions of increasing responsibility over the course of his employment. In 2011, he was promoted to a management role with responsibility for the mechanical design group at the Goldsboro, NC facility and assumed additional responsibility for the engineering coordinators in 2015. Brian has a Bachelor of Science Degree in Industrial Supervision from East Carolina University as well as an associate degree in mechanical engineering, drafting and design from Lenoir Community College.

Aaron Tyndall  
Senior Mechanical Engineer

Aaron joined Prolec GE Waukesha in May 2018, as a Mechanical Programmer at the Goldsboro, NC facility. He serves today as a Senior Mechanical Engineer with responsibilities ranging from design automation to engineering solutions. Aaron has a Bachelor of Science Degree in Engineering with Mechanical concentration from East Carolina University.



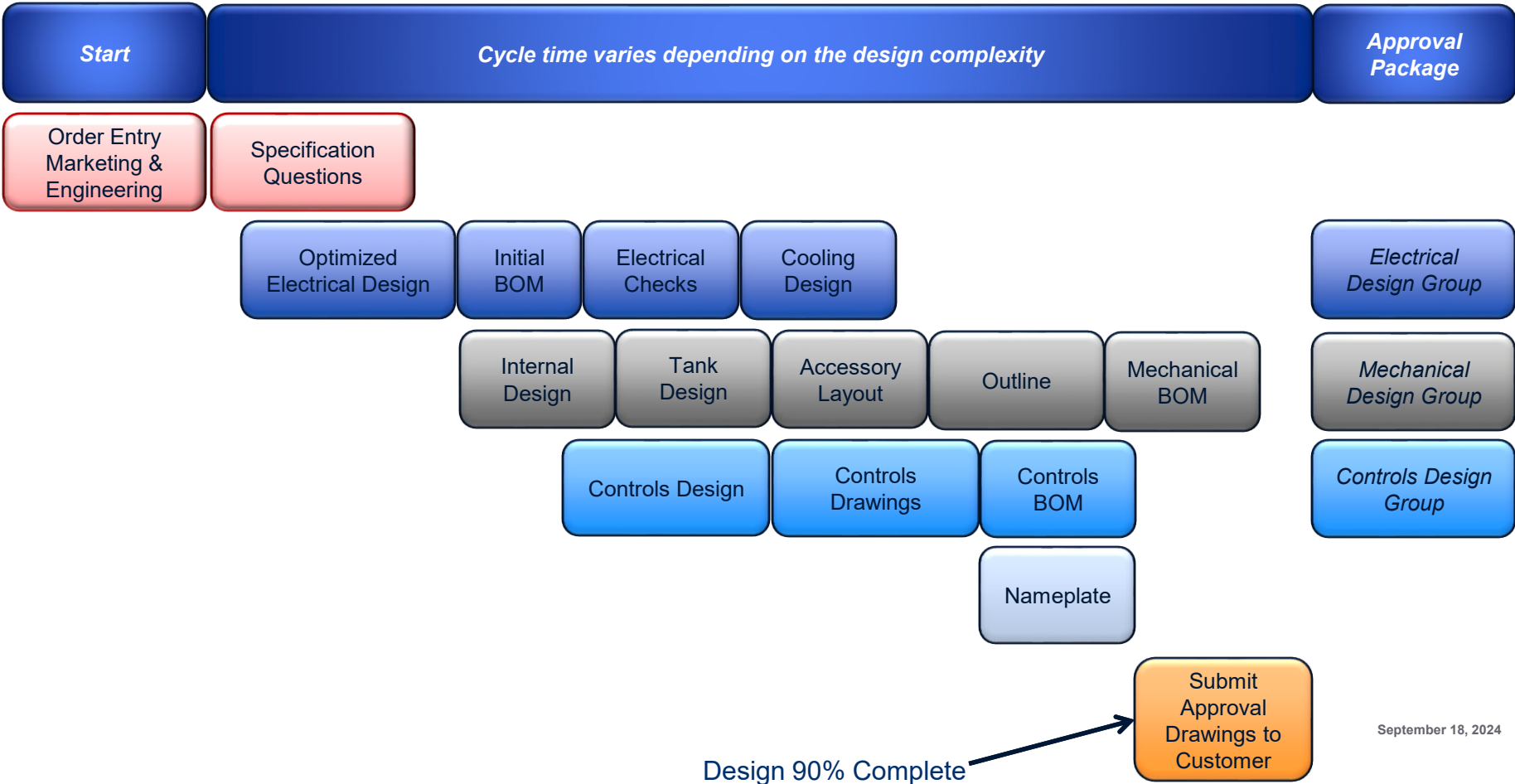


- 1. Design Process Overview**
- 2. Approval Package**
- 3. Design Tools**
  - CAD – Computer Aided Design
  - FEA – Finite Element Analysis
- 4. Mechanical Design**
  - Internal Design Features
  - External Design Features
- 5. Things to Consider**
- 6. Oil Preservation**



# DESIGN PROCESS OVERVIEW

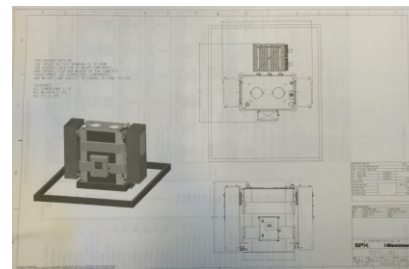
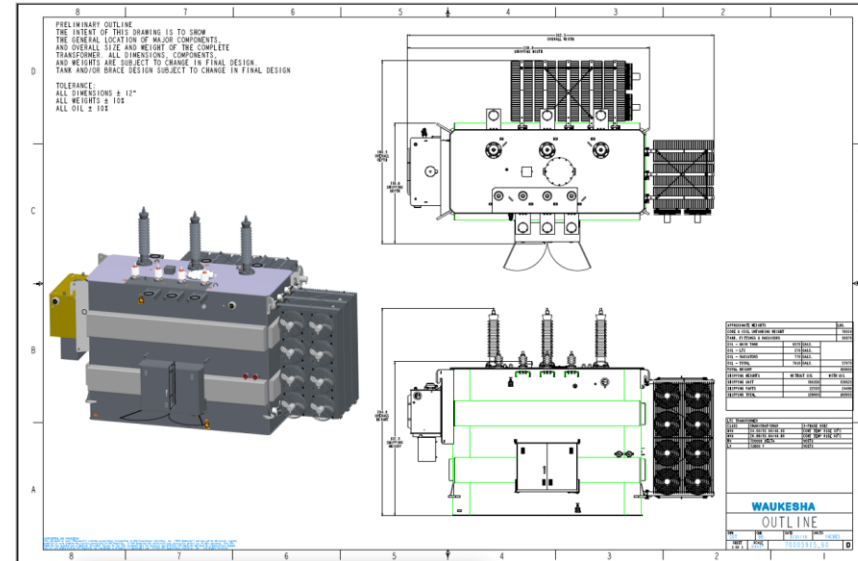
# DESIGN PROCESS



# BID OUTLINES

- Basic layout of transformer with anticipated location of major components only (LTC, radiators, control cabinet, etc.)
- Should not be used for construction purposes, only to give a general idea of what the transformer will look like
- Dimensions provided include overall height, overall width, overall depth, shipping height, shipping width and shipping depth
- Preliminary outlines are reserved for units with strict dimensional requirements ex: retrofit, pad design

Bid and preliminary outlines are by request only as they could take several days to complete.

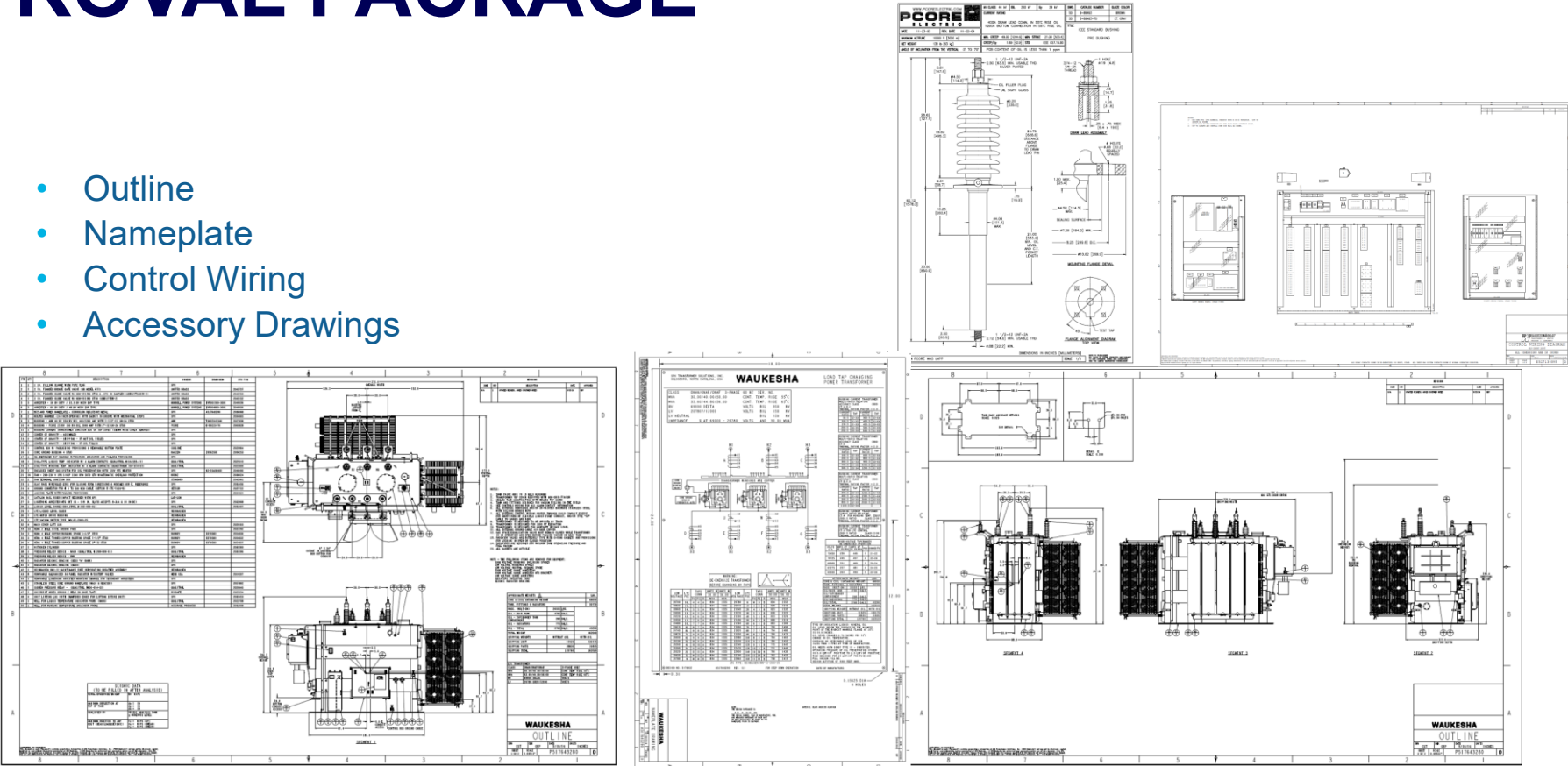




# APPROVAL PACKAGE

# APPROVAL PACKAGE

- Outline
- Nameplate
- Control Wiring
- Accessory Drawings



Typical review period for approval package is 1 week, delaying return beyond planned review period could compromise ship date.



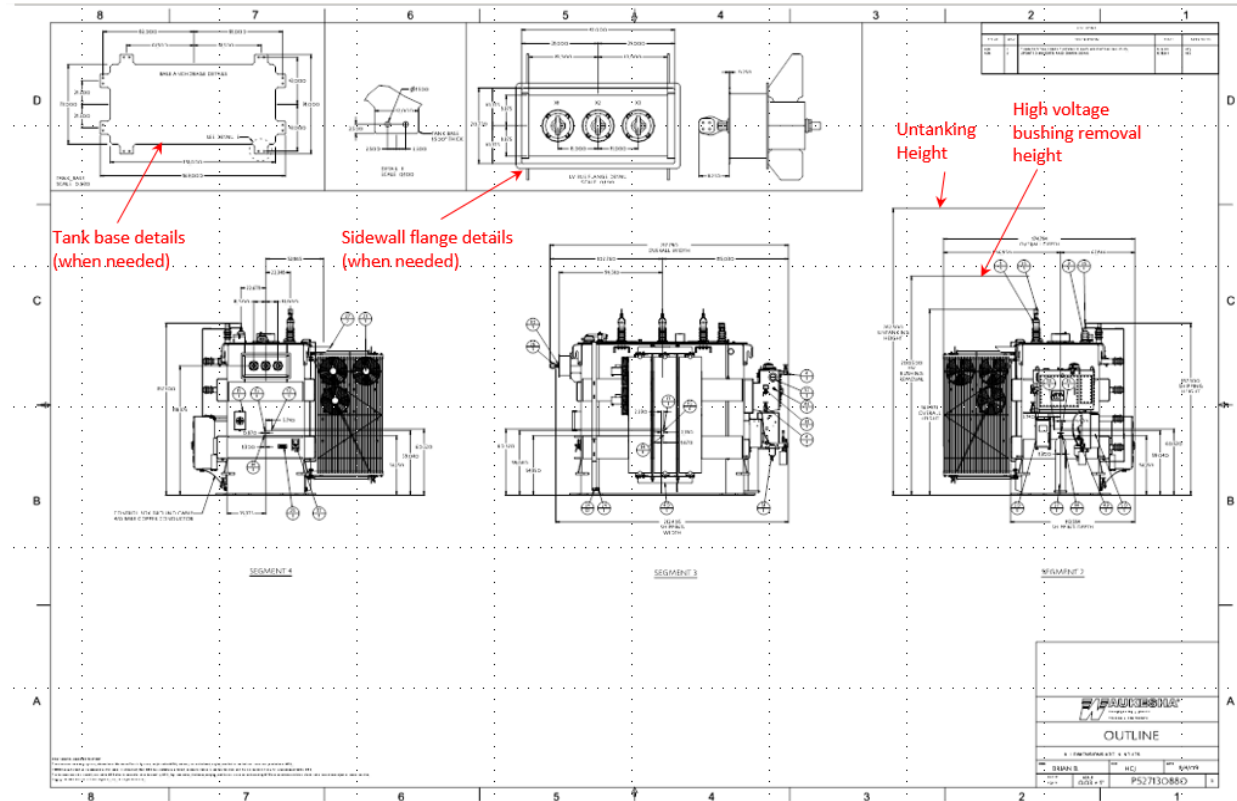
# OUTLINE DRAWING – PG 1

The drawing shows a motor assembly with various components labeled. Annotations include:

- Revisions:** A table in the top right corner listing changes to the drawing.
- Notes and items to be removed for shipment:** A list of specific items to be excluded from the final shipment.
- Weights and Oil Volumes:** A table detailing the weight and oil volume for different parts of the motor.
- Shipping weights with and without oil:** A table providing shipping information for the motor with and without oil.
- Design Information:** A section containing technical specifications and design notes.
- Customer Information:** A section containing customer-specific details.
- Item # and Qty:** A circular stamp indicating the item number and quantity.
- Vendor Drawing Number:** A label pointing to a specific part in the drawing.
- Part Number:** A label pointing to a specific part in the drawing.
- Detailed description of major components or accessories:** A table providing detailed descriptions of the major components and accessories.
- Vendor:** A label pointing to the vendor information in the drawing.
- Balloons are tied to table:** A label pointing to the balloons used to tie the drawing to the table.

Special requirements should be noted at quote stage not at approvals, changes to requirements at approval stage may impact price and delivery.

# OUTLINE DRAWING – PG 2



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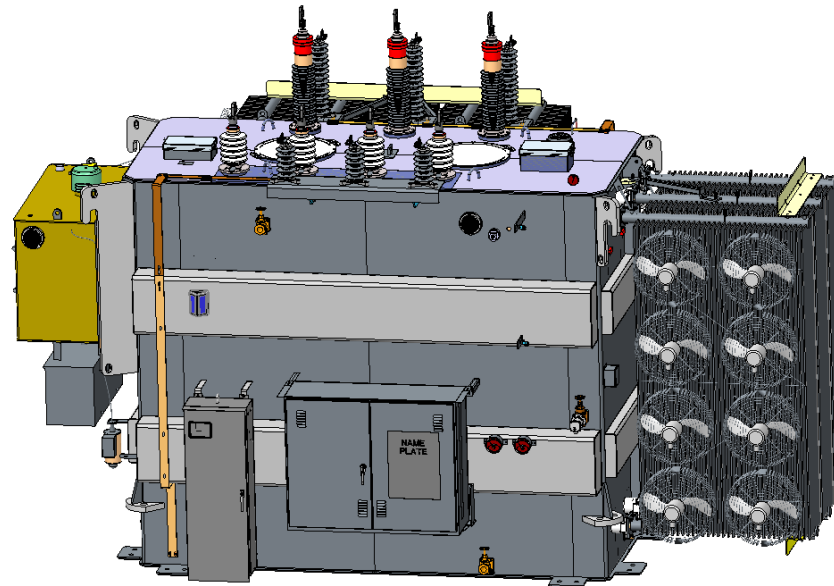
# DESIGN TOOLS

# COMPUTER AIDED DESIGN (CAD)

## Model Based Drawings vs. Traditional 2D Drawings

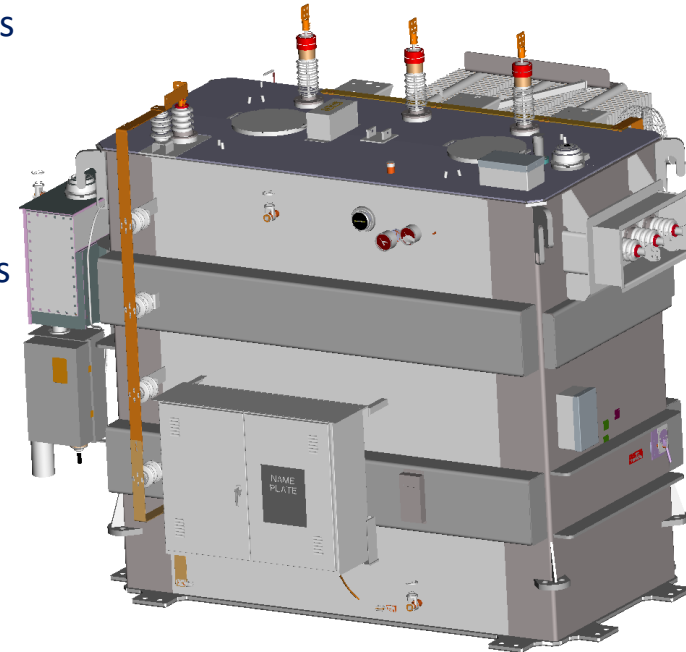
### Advantages:

- Parts and drawings created at 1:1 scale
- Ability to visually check fitment
- Sheet metal parts cut directly from models
- Ability to create drawings quickly
- Accuracy of drawing views
- Items ballooned automatically
- Balloon legend on drawings
- Parametric drawing views
- Parametric dimensions
- Preset view orientations linked to model
- Allows automation of common part details



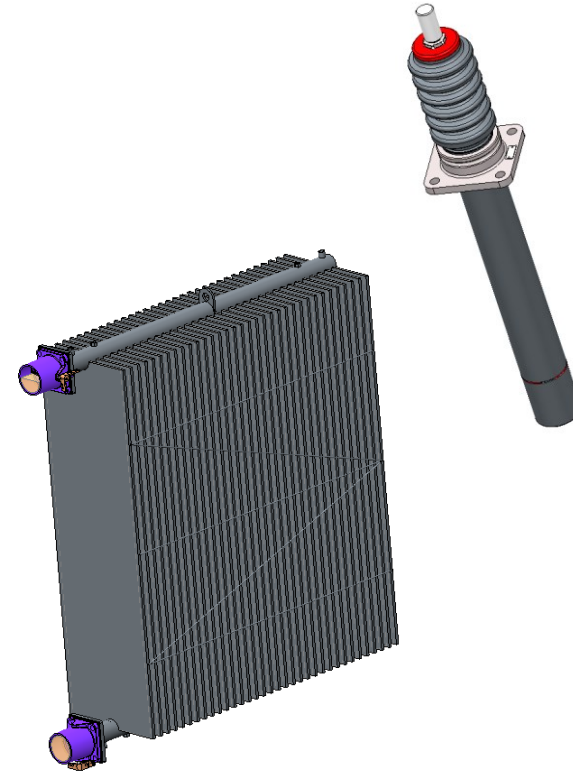
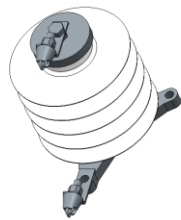
# PARAMETRIC MODELS

- Core, coils, and accessory specifications from design engineers are used by the mechanical design team to build the model; utilizing existing, proven mechanical design programs
- Model reflects proven, producible designs
- Contain standard pre-designed transformer options/variations
- Customizable to meet customer specifications
- Contain material properties to provide weights and center of gravity
- Assembled from parts which carry plant level bill of material (BOM) attributes; model drives BOM



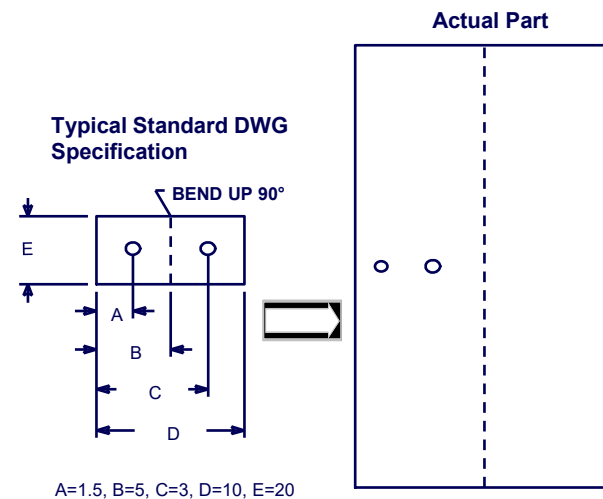
# STANDARD PARTS LIBRARIES

- Save time by modeling parts once
- Error reduction on purchased parts
- Electronic pick list of common parts
- Part data associated with models
  - Waukesha part number
  - Manufacturing data
  - Component description
  - Weight



Some suppliers have 3D CAD models saving us from having to remodel these parts.

# MANUFACTURING DOCUMENTATION



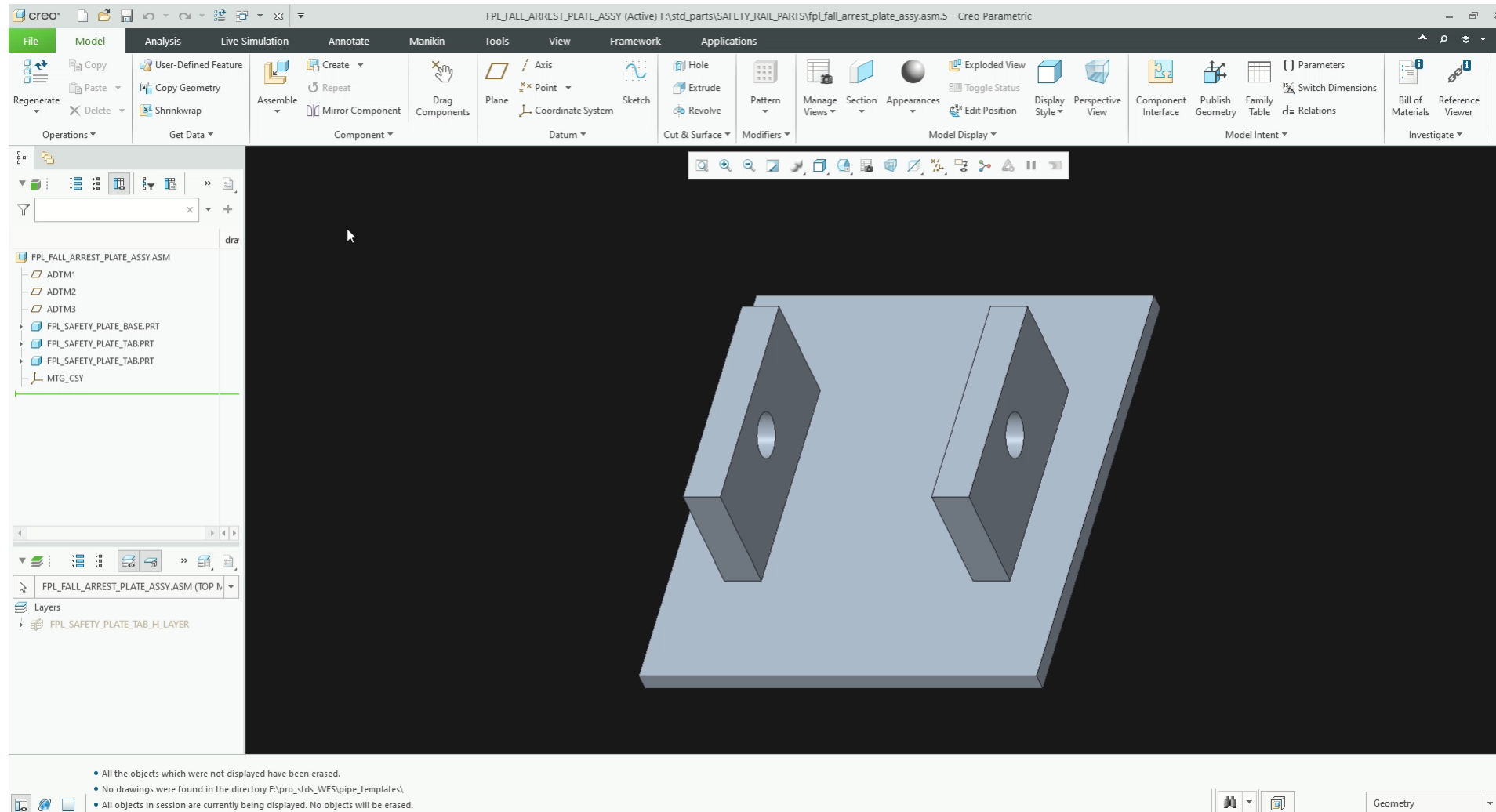
Example of perception problem

## Model Based – Shop Drawings

- All job specific parts made are shown true to scale, eliminating perception problems
- Parts and assemblies are detailed for plant level processes
- Pre-programmed drawings that reflect the standard model improve consistency and accuracy
- Drawing details customizable to reflect changes not pre-programmed
- Key BOM information displayed on drawings eliminates constant cross referencing

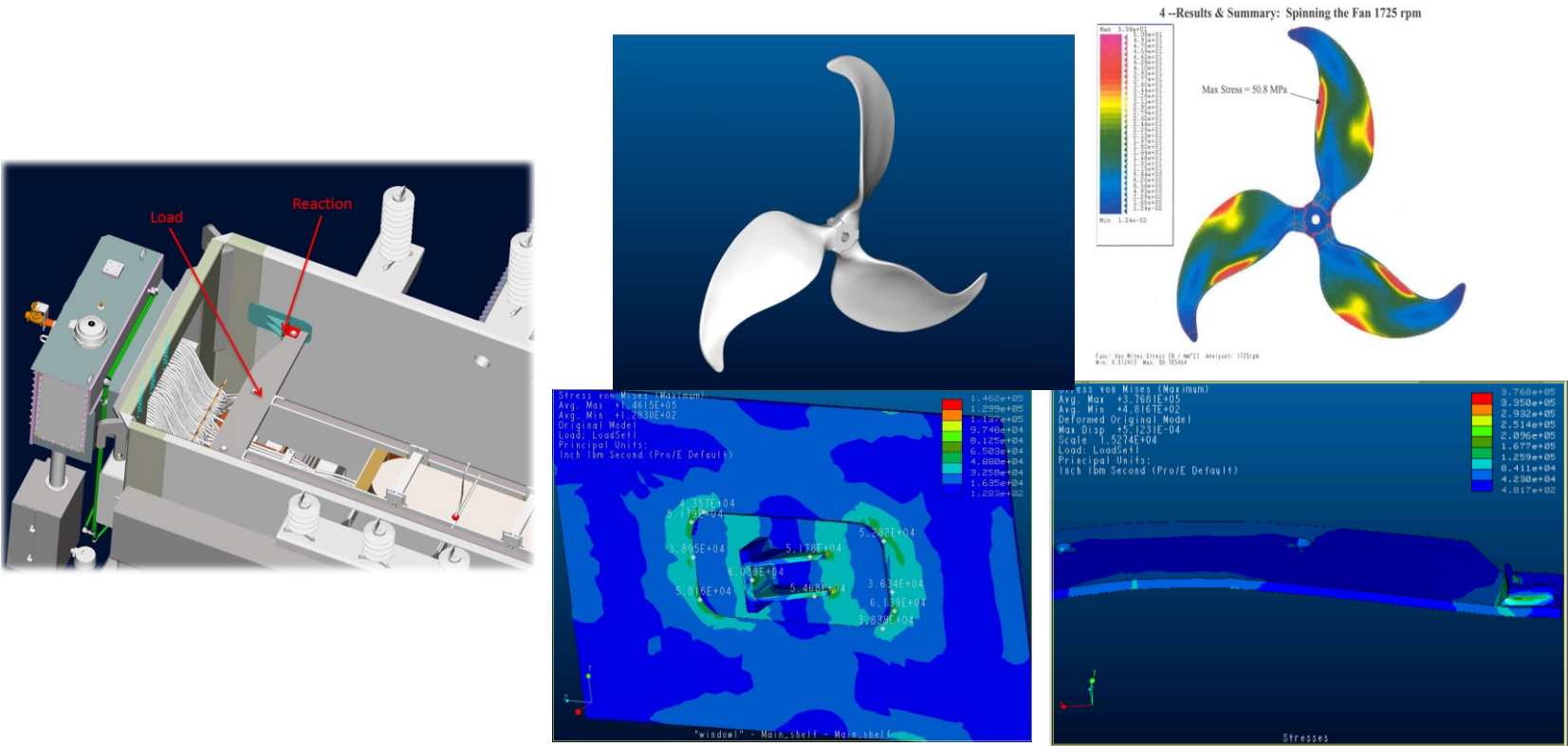
We can utilize computers with the 3D CAD models on the shop floor to further improve visualization.

# SAMPLE DRAWING VIDEO





# FINITE ELEMENT ANALYSIS



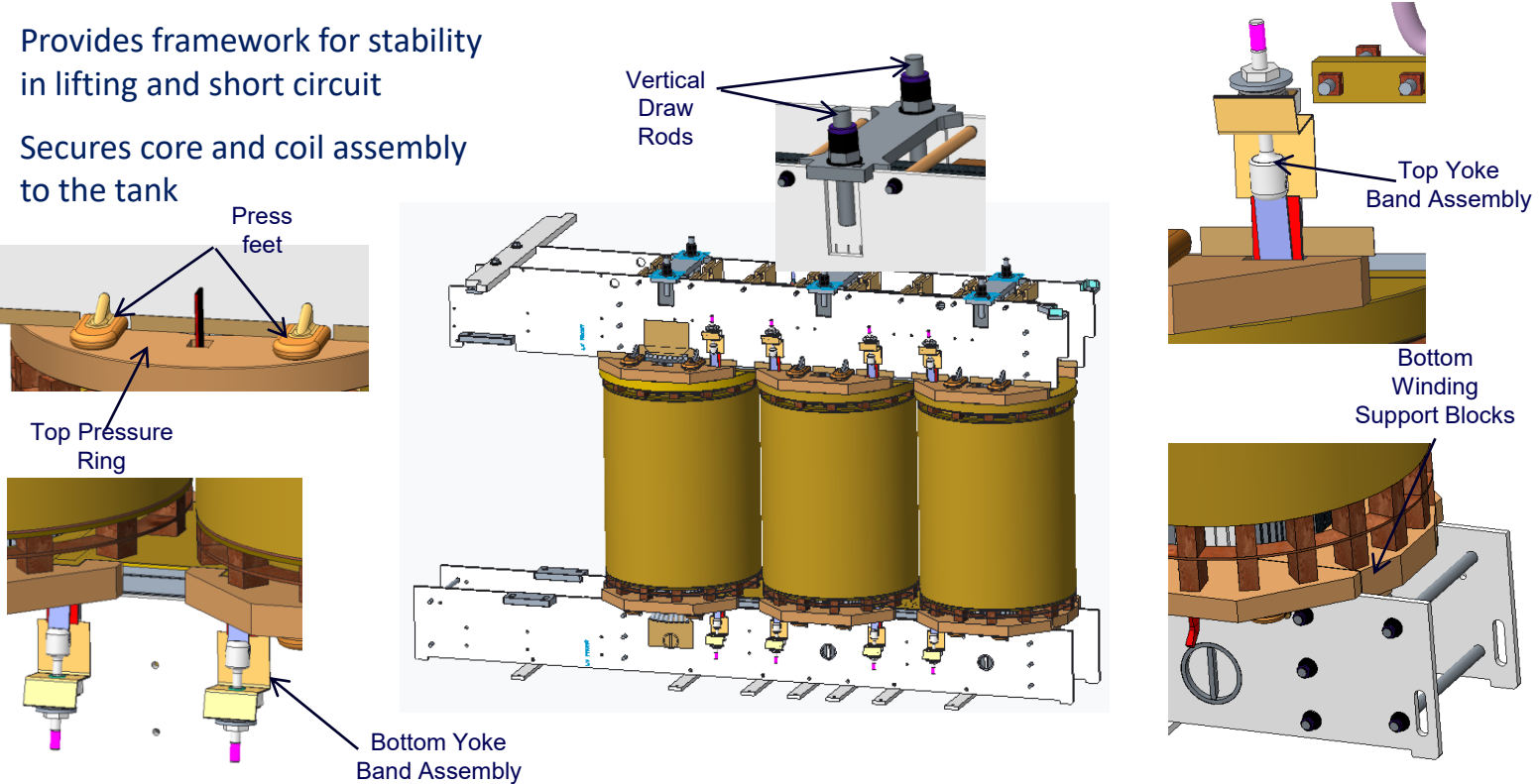
Utilizing our CAD models and FEA packages we can analyze our designs to establish design standards.

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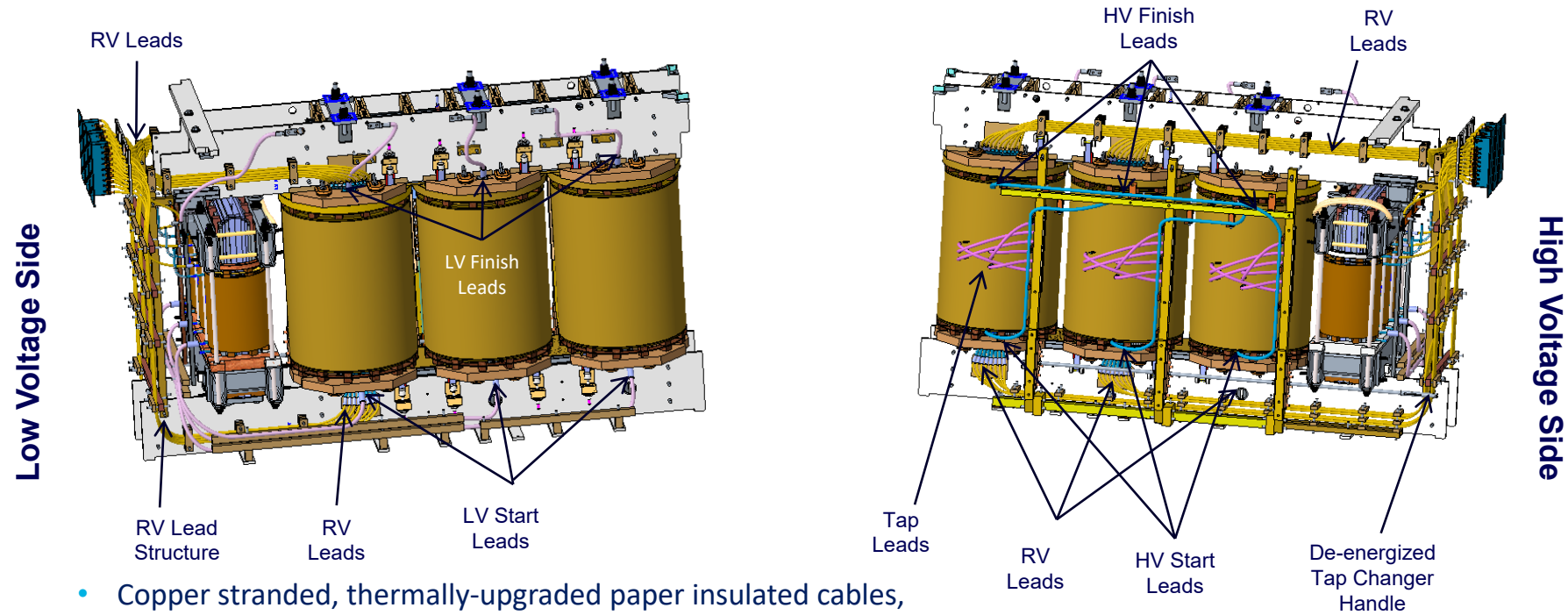
# MECHANICAL DESIGN

# INTERNALS: ADJUSTABLE FLAT CLAMP

- Provides framework for stability in lifting and short circuit
- Secures core and coil assembly to the tank

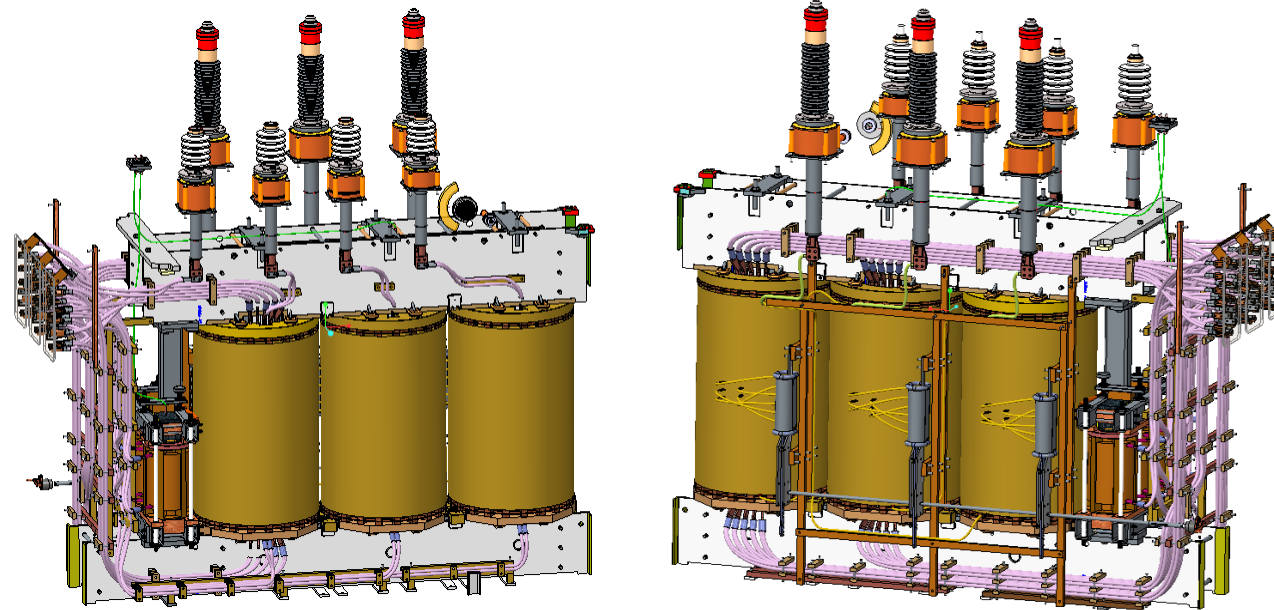


# INTERNALS: ADJUSTABLE FLAT CLAMP



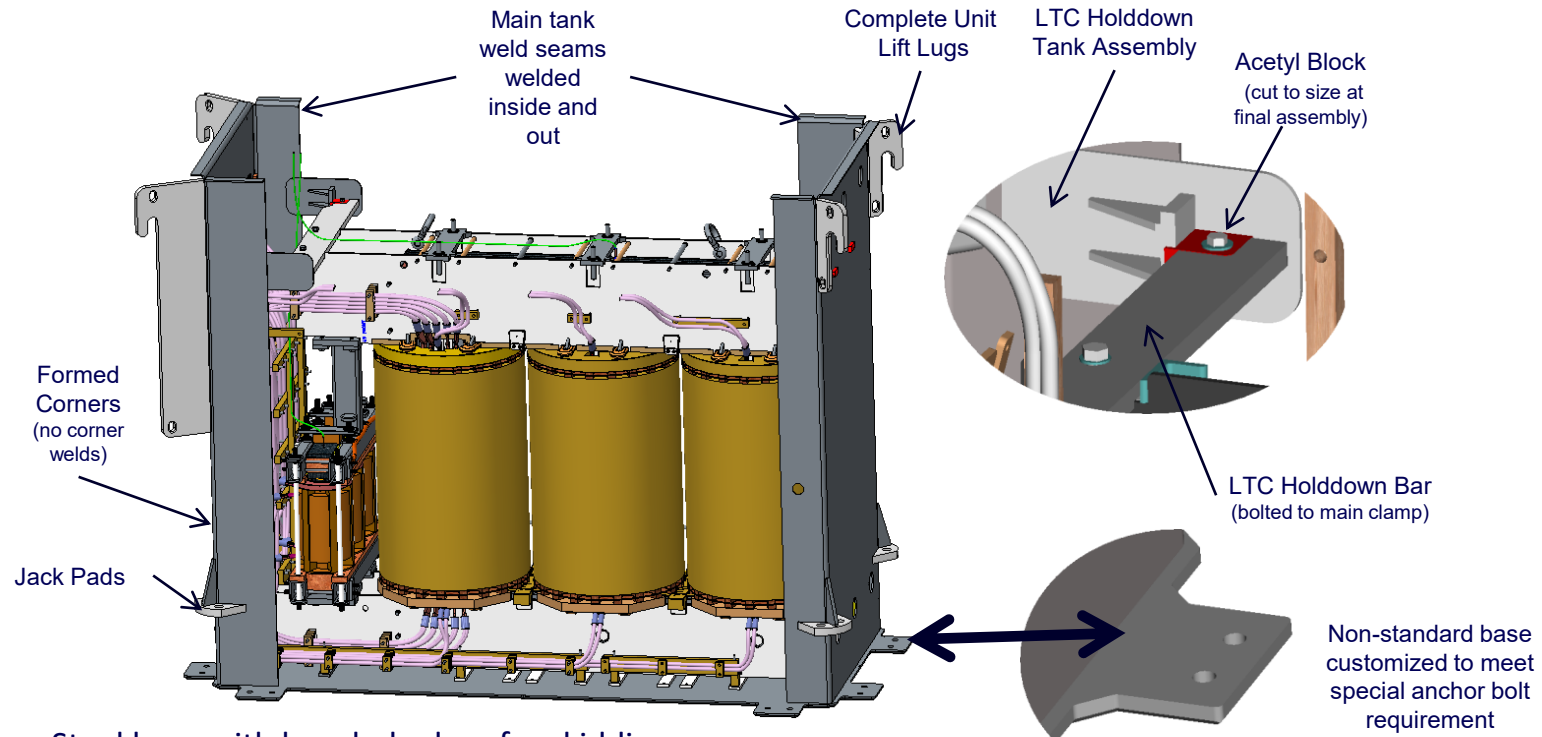
- Copper stranded, thermally-upgraded paper insulated cables, secured for short circuit forces
- Insulation and clearances vary depending on the voltage

# INTERNAL WIRING



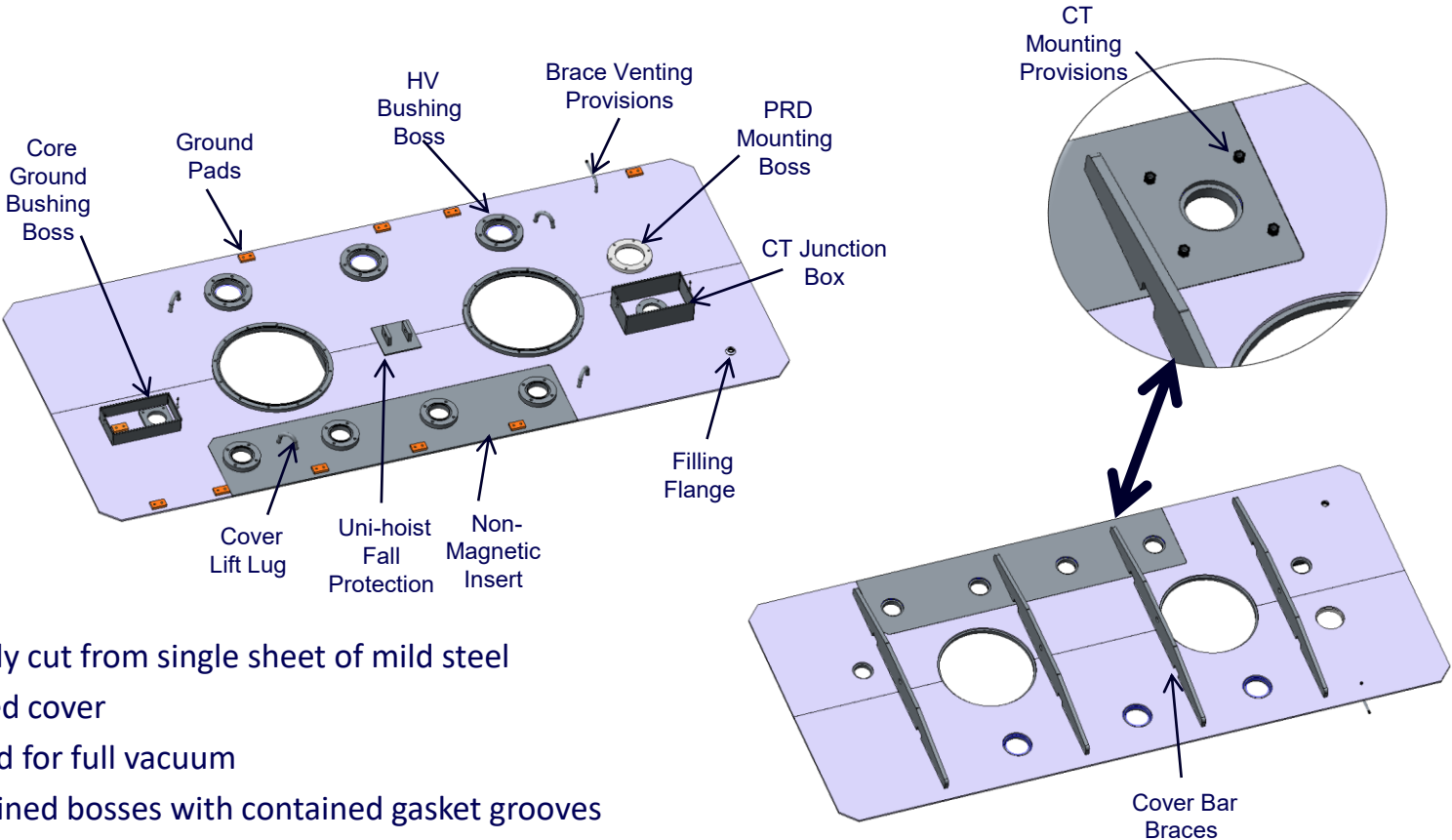
- Simplified representations of complete transformer for routing of cables and checking clearances
- Cables routed in Pro/E allow for accurate support structures, correct cable lengths with minimal waste, and enable designers to verify electrical clearances

# TANK END WALLS AND BASE



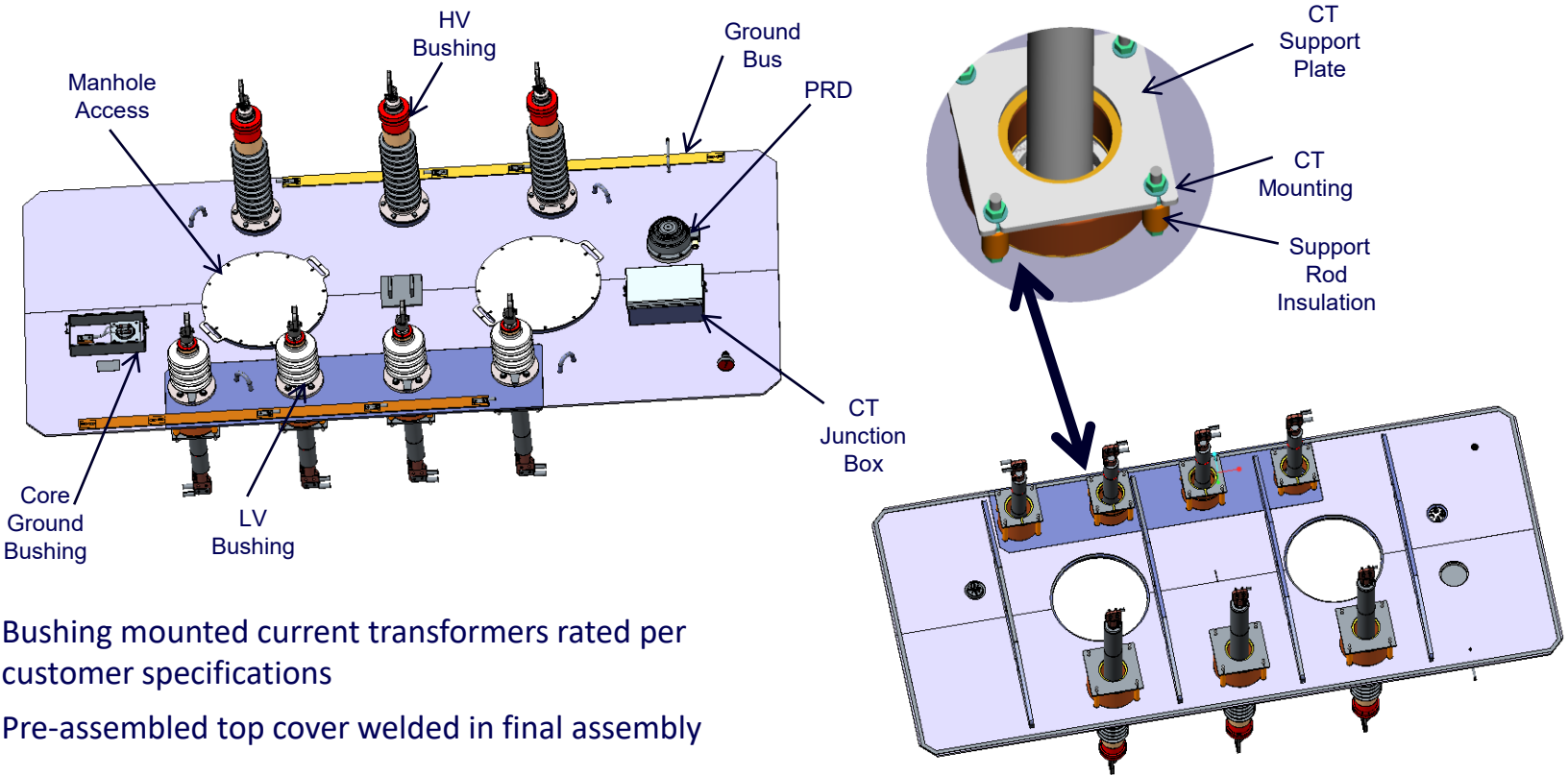
- Steel base with beveled edges for skidding
- End wall assemblies welded to base

# TOP COVER



- Usually cut from single sheet of mild steel
- Domed cover
- Braced for full vacuum
- Machined bosses with contained gasket grooves

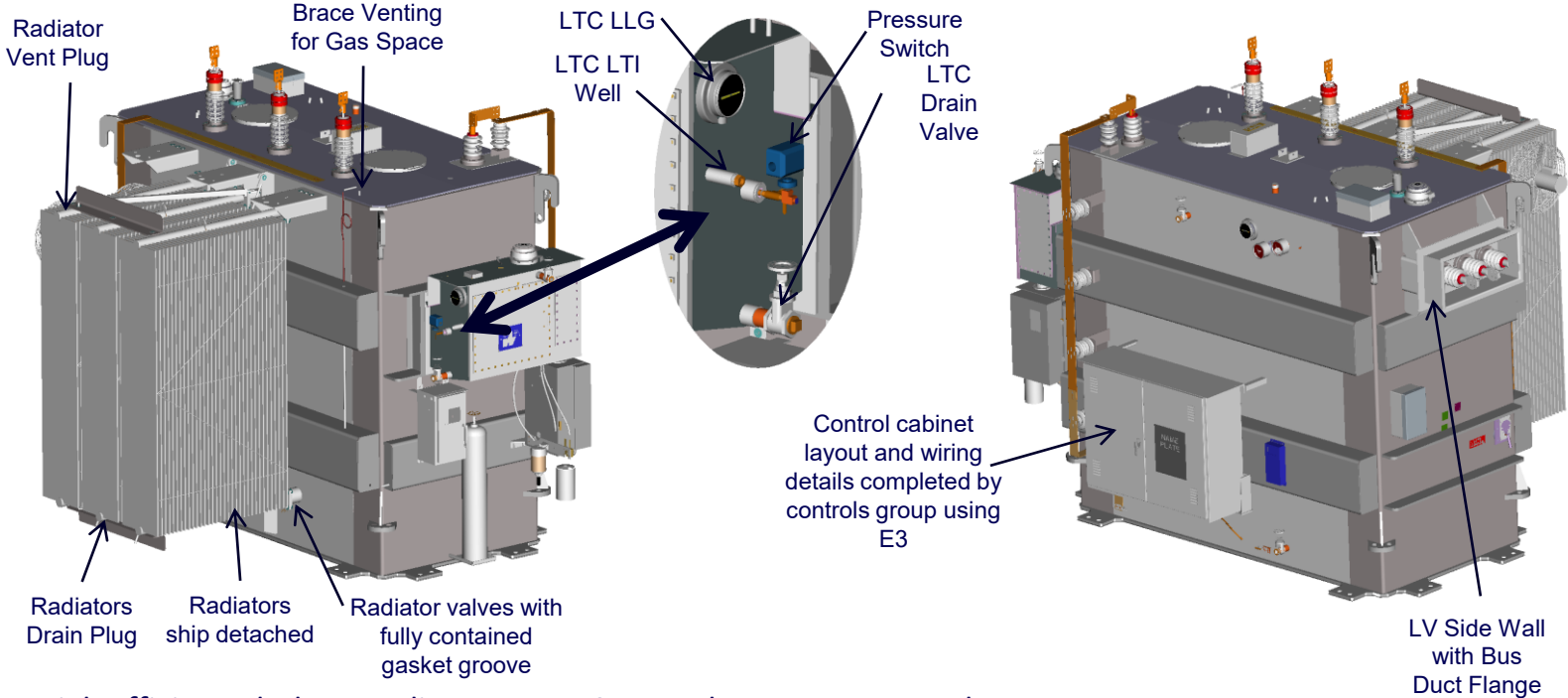
# TOP COVER ASSEMBLY



- Bushing mounted current transformers rated per customer specifications
- Pre-assembled top cover welded in final assembly

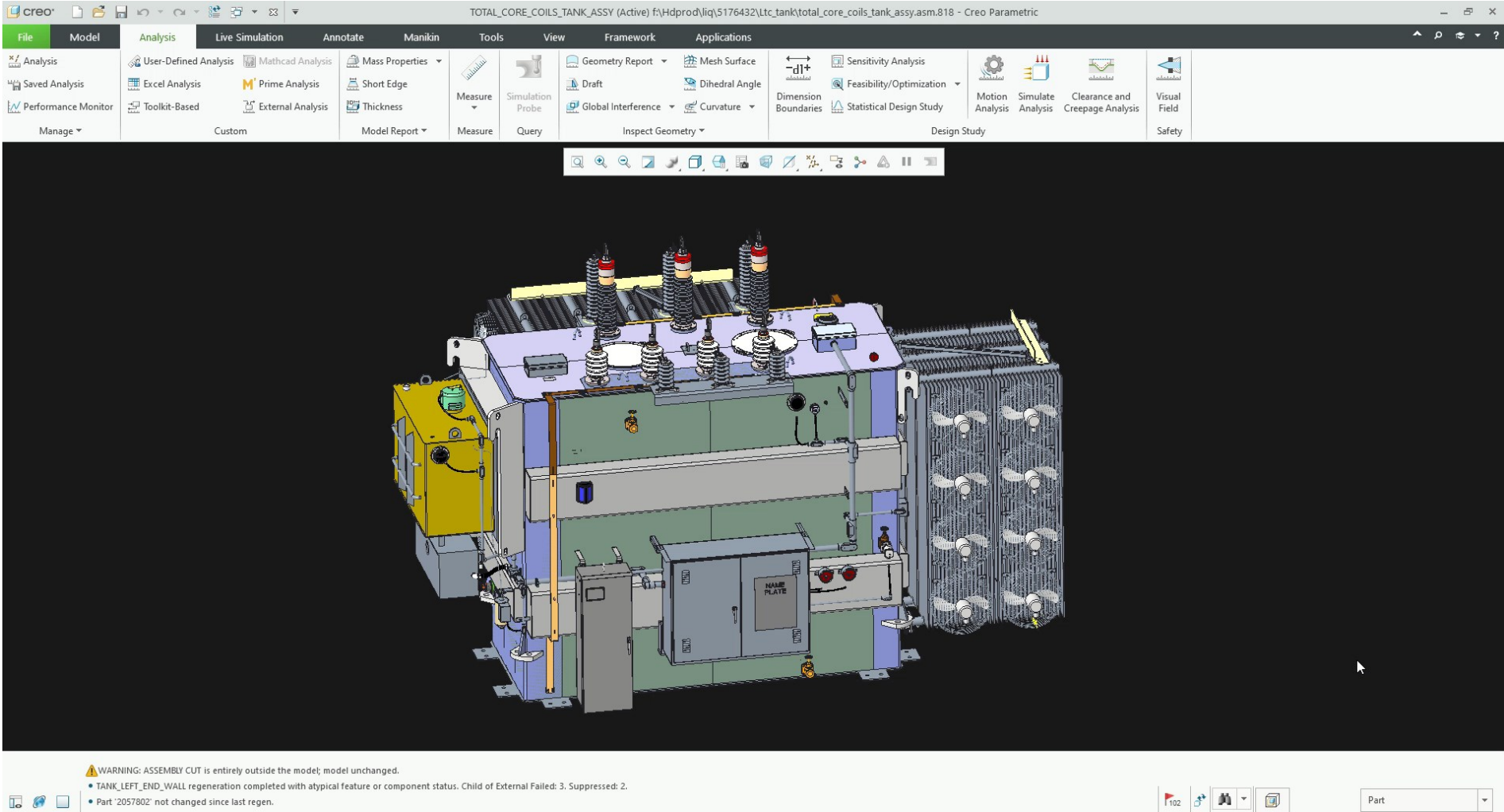


# COMPLETE TANK ASSEMBLY



- High efficiency bolt-on radiators 17 or 34 panels or custom panels
- Standard radiators are hot dipped galvanized, equipped with lift lugs and drain/vent plugs

# ASSEMBLY SAMPLE VIDEO



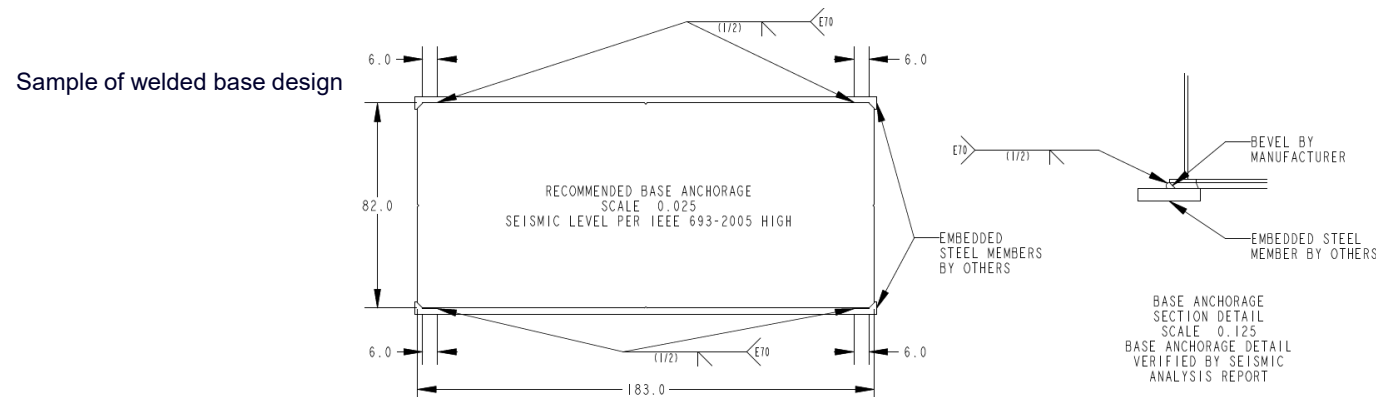


# THINGS TO CONSIDER

# THINGS TO CONSIDER: SEISMIC

## Do you need your transformer designed for seismic?

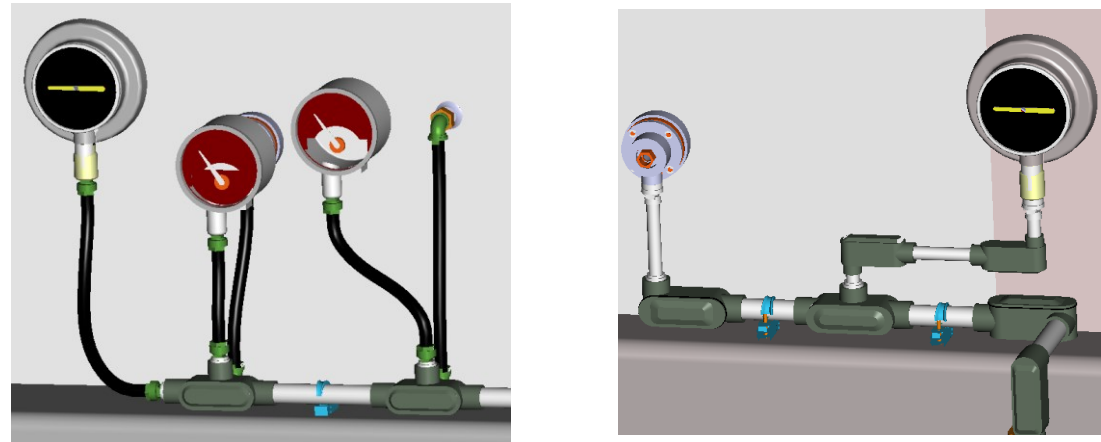
- Most designs that specify seismic requirements specify IEEE 693
- IEEE 693 has three qualification levels: “High” – “Moderate” – “Low”
- Unless specified a certified seismic report will not be supplied, the transformer will be designed to meet the required standards based on our internal design practices only
- Typical seismic reports can cost \$10,000 or more and average 8–10 weeks for completion
- If a customer specifies IEEE 693 but does not specify the fastening method, then the transformer will be designed for a welded base, not bolted



# THINGS TO CONSIDER: CONDUIT

## All rigid conduit vs. rigid conduit with short (<36") runs of flex

- All rigid conduit typically does not allow for ease of installation of gauges, etc., causing a maintenance headache
- Rigid conduit with shorts runs of flex to gauges and fans will allow for simpler and more user-friendly conduit runs
- Waukesha standard flexible conduit is rated  $-60^{\circ}$  to  $+150^{\circ}$  C sunlight resistant



If you need all rigid conduit, make sure to specify it, otherwise consider allowing short runs of conduit to gauges and fans.

# THINGS TO CONSIDER: ENVIRONMENT

Did you know that there are many different environmental conditions that can affect your transformer?



Environment	Considerations
High Altitude	Decreased dielectric strength warrants additional phase to phase spacing, cooling, potentially special bushings, etc.
Cold Climate	Special gaskets, additional heaters in control cabinets, special control components, consideration of oil drop
Open Mines, Heavy Industry, Refinery, Geothermal, Paper Mills	Depends on the specifics of the conditions



Many of these conditions warrant the use of special breathers, etc., so keep in mind the more information you tell your supplier, the better!

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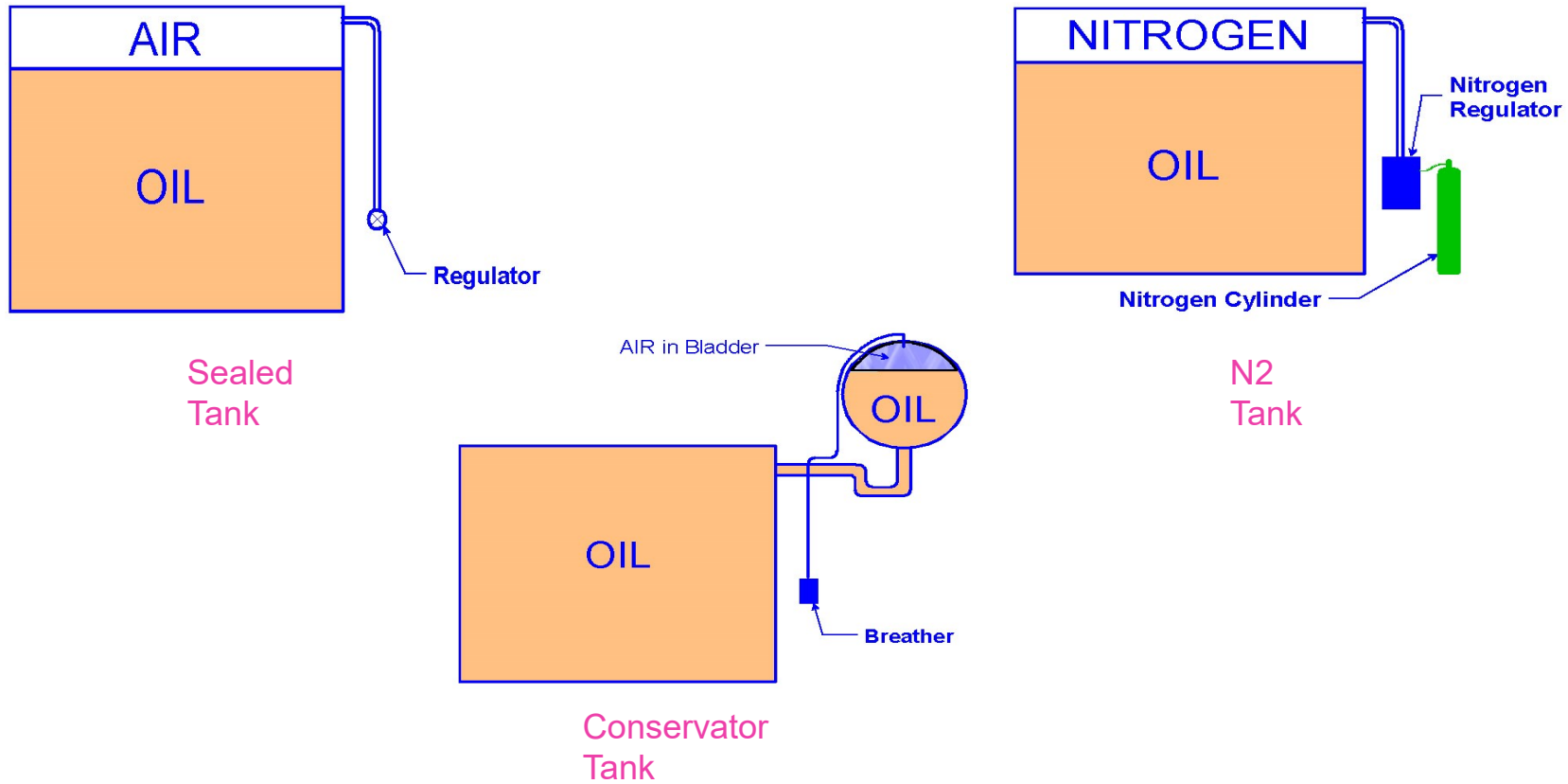
# OIL PRESERVATION

# OIL PRESERVATION SYSTEMS

System Type	Typical Operating Pressure Range	Sub-type
Sealed Tank	-5 and +7.5 psig	
Nitrogen (inert gas) System	+0.5 and +5.0 psig	Enclosed, Open, N2 Generator
Conservator System	0 and +2 psig	With Air Cell, Without Air Cell



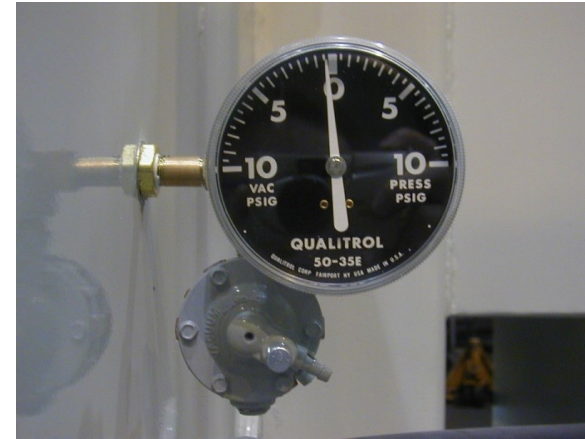
# OIL PRESERVATION



# SEALED TANK

## Pressure Vacuum Gauge\ Bleeder

- Provides indication of pressure/ vacuum inside transformer
- Can be used in conjunction with a pressure-vacuum bleeder on sealed tank designs to bleed and breathe in at pre-set levels
- Also used for shipping units filled with dry air or nitrogen if inert air system is not installed and activated for shipment



# NITROGEN SYSTEMS

Enclosed Style



Open Style

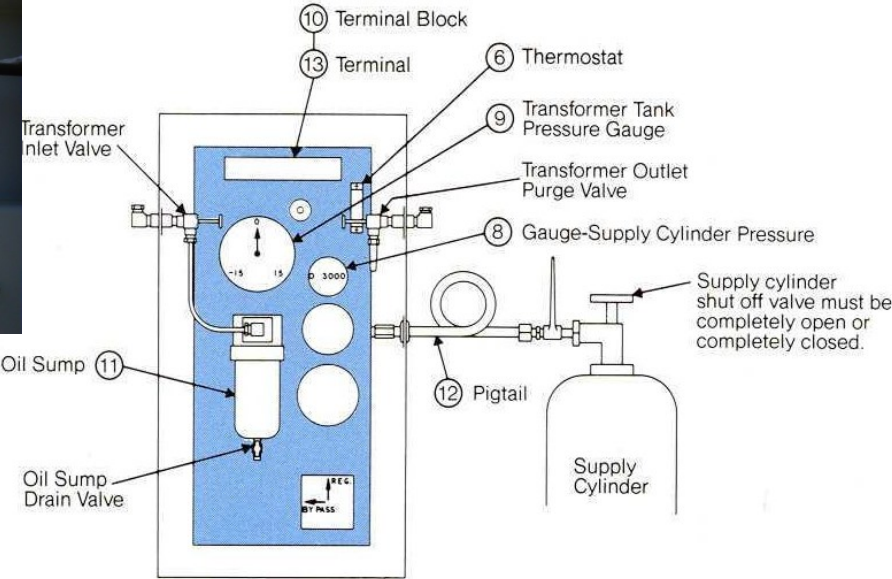


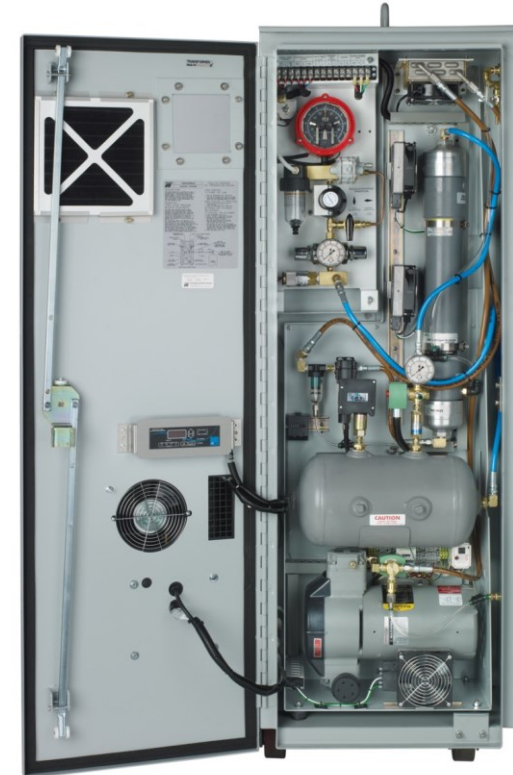
Fig. 2 Front View of Panel in Box

Enclosed = bottle inside cabinet

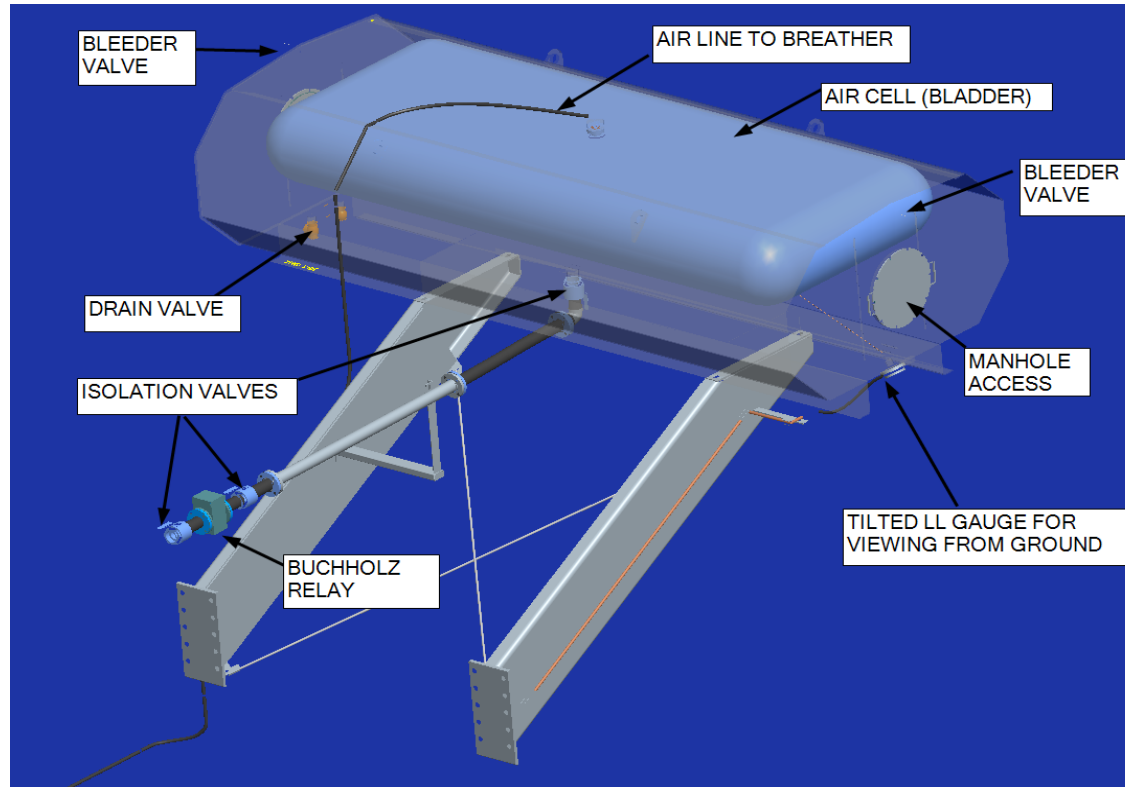
Open = bottle outside cabinet

# NITROGEN SYSTEMS: GENERATOR

- Generates N2 on demand
- Eliminates need to transport and replace N2 bottles
- Nitrogen gas is generated as needed and stored in a tank to provide a reserve supply of nitrogen in the event of power failure
- Fits same footprint as standard N2 enclosure
- Nitrogen Purity: 99.0% to 99.5%



# CONSERVATOR SYSTEM



- Conservator shapes vary from round to octagonal
- Size is dependent on volume of oil in main tank



## Contact

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