



# Transformer Components & Accessories

Transformer Concepts & Applications Seminar  
Goldsboro, NC  
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a prolec ge company

## Cesar Duque Key Account Manager

Cesar started with Prolec GE Waukesha in 2012 at the Goldsboro, North Carolina, location. Starting out as an Application Engineer, where he was responsible for quoting transformers of all sizes for the South-Central Region. In 2021 he was promoted into a Project Manager role and in 2022 he was promoted to Key Account Manager position. He is now responsible for three key accounts managing from receipt of RFQ through manufacturing and delivery of the unit. Cesar has a bachelor's degree in Mechanical Engineering from North Carolina State University.

## Jacob Crass Key Account Manager

Jacob joined Prolec GE Waukesha in June 2019. He began his career with Prolec GE Waukesha as an Application Engineer for the company's south-central region. He has now held the role of Key Account Manager since 2022, which he is responsible for two key accounts managing from receipt of RFQ through manufacturing and delivery of the unit. Jacob has a Bachelor of Science in Engineering, Mechanical Engineering, from East Carolina University.



# Agenda

- Standards / Equipment Overview
- Bushings
- Arresters
- Cooling Equipment
- Instrument Transformers
- Gauges
- Pressure Controls & Relays
- Valves
- Transformer Health Equipment



# Standards / Equipment Overview

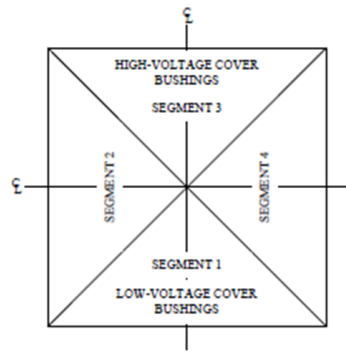
# Standards

- IEEE Standards
  - C57.12.10 Standard Requirements for Liquid-Immersed Power Transformers
  - C57.12.00 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
  - C57.19.00 Standard General Requirements and Test Procedure for Apparatus Bushings
  - C57.19.01 Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
  - C57.13 Standard Requirements for Instrument Transformers

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# C57.12.10 – “Basic Standard”

IEEE Std C57.12.10-2010  
IEEE Standard Requirements for Liquid-Immersed Power Transformers



NOTE—Some designs include accessories and wiring connections as part of the LTC equipment assembly. In such cases, accessories may be located in the same segment as the LTC and may be viewed parallel to the segment centerline.

Figure 1 — Accessories

Accessories	Locations	Clause ref.
DETC operating handle	S1, S4, see Clause ref.	Table 4
Liquid level indicator	S1	5.1.2
Liquid temperature indicator	S1	5.1.3
Winding temperature indicator	S1	5.1.4
Pressure-vacuum gauge	S1 or S4	5.1.5
Pressure-vacuum bleeder valve	S1	5.1.6
Pressure relief device	Cover	5.1.7
Drain and filter valves	S1	5.1.8
Jacking facilities	See ref.	5.3.4
Nameplate	S1	5.4
Ground pad(s)	See ref.	5.5
†Auxiliary cooling control	S1 or S2	5.9
‡LTC equipment	S1 or S2	6

†When furnished.

Table 4 — “Basic standard” construction features (continued)

Clause	Items	Without LTC	With LTC
5.2.1.3	Constructions for Neutral Terminations	A	A
5.3	Lifting, Moving, and Jacking Facilities	S	S
5.3.3.2	Other Moving Facilities (Wheels)	A	A
5.3.4	Jacking Facilities	S	S
5.4	Nameplate	S	S
5.5	Ground Pads	S	S
5.6	Polarity, Angular Displacement, and Terminal Markings	S	S
5.7	Liquid Preservation System	S	S
5.8	Tanks	S	S
5.8.3.2	Bolted Cover	A	A
5.9	Auxiliary Cooling Equipment	A	A
5.9.1	Controls for Auxiliary Cooling Equipment	A	A
5.9.2	Fans	A	A
5.9.2.2	Future Forced-Air Cooling	A	A
5.9.3	Pumps	A	A
5.10	Auxiliary Equipment Power Supply	A	A
5.11	Terminal Board	A	A
5.12	Junction Box	A	A

Table 4 — “Basic standard” construction features

Clause	Items	Without LTC	With LTC
5.1	Accessories		
Table 4	DETC	A	A
5.1.2	Liquid Level Indicator	S	S
5.1.3	Liquid Temperature Indicator	S	S
5.1.4	Winding Temperature Indicator	S	S
5.1.5	Pressure-Vacuum Gauge	A	A
5.1.6	Pressure-Vacuum Bleeder Valve	A	A
5.1.7	Pressure Relief Device	S	S
5.1.8	Drain and Filter Valves	S	S
5.1.9	Sudden Pressure Relay	A	A
5.1.10	Alarm Contacts	S	S
5.1.11	Contact Wiring and Wire Color Coding	S	S
5.2	Bushings	S	S
5.2.1	Neutral Terminations	S	S
5.2.1.1	Y-Connected High-Voltage Windings	A	A
5.2.1.2	Y-Connected Low-Voltage Windings	A	A

5.12.1	High Voltage	A	A
5.12.2	Low Voltage	A	A
5.13	Disconnecting Switches	A	A
5.13.1	High-Voltage Terminal Chamber	A	A
5.13.2	Low-Voltage Terminal Chamber	A	A
5.14	Throat Connection	A	A
5.14.1	High-Voltage Throat	A	A
5.14.2	Low-Voltage Throat	A	A
5.15	Current Transformers		
5.15.1	Bushing Type Current Transformer	A	A
0	Terminal Blocks	A	A
5.16	Surge Arresters	A	A
5.17	Other Insulating Liquid	A	A
6	LTC Equipment	–	
6.1	LTC	–	S
6.2	Tap Selection Switch	–	S
6.3	Motor and Drive Mechanism	–	S
6.4	Position Indicator	–	S
6.5	Control Equipment and Accessories	–	S
A.2	Transformer Paralleling	–	A

NOTE: “S” indicates “standard”, “A” indicates “available when specified.”

# C57.12.10 “Basic Standard” Features

## Standard Equipment - All Units

Liquid Level Indicator
Liquid Temperature Indicator
Winding Temperature Indicator
Pressure Relief Device
Drain and Filter Valves
Bushings
Neutral Terminations
Lifting, Moving, and Jacking Facilities
Ground Pads
Liquid Preservation System
Tanks
Alarm Contacts
Contact Wiring and Wire Color Coding
Nameplate
Polarity, Angular Displacement, and Terminal Markings

## Standard Equipment - LTC Units

LTC
Tap Selection Switch
Motor and Drive Mechanism
Position Indicator
Control Equipment and Accessories

## Cooling Dependent Equipment

Auxiliary Cooling Equipment
Controls for Auxiliary Cooling Equipment
Fans
Future Forced-Air Cooling
Pumps

## Liquid Preservation Dependent Equipment

Pressure-Vacuum Gauge
Pressure-Vacuum Bleeder Valve

## Common Accessories

DETC
Sudden Pressure Relay
Current Transformers
Surge Arresters

## Other Accessories

Terminal Board
Junction Box
Disconnecting Switches
Terminal Chambers
Bushing Throat
Bolted Cover
Other Moving Facilities (Wheels)
Bushing Type Current Transformer
Other Insulating Liquid
Auxiliary Equipment Power Supply
LTC Paralleling Equipment

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# Bushings

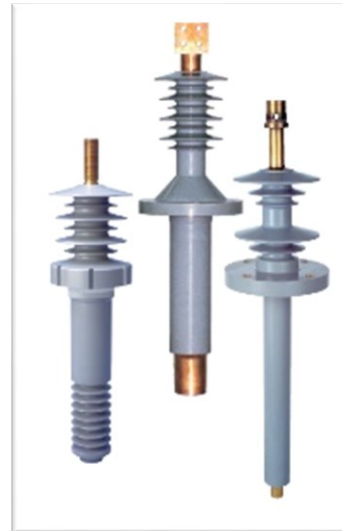


# Common Bushings Types

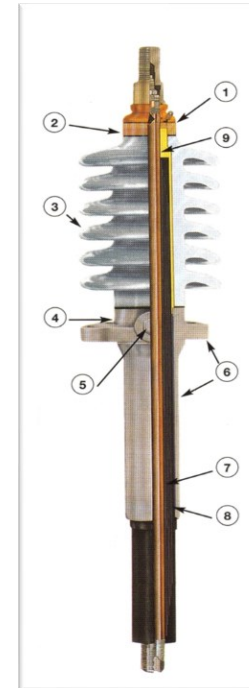
Dry (Bulk)  
≤ 25kV



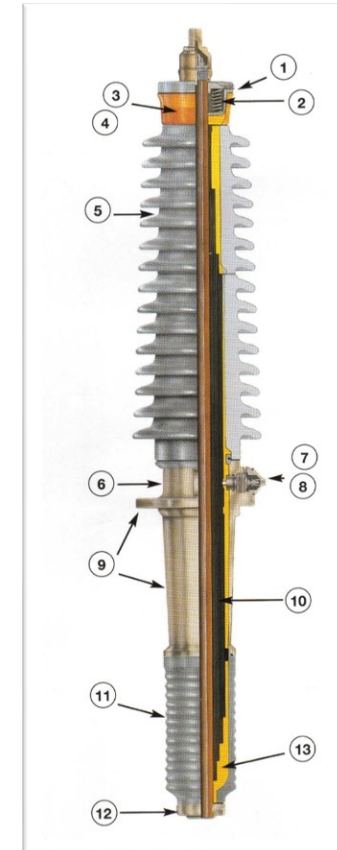
Composite  
25kV – 138kV



Paper Resin  
Capacitor  
25kV – 72.5kV



Paper Oil  
Capacitor  
25kV – 500kV



While grey porcelain is the industry standard polymer sheds are becoming more commonly accepted.

# Bushing Selection Considerations

- **Electrical Rating Requirements**
  - Nominal System Voltage
  - BIL Rating
  - Nominal Current and any Overload Requirements
  - Draw-lead vs Bottom Connect or split conductor
- **Other Considerations**
  - Existing supply of spare bushings
- **Mechanical Requirements**
  - Vertical Mount vs Horizontal Mount (important for bushings with oil)
  - Temperature Requirements
  - High temp bushings may be necessary for use in enclosed ducts or other conditions
  - Environmental Requirements
  - Bushing Mounting
  - Oil – Air / Oil – SF6 / Oil - Oil
  - Flange bolting and gasket requirements for retrofits
  - Mechanical Strength
  - Cantilever Requirements
  - Seismic Certification if required
  - Bushing clearances (both external and internal)
  - Ground Sleeve Length (CT Pocket)

# Bushings Mounting

Cover Mounted



Horizontal Mounting



Angled Mounting



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# Arresters

# Common Arresters Types

Polymer Arrester



## Advantages

- Light Weight
- Compact
- Durability
- Smaller Phase to Phase & Phase to Ground Clearances
- Will not shatter explosively like porcelain arresters

Porcelain Arrester



## Advantages

- High cantilever strength for windstorms or earthquakes
- Better UV resistance than polymer arresters

Both types are available in Station and Intermediate Classes

# Arrester Selection Considerations

- **Electrical Rating Requirements**
  - Maximum system voltage
  - System grounding practices (effectively grounded, impedance grounded, ungrounded)
  - Insulation level of equipment to be protected
  - Desired margins of protection to be provided
- **Mechanical Requirements**
  - Vertical Mount vs Horizontal Mount
  - Operating Conditions (Ambient temperature, altitude, etc.)
  - Mechanical Strength
    - Cantilever Requirements
    - Seismic Certification if required
- **Other Considerations**
  - Existing supply of spare arresters



# Cooling Equipment

# Radiators

- Panel-type – galvanized (standard) or painted (ANSI 70 or another color)
- Cool through natural convection, ONAN transformer rating does not require auxiliary equipment

Galvanized

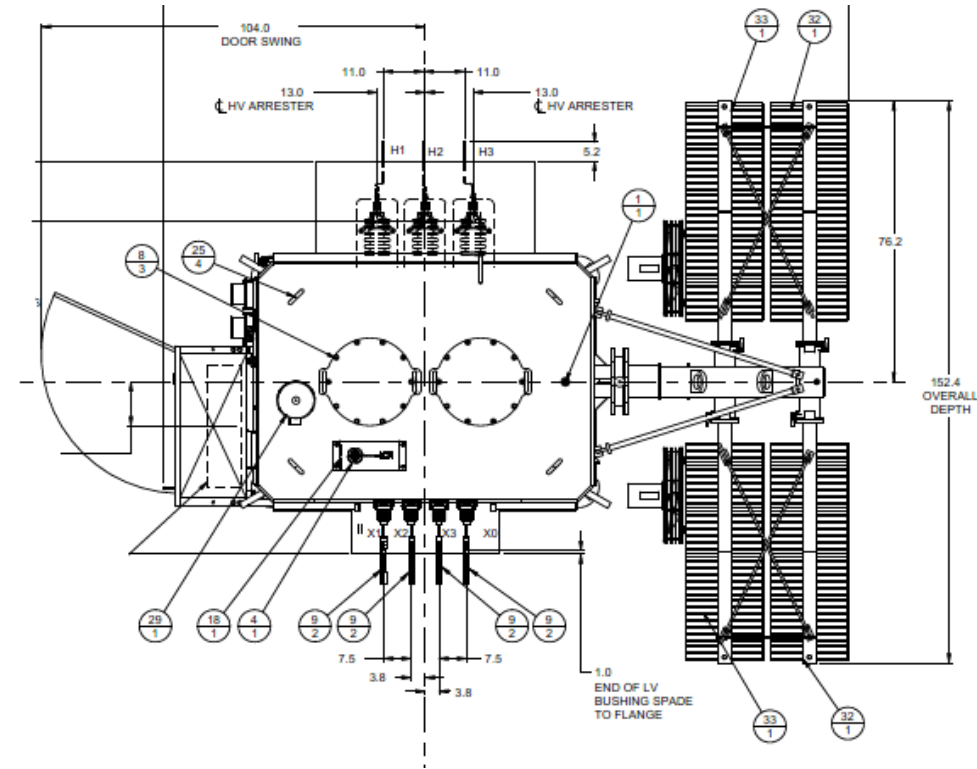


Painted





# Radiator Header Banks



- Typically used when cooling needs exceed the space available for direct mount
- Common on larger transformers or when there are limitations on where radiators can be placed

# Fans

- Available in variety of voltages including single phase and three phase
- Higher RPMs and larger diameter provide more cooling but increase sound level and power requirements
- Sound level and CFM are main concerns

Radiator Mounted



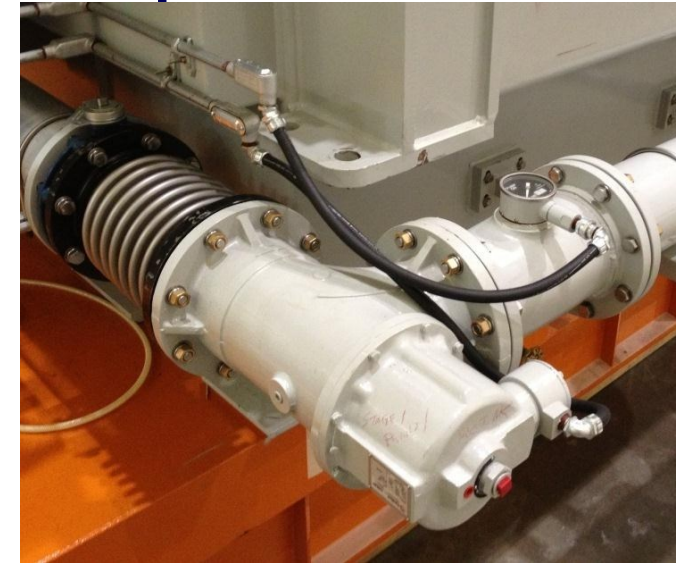
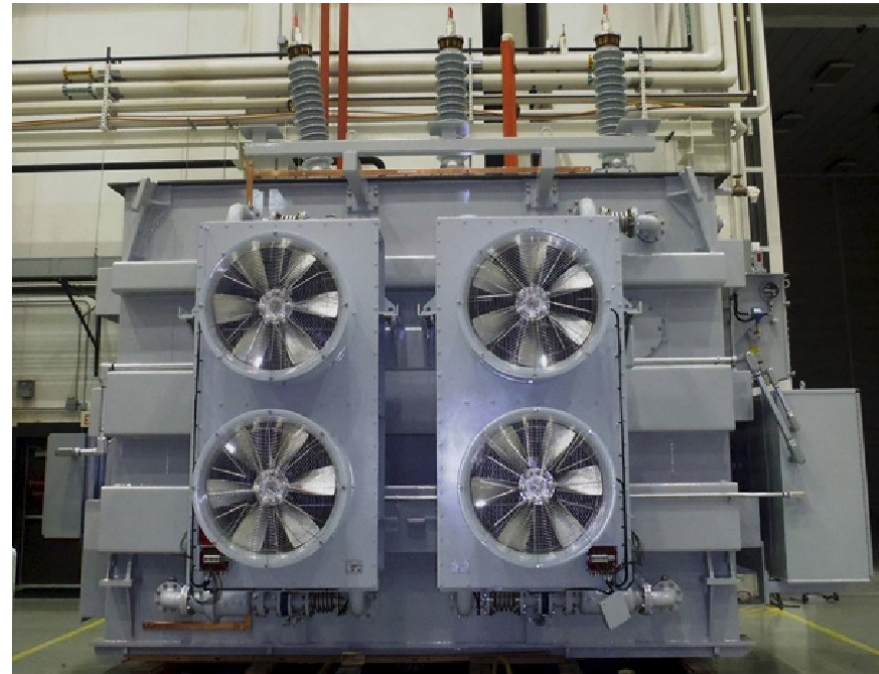
Frame Mounted



Careful consideration is given in the cooling design to ensure the optimal size, type, and quantity of fans is selected to meet all the design requirements.

# Oil to Air & Oil to Water Coolers with Pumps

- Oil to Air Coolers with Pumps
  - Used primarily when space / weight is a concern, such as mobile transformers, large power transformers and when remote cooling is required
  - Pumps require power at all times
- Oil to Water Coolers with Pumps
  - Small physical footprint
  - Require cool water supply and pumps require power at all times



- Pumps
  - Axial
  - Centrifugal
- Flow Indicator
- Isolation Valves
- Expansion Joints



# Instrument Transformers

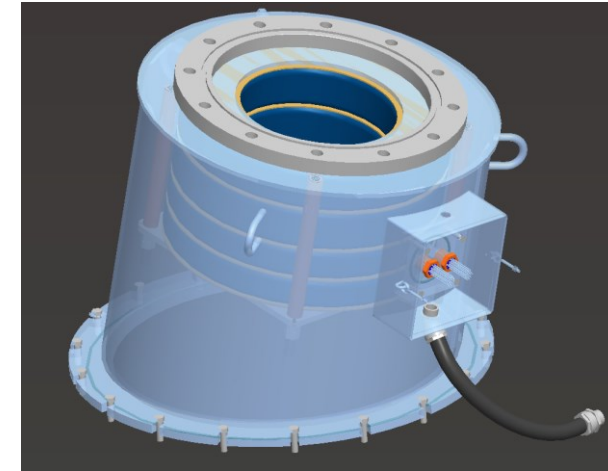
# Bushing Current Transformers



Typical internal CT



Under-Cover Mounted CTs



Turret Mounted CTs

- Typically mounted so that bushing passes through CT
- In some cases line lead will be routed through CT
- Available as internal or external to tank
- Metering and relaying accuracy

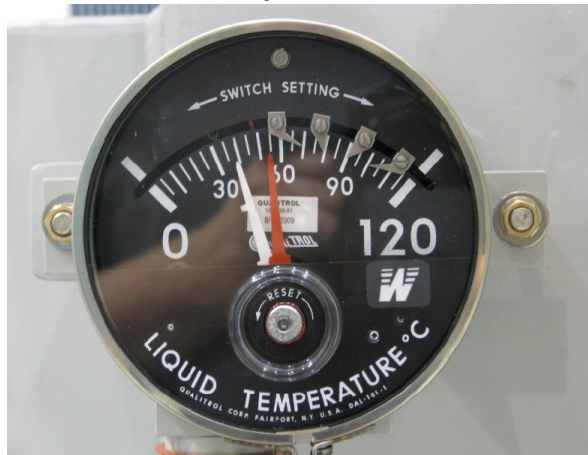
Depending on CT requirements a single CT can cost as little as \$200 each or as much as \$25,000 or more!

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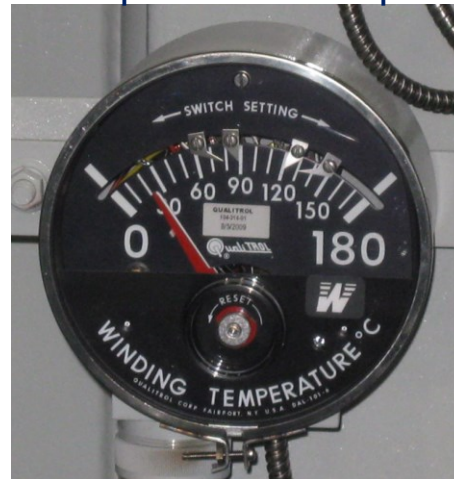
# Gauges

# Analog Temperature Gauges

Liquid Temperature  
measures Top Oil  
Temperature



Winding Temperature  
simulates Winding  
Temperature Hotspot



Analog Gauges



Analog w/SCADA Output

- Analog gauges typically mounted between 4-6ft above the base with a capillary tube to the respective well
- Direct mount gauges are available when required tilted downward to aid viewing
- LTC transformers may be requested with additional liquid temperature indicators
- Winding temperature gauges can be specified to monitor additional windings

# Electronic Temperature Monitors



## Examples

- Electronic temperature monitors are becoming more and more common
- Still fairly common to see both analog and electronic monitors for redundancy
- Consider whether or not you plan to do your own programming in the field
- Make sure your spec is clear if you want the transformer manufacturer to do the programming for you as this can be costly

Its not uncommon for the programming to cost several times more than the device. Scheduling of the programming with vendor can create delays in production.



# Liquid Level Gauges



Typical tank mounted liquid level gauge



Remote liquid level gauge and monitor

- Provides indication of oil level in transformer or oil filled compartment
- Can be provided with alarm/trip contacts for high / low / critical low oil level
- Typically must be mounted at the 25 degrees C oil level
- LTC with separate oil filled compartment will have separate gauge
- Remote gauges can be used on conservators when gauge is too far away to read from ground level



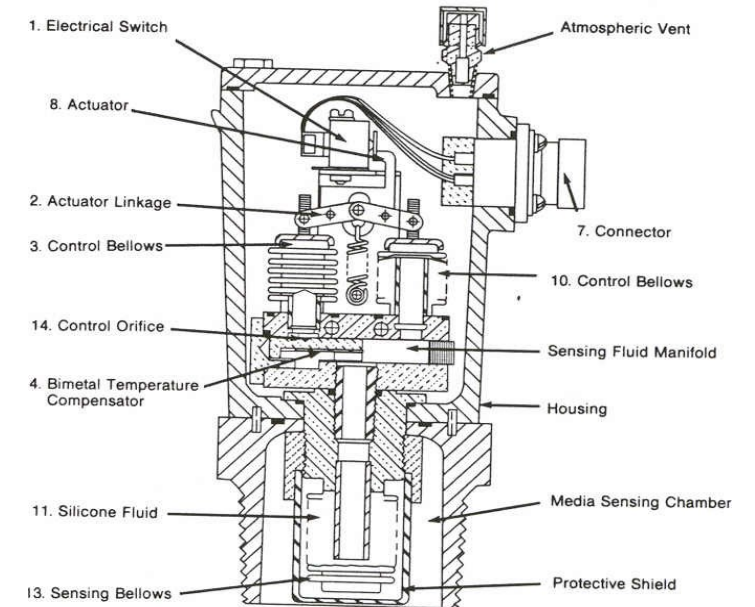
# Pressure Controls and Relays

# Rapid Pressure Rise Relay

Qualitrol Gas  
space mounted



Qualitrol Oil Flange  
mounted



**Figure 1:** Simplified cross section of rapid pressure rise relay.

- Relay typically mounted in the gas space but can be mounted in oil if specified
  - Qualitrol Gas space 910 series; Oil space mounted 900 series
  - ABB only offers gas space type
- When mounted in oil it should be mounted on a full bore valve to ensure functionality is not compromised and to ease maintenance
- Gas space mounted relay operates slightly faster than oil flange mounted
- Buchholz offers model which can be used only on conservator units

# LTC Pressure Switch & Buchholtz Relay



LTC Pressure Switch

- LTC can use the same pressure relay as main tank or could utilize pressure switch



Buchholz Relay

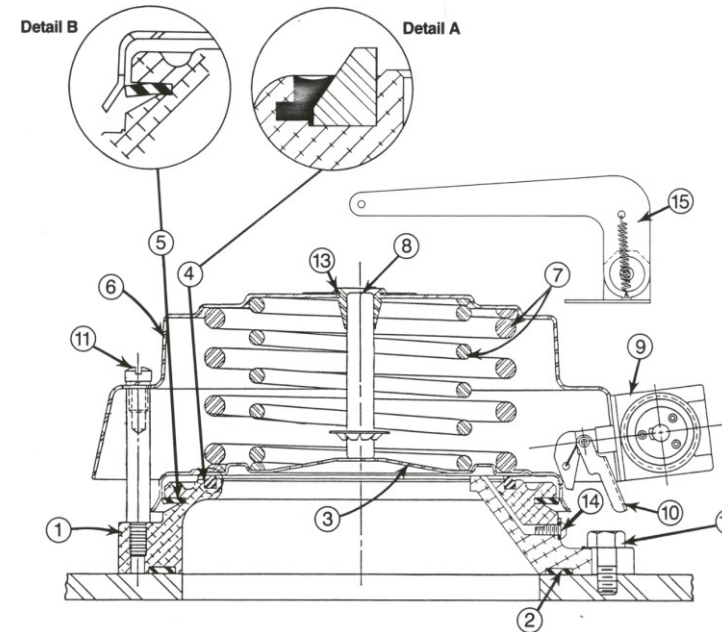
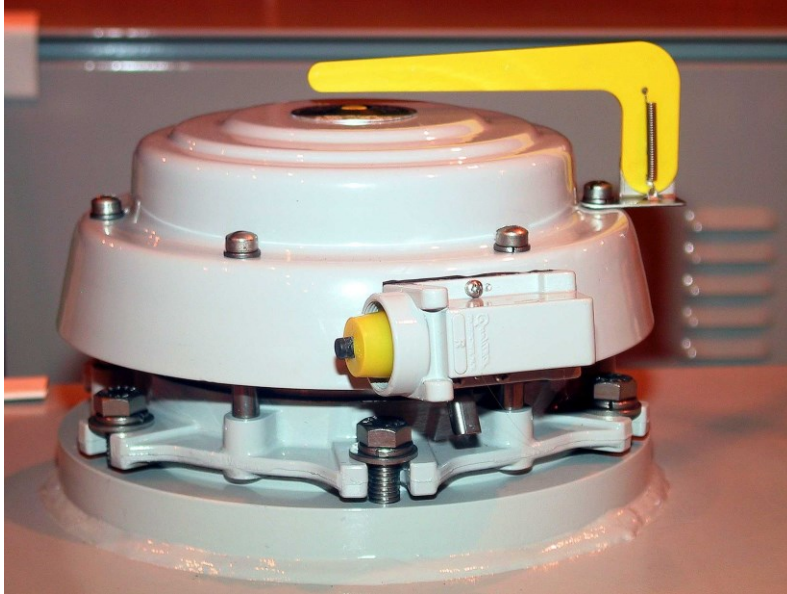
- Installed between the main tank and conservator
- Device will alarm / trip on
  - Gas accumulation
  - Loss of fluid (low oil level)
  - High pressure wave
- Site glass for visual indication of gas on inspection
- Bleeder valve and sampling port are available

# Gas Accumulator Indicator – Conservator

- Provides visual evidence of gas generation
- Can be wired to alarm when the amount of gas reaches a preset level
- Factory tested by injecting air in through a valve located opposite the device
- Do not inject air through the bottom drain valve as these frequently have scuppers which trap the injected air



# Pressure Relief Devices

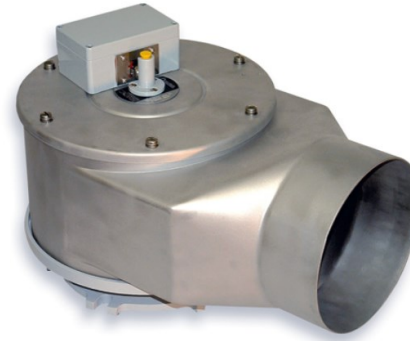


- Spring operated device which operates at a factory preset pressure (typically 10 psi)
- Self-resetting (great improvement on early rupture discs)
- Options:
  - Contacts to alarm for operation
  - Semaphore (flag) to visually indicate operation
  - Discharge Piping to direct oil to safe location

# Pressure Relief Devices

## Directional Piping

- Qualitrol XPRD most common
  - 8" Pipe
- Directed blow off piping
- Discharge routed to ground
- Screen option available to keep out critters
- Tubing available in PVC, aluminum and steel



Qualitrol XPRD



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# Valves



# Valve Applications

## Filling and Draining

- Required for filling and draining the main tank, LTC compartment, and conservator when applicable

## Isolation of Components

- Allows for isolation of components which may require removal in the future for maintenance or replacement
- Limits the amount of oil removed from the transformer when replacing components
- Some examples are radiators, RPRR, Buchholz Relay, and Monitoring Equipment

## Vacuum Isolation / Equalization

- Applicable to some LTC compartments and conservator air cells

# Common Valve Variations

## Valve Types

- Globe
- Gate
- Ball
- Butterfly
- Pressure Relief
- Sampling / Venting

## Valve Connection

- Flanged
- Threaded

## Valve Materials

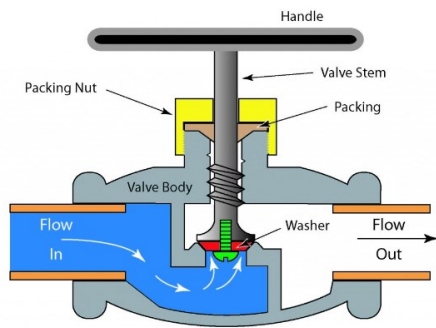
- Bronze
- Brass
- Cast Iron
- Stainless Steel

## Valve Construction

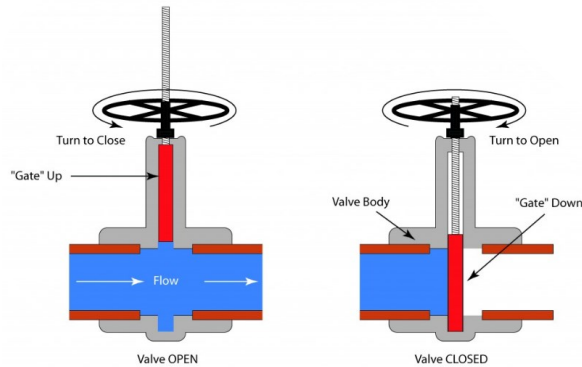
- Uni-body
- 2-Piece
- 3-Piece

# Valve Types

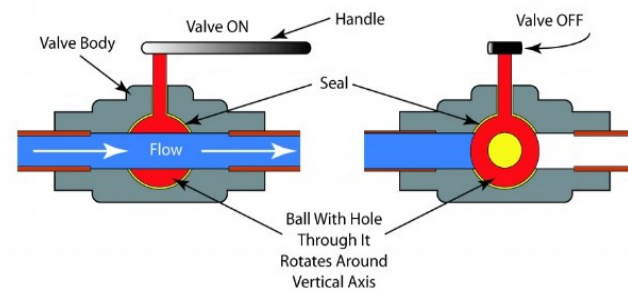
## Globe



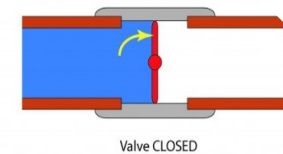
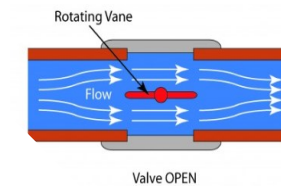
## Gate



## Ball



## Butterfly



# Valve Materials

## Bronze

- Relatively low cost and available in 3" sizes and below
- Good corrosion resistance for most environments including salt spray
- Less availability above 2" for some valve / connection combinations



## Brass

- Lowest cost valve material
- Limited availability in larger sizes
- More susceptible to galvanic corrosion than Bronze
- Softer than bronze, more susceptible to thread damage



## Stainless Steel

- Highest cost valve material
- Excellent corrosion resistance including refinery / high sulfur environments
- Available for all valve types, sizes and materials



## Cast Iron / Steel

- Much lower cost than stainless for large valves
- Readily available in larger sizes
- Requires painting for corrosion resistance



# Valve Connections

## Flange In – Thread Out

- Typical for filling applications when a threaded connection is required for field use
- Limited availability in uni-body styles for ball valves and sizes above 2”
- May require custom design



## Thread In – Thread Out

- Widely available for all valve types, sizes, and materials
- Not recommended for sizes above 2” due to greater potential for leaks



## Flange In – Flange Out

- Excellent Seal
- Good for in-line applications
- May not be best for filling/ draining unless fill hoses are equipped with adapters
- Not as readily available for smaller sizes in all materials

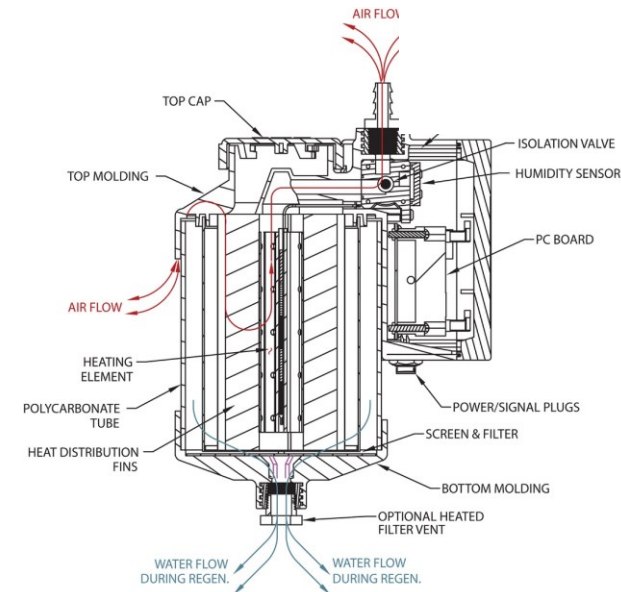




# Transformer Health Equipment

# Dehydrating Breathers

- Ensure dry air is maintained inside LTC, conservator, sealed tank or control cabinet, improving reliability
- Air flows through silica gel to remove moisture prior to entering air space
- Silica gel may be recharged by heating or replaced with new gel
- Auto-Recharging Breathers
  - Recharge automatically, eliminating the need for manual regeneration or replacement of silica gel
  - Remote indication of recharging cycles and equipment alarms is possible



# LTC Oil Filtration Systems

- Typically used on non-vacuum LTCs to remove carbon and metallic particle contaminants (down to 3 microns) and free moisture in oil
- Maintain condition of LTC oil to extend the life of equipment and can extend the period between maintenance intervals
- Retrofit to existing units in the field





# Electronic Monitoring

- Monitoring and control are available in a variety of packages and units, transformer requirement vary by make and model
  - Alarm conditions
  - Transformer loading and calculations
  - LTC condition and control
  - Online DGA
  - Online bushing power factor and capacitance measurement
  - Fiber optic temperature monitoring
- Useful on older equipment to monitor unit condition
- Less value on new equipment but does provide baseline information for future condition assessment



# QUESTIONS



## Contact

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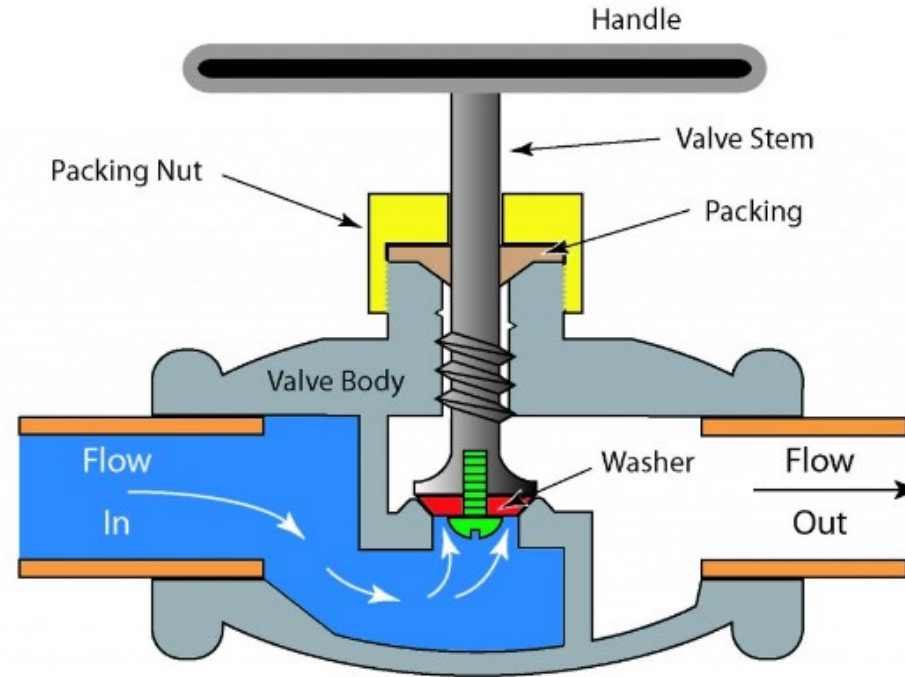
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[www.waukeshatransformers.com](http://www.waukeshatransformers.com)

# Additional Information

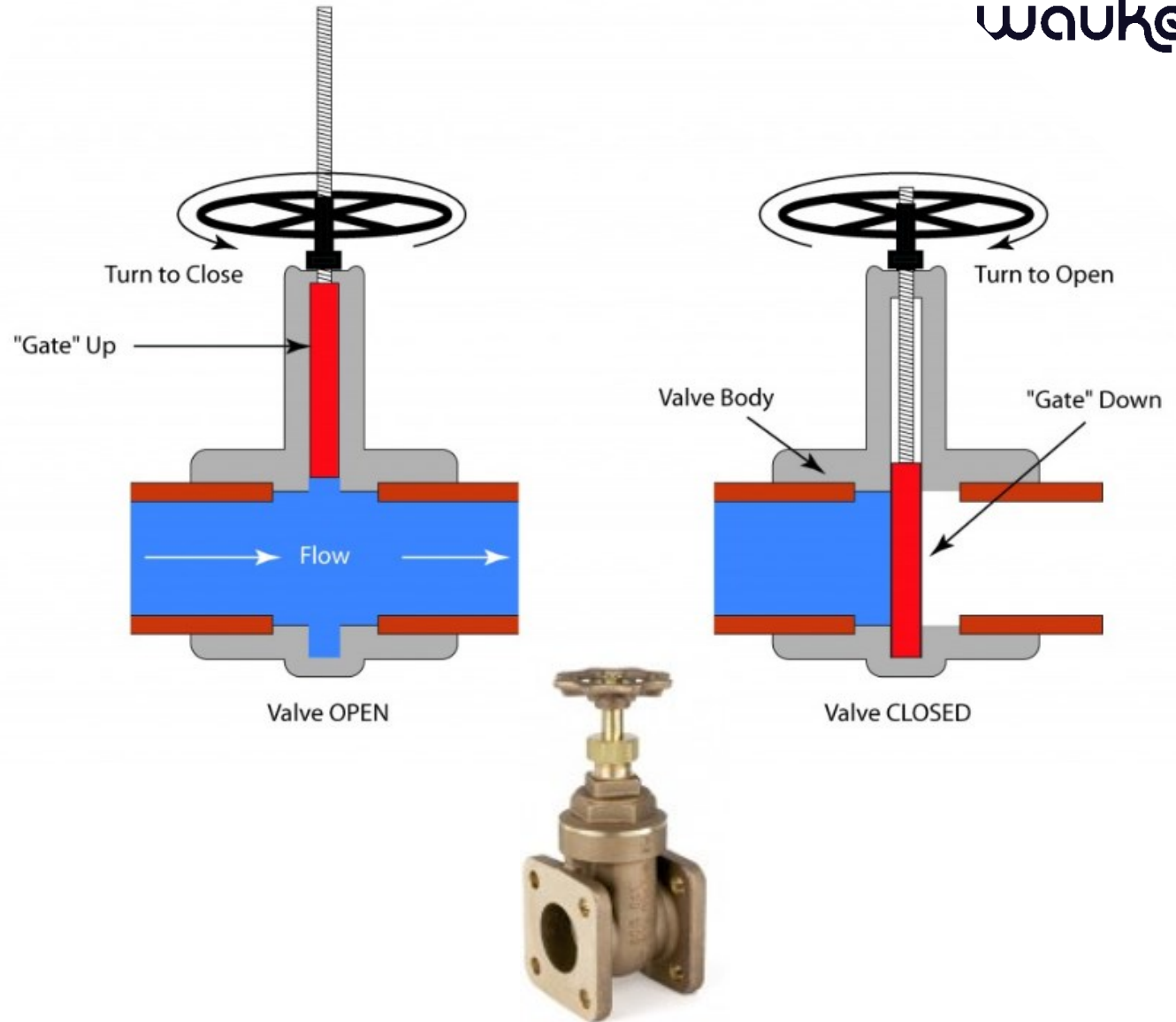
# Globe Valves

- Good throttling
  - Excellent for filling applications to control flow rate
- Leak resistance
- Optional Sampler
- Flange or screw attachment
- High head loss
  - Lower flow rates

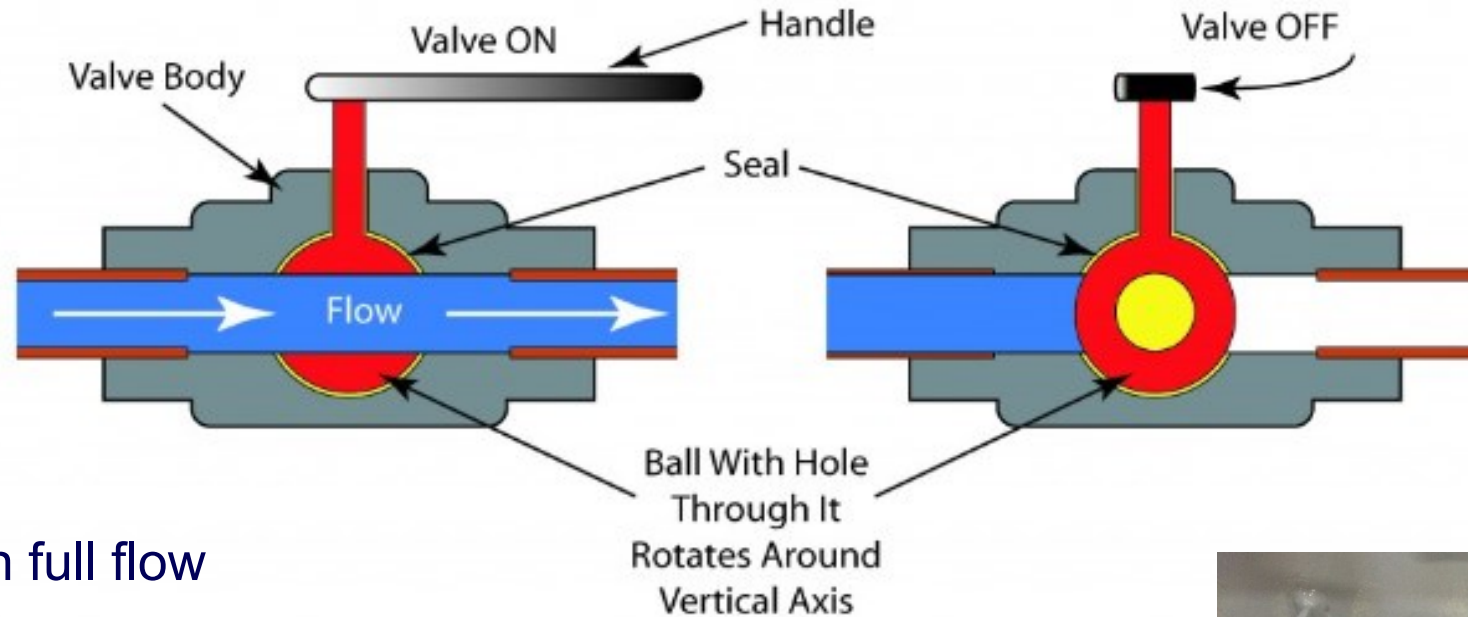


# Gate Valves

- Linear motion valve
- Used to start or stop fluid flow, does not regulate or throttle flow
- Minimum leakage is allowed
- Virtually no resistance across valve – used on rapid pressure relay type devices
- Rising and non-risings stem styles
- Can be expensive in larger sizes



# Ball Valves



- Quick open – ¼ turn full flow
- Excellent sealing
- High flow – low head pressure
- Hard to find with Sampler valve
- Expense in sizes over 3"



