

OTCF

Capacitor Voltage Transformers 72.5 kV to 800 kV

In high and extra high voltage transmission systems, capacitor voltage transformers (CVTs) are used to provide potential outputs to metering instruments and protective relays. In addition, when equipped with carrier accessories, CVTs can be used for power line carrier (PLC) coupling.

Designed for Long Service Life

Decades of experience have resulted in strong and reliable units, able to meet the highest standards. These units are manufactured using the most modern insulation impregnation technology and equipment.

GE's CVTs provide excellent reliability because the major insulation of the CVT, the capacitor stack, comprised of homogeneously assembled capacitor elements, is extremely surge resistant irrespective of the waveform of the surge voltage.

CVT insulation integrity is assured by the fact that a metallic bellows assembly hermetically seals the oil from the atmosphere.

All external parts are made from marine grade aluminum and stainless steel hardware is used, no painting is required.

Applications

- For revenue metering and protection in high voltage networks
- PLC application

Performance

- V_n : 36 to 800 kV
- C_n : from 1,750 to 37,500 pF
- Accuracy classes from 0.15 % to 1.2 %



Quality Product Design

- High quality film / paper-oil insulation
- Oil expansion by stainless steel bellows
- Superior transient response
- Porcelain or composite insulator

Seismic Withstand Capability

- The standard OTCF resists medium intensity seismic events
- Applicable for highly seismic regions
- Compliance with ANSI / IEEE, IEC or equivalent standard

Key Benefits

- Conservative and safe design
- Extensive field and extreme climate experience, including high seismic regions
- Operation as coupling capacitor for power line carrier
- Rugged, leak-proof design
- Maintenance-free
- Easy transport and installation



Reliable Design for High Life Expectancy

Insulating Systems

The external insulation is provided by the porcelain or composite housing and coordinated with the capacitor stack, consisting of virtually identical elements so that the axial voltage distribution from the line terminal to ground is essentially uniform.

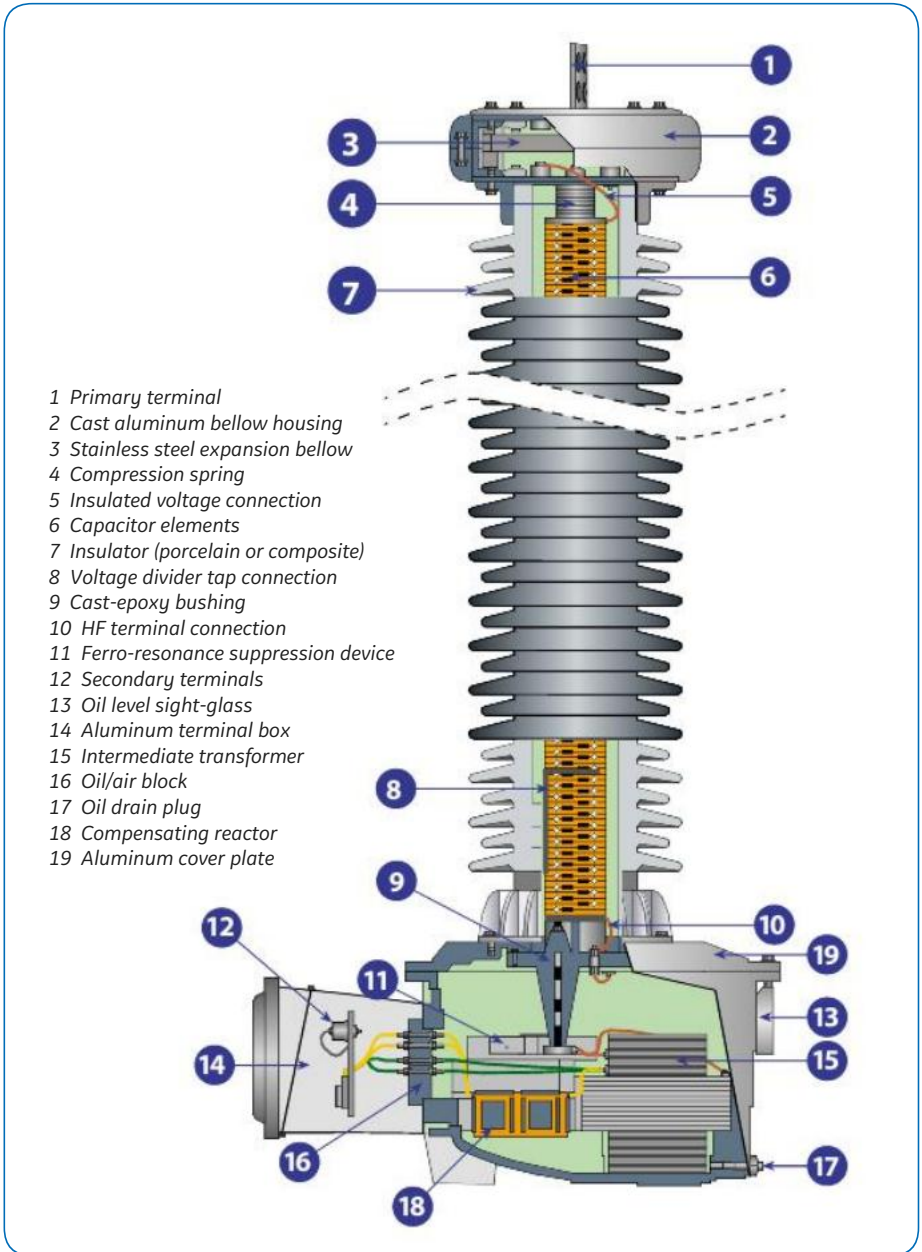
The capacitor elements have a mixed dielectric material consisting of alternating layers of polypropylene film and kraft paper. The kraft paper layers serve as a wicking agent to ensure homogenous synthetic oil impregnation and stabilize capacitance over a wide temperature range.

The electromagnetic unit (EMU) is housed in an oil-filled tank at the base of the capacitor stack. Mineral oil is employed as the insulating medium instead of air because of its superior insulating and heat transfer properties. The use of an oil-filled base tank removes the need for space heaters in the secondary terminal box as this area is warmed by heat transfer from the insulating oil, but is available on request. This results in a more reliable, compact and cost effective design.

Insulating Oil

We use insulating oils with excellent dielectric strength, aging, and gas absorbing properties. The synthetic oil used for the capacitor units possesses superior gas absorption properties resulting in exceptionally low partial discharge with high inception/extinction voltage ratings. The oil used for the EMU is premium mineral oil. The oil is filtered, vacuum dried and degassed with in-house processing. It contains no PCB.

Typical Section



- 1 Primary terminal
- 2 Cast aluminum bellow housing
- 3 Stainless steel expansion bellow
- 4 Compression spring
- 5 Insulated voltage connection
- 6 Capacitor elements
- 7 Insulator (porcelain or composite)
- 8 Voltage divider tap connection
- 9 Cast-epoxy bushing
- 10 HF terminal connection
- 11 Ferro-resonance suppression device
- 12 Secondary terminals
- 13 Oil level sight-glass
- 14 Aluminum terminal box
- 15 Intermediate transformer
- 16 Oil/air block
- 17 Oil drain plug
- 18 Compensating reactor
- 19 Aluminum cover plate

Capacitor Stack

The capacitor stack is a voltage divider which provides a reduced voltage at the intermediate voltage bushing for a given voltage applied at the primary terminal.

The capacitor stack is a multi-capacitor-unit assembly. Each unit is housed in an individual insulator. A cast aluminum cover is on top of the upper capacitor assembly and is fitted with an aluminum terminal. An adapter for mounting a line trap on top of the CVT can be provided with an optional (and removable) HV terminal.

The capacitor units are mechanically coupled together by means of stainless steel hardware passing through the corrosion resistant cast aluminum bellows housing. The mechanical connection also establishes the electrical connection between capacitor units. This facilitates field assembly of the CVT.

Each capacitor unit is hermetically sealed; a stainless steel diaphragm (expansion bellow) preserves oil integrity by maintaining the hermetic seal while allowing for thermal expansion and contraction of the oil. The capacitor units operate in a practically pressure-free mode over a very wide ambient temperature range

The capacitor stack consists of a series of capacitor elements. The dielectric spacers are a combination of kraft paper and polypropylene film. The ratio of paper/film is carefully determined to provide constant capacitance for a wide range of operating temperature. The aluminum electrodes capacitor elements are precision wound by microprocessor controlled machinery. The capacitor elements are connected with low inductance tinned copper tabs.

The stack assemblies are hydraulically compressed and bound with epoxy fiberglass tape to obtain the optimum space factor for capacitance requirement and oil circulation. This capacitor design results in stable accuracy performance over time and temperature.

After assembly in the insulator, capacitor units are individually oven dried under vacuum and then impregnated with the processed synthetic oil.



Thousands of installed units to attest to their reliability



Electromagnetic Unit (EMU)

The EMU steps down the intermediate voltage provided by the voltage divider to values suitable for relay and metering applications.

A compensating reactor cancels the phase shift introduced by the capacitor voltage divider. A set of internal taps is used for factory accuracy and phase angle adjustments to provide optimum performance. Over-voltage protection is provided by a protective gap connected in parallel to the series reactances.

The inherent capacitance of the divider and the inductances in the EMU of a CVT require the suppression of ferro-resonance.

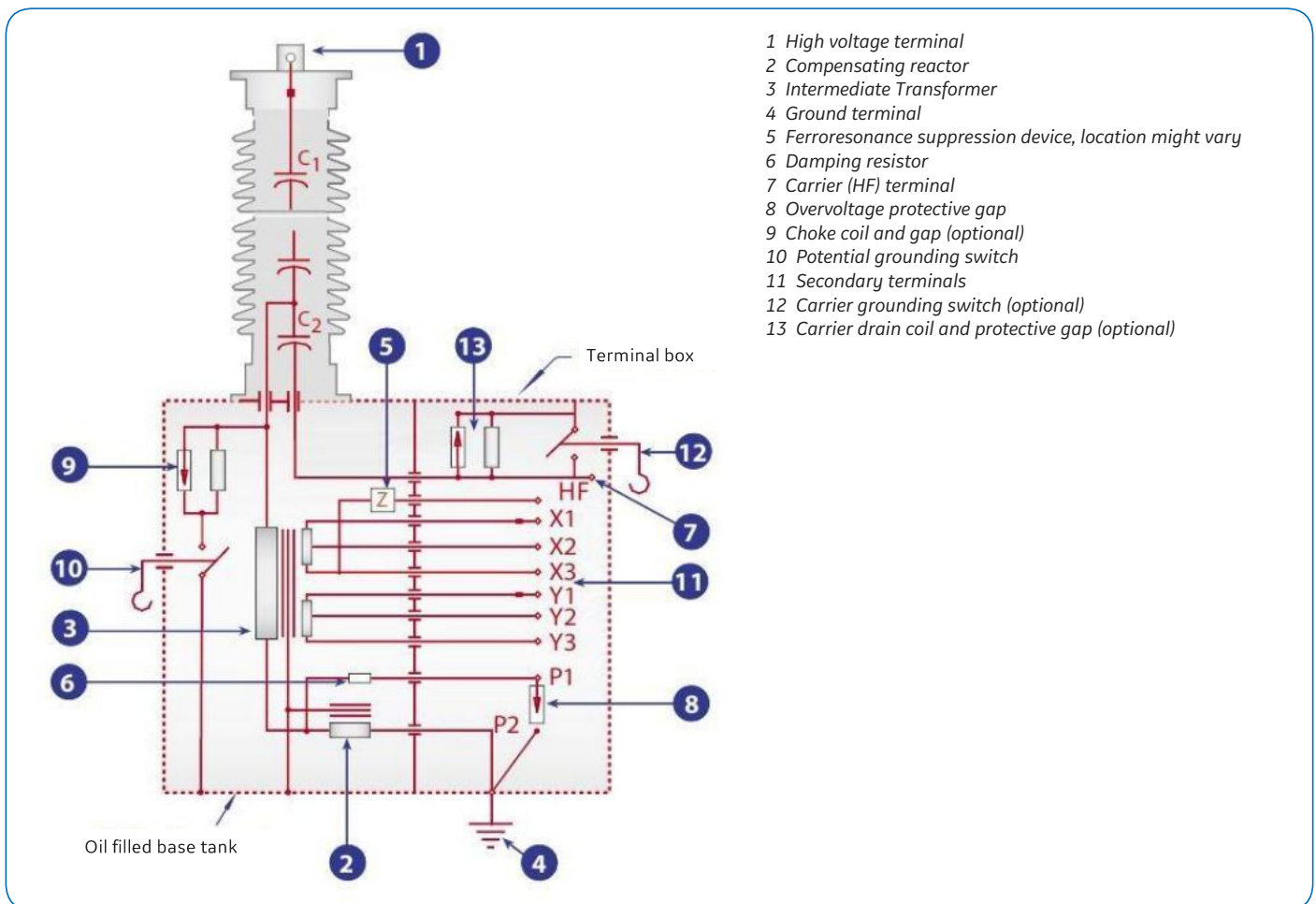
The passive ferroresonance suppression device (FSD) contains a saturable reactor, which acts like a switch. It presents a very high impedance under normal conditions and switches on a damping resistor across the secondary at a prescribed voltage. When the voltage has normalized it switches off the damping load. The voltage sensitive switching strategy effectively suppresses ferroresonance without imposing a heavy permanently connected stabilizing burden on the unit, significantly improving the accuracy and the transient response performance of the CVT.

No field adjustment of the unit is necessary.

The EMU is housed in a cast aluminum base tank with a cast aluminum cover. Ground pads are located on both sides of the tank to provide flexibility for connections. These pads can accommodate either NEMA / IEC 2 hole or customer specified grounding connection. The base tank is filled with treated mineral oil and hermetically sealed from the environment and from the synthetic oil in the capacitor units. A sight glass at the rear of the tank provides for easy oil level monitoring. No oil maintenance is necessary throughout the service life of the unit. An oil drain plug or oil sampling valve is provided on the base tank.

External potential grounding switch (PGS) is installed on all ANSI / IEEE units for safety purposes. A ground shield is provided between the intermediate voltage winding and the secondary windings, in the event of insulation failure, the voltage on the secondary circuits is reduced. It also protects the secondary from voltage transients. PGS and CGS (Carrier Grounding Switch) ice shields available as option.

Typical Schematic Diagram



Carrier Accessories

When the CVT is equipped with carrier accessories for PLC service, an external carrier grounding switch (CGS) and carrier entrance bushing are provided in the terminal box. The carrier accessories include a carrier drain coil with protective spark gap. A choke coil and a protective spark gap are installed in the base tank when a potential ground switch (PGS) is provided to prevent the loss of the carrier signal when the PGS is in the closed position.

Secondary Terminal Box

The terminal box is spacious and can accommodate all required connections. The secondaries of the EMU are brought out of the base tank through an oil/air seal block assembly and terminated on separate terminal blocks with 8-32 screws. Other terminal blocks available on request. The secondary terminal box area is warmed by heat transfer from the oil filled tank. This prevents condensation in the terminal box and removes the need for a space heater in service, but is available on request. An aluminum gland plate is provided to accommodate customer conduit hubs. The door can be made lockable on request. An interlock with the PGS can be provided on request.

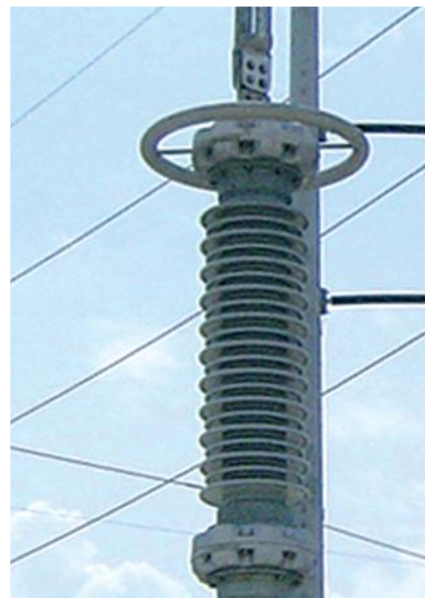
Corona Suppression

Corona suppression is considered in the design and construction of every part of the CVT. Designs requiring corona suppression are supplied with an aluminum corona ring to ensure insulation performance.

Dielectric loss factor	Less than 0.08 % @ rated voltage
Radio Influence Voltage (RIV)	Less than 750 μ V at U_m
Partial Discharge	Less than 10 pC at U_m
Frequency	50 Hz or 60 Hz
Ambient temperature	- 40 °C to + 45 °C on a 24h average
Other values on request	

Secondary Windings

To meet the requirements for measuring and protection, generally two secondary windings are provided with an option of up to four windings, including the ground fault winding. The maximum burdens can be seen on page 7.



Insulator

Gray (ANSI 70) or brown (RAL 8016). High creepage distances are available as standard according to the dimension tables. GE also offers CVTs with extra high creepage insulators in porcelain and composite material. Composite insulators are made of an epoxy resin fiberglass tube with silicone sheds.

Ambient Conditions

All OTCF are designed to operate in ambient temperature from - 40 °C to + 45 °C, withstand wind speeds of 100 mph, site location up to 3,300 ft and 0.2 g lateral force. GE can design to meet unusual site conditions when specified.

Service Life and Maintenance

OTCF have been designed for a 30 years plus lifetime. They have near-zero maintenance requirements: the oil is hermetically sealed from the air by a stainless steel diaphragm assembly and all external parts are of corrosion-resistant material.

Tests

Routine tests are performed in accordance with national, international and internal quality standards. Each capacitor unit is routine tested for lightning impulse, power-frequency withstand, partial discharge, dissipation factor and capacitance. A routine test report is provided for each unit. Existing type test reports can be provided on request.

Partial discharges

For the capacitor units, the partial discharge intensity is less than 5 pC at $1.2 U_m / \sqrt{3}$ and less than 10 pC at U_m after the power frequency voltage test.

Ferro-resonance check

After routine accuracy tests, the unit is checked for ferro-resonance suppression by applying secondary short-circuits. The secondary voltage is monitored with an oscilloscope to ensure that the recovery of normal waveform is satisfactory.

Dissipation factor or Tan δ

Dissipation factor measured at the rated voltage is less than 0.08 %.

Inquiry Check List

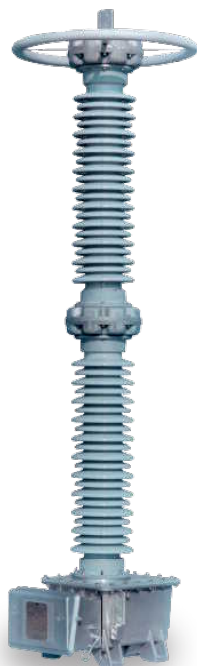
- Applicable standards
- Rated frequency
- Highest system voltage
- Power-frequency withstand test voltage
- Lightning impulse test voltage
- Switching impulse test voltage, if applicable
- Rated capacitance C_n in pF
- Overvoltage factor (ex. $1.5 U_n$ 30 s)
- Voltage ratio
- Number of secondaries
- Accuracy class and rated burden for each secondary winding
- Transient response
- Thermal burden
- Environmental conditions (altitude, temperature, site pollution, seismic conditions...)
- Required creepage distance in mm or in mm/kV
- Options as required:HV terminal (material and dimensions)
 - Carrier accessories
 - Composite insulator (light grey)
 - Suspension mounting
 - Secondary terminal box heater
 - HV and ground connectors
 - Line trap adapter

If a line trap is to be mounted on the CVT, please specify the weight and overall dimensions and load conditions.

Easy Transport and Installation

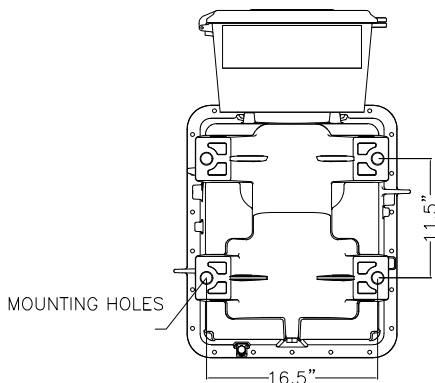
CVTs must be transported and stored in the upright position. Multi capacitor unit assemblies are delivered with the upper capacitor units packed in the same crate.

The base unit and upper stack elements can easily be assembled by following the instruction manual (IBCVT01). No special tools are required.



Base Tank Dimensions

Base Tank Mounting Pattern



Designation

OTCF ... SR	Standard High Capacitance Relay Accuracy
OTCF ... SI	Standard High Capacitance Intermediate Accuracy
OTCF ... II, ... SM	Intermediate High Capacitance Metering Accuracy
OTCF ... IM	Intermediate High Capacitance Metering Accuracy
OTCF ... ER	Extra High Capacitance Relay Accuracy
OTCF ... EM	Extra High Capacitance Metering Accuracy

Ratings

Capacitive voltage transformers can be rated for metering and/or protection purposes.

The Following Burdens (as a Sum of all Windings except the Ground Fault Winding) can be achieved

TYPE OTCF	SR ER	SI	SM or II	IM	EM
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Rated Burden According to IEEE

60 Hz	1.2Z (200VA)	0.6Z (200VA) 0.3Y (75VA) 1.2ZZ (400VA)	0.3Z (200VA) 0.6ZZ (400VA) 0.15Y (75VA)	0.3ZZ (400VA) 0.15Z (200VA)	0.3ZZ (400VA) 0.15Z (200VA)
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Thermal Burden (VA)

60 Hz	1,000	1,000	1,000	1,000	1,500
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Transient Response

Residual voltage (1 cycle)	9%@ZT(SR) 6%@ZT(ER)	9%@ZT	9%@ZT	9%@ZZT 6.5%@ZT	5%@ZZT
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Rated burdens noted at 60 Hz available on X & Y windings.
Auxiliary winding (Y) available with rated accuracy/burden 1.2Y

The Following Capacitances are Standard for the Various Voltage Levels

Type (U _m [kV])	... SR ... SI	... II ... IM ... SM	... ER ... EM
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Capacitance (pF)*

OTCF 72.5	12,500	16,700	37,500
OTCF 123	7,500	10,000	22,500
OTCF 145	6,250	8,300	18,800
OTCF 170	5,250	6,700	16,200
OTCF 245	3,750	5,000	11,250
OTCF 362	2,650	3,350	8,100
OTCF 550	1,750	2,250	5,400
OTCF 765			4,000

* Other values on request

Dimensions*

Maximum system voltage (V _m)	kV	72.5	123	145	170	245	362	550	765
Impulse test voltage (BIL)	kV	350	550	650	750	1,050	1,300	1,800	2,100
OTCF Creepage distance	in	71.4	124.0	147.6	180.4	248	360.8	541.2	-
... SR Dimensions in	A	54.0	68.9	75.4	83.9	121.4	151.3	218.8	-
... SI	B	25.8	40.7	47.2	55.7	2 x 40.7	2 x 55.7	3 x 55.7	-
... SM	C	19.3	19.3	19.3	19.3	19.3	19.3	19.3	-
... II	Ø D	Ø 14.6	Ø 14.6	Ø 14.6	Ø 14.6	Ø 25.5	Ø 34.0	Ø 34.0	-
...	E	-	-	-	-	11.7	11.7	2x11.7	-
Total weight (approx.)	pound	452	531	561	593	786	913	1,225	-
Weight of oil (approx.)	gal	7.9	8.6	8.9	9.9	11.2	12.6	15.9	-
OTCF Creepage distance	in	71.4	124	147.6	180.4	248	360.8	541.2	-
... IM Dimensions in	A	55.4	70.4	76.9	85.3	122.8	152.8	220.2	-
	B	25.8	40.7	47.2	55.7	2 x 40.7	2 x 55.7	3 x 55.7	-
	C	20.7	20.7	20.7	20.7	20.7	20.7	20.7	-
	Ø D	Ø 14.6	Ø 14.6	Ø 14.6	Ø 14.6	Ø 25.5	Ø 34.0	Ø 34.0	-
	E	-	-	-	-	11.7	11.7	2 x 11.7	-
Total weight (approx.)	lb	610	689	719	751	944	1,071	1,383	-
Weight of oil (approx.)	gal	12.4	13.1	13.4	13.8	15.7	17.1	20.4	-
OTCF Creepage distance	in	71.4	124.0	147.6	180.4	248	360.8	541.2	721.6
... ER Dimensions in	A	55.3	70.3	76.7	85.2	124.3	154.2	223.2	292.3
	B	25.8	40.7	47.2	55.7	2 x 40.7	2 x 55.7	3 x 55.7	4 x 55.7
	C	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
	Ø D	Ø 17.2	Ø 17.2	Ø 17.2	Ø 17.2	Ø 34.0	Ø 34.0	Ø 34.0	Ø 40
	E	-	-	-	-	13.3	13.3	2 x 13.3	3 x 13.3
Total weight (approx.)	lb	610	689	719	751	944	1,071	1,383	-
Weight of oil (approx.)	gal	12.4	13.1	13.4	13.8	15.7	17.1	20.4	-
OTCF Creepage distance	in	71.4	124	147.6	180.4	248	360.8	541.2	721.6
... EM Dimensions in	A	56.7	71.7	78.2	86.6	125.7	155.6	224.7	293.7
	B	25.8	40.7	47.2	55.7	2 x 40.7	2 x 55.7	3 x 55.7	4 x 55.7
	C	21.2	21.2	21.2	21.2	21.2	21.2	21.2	21.2
	Ø D	Ø 17.2	Ø 17.2	Ø 17.2	Ø 17.2	Ø 34	Ø 34	Ø 34	Ø 40
	E	-	-	-	-	13.3	13.3	2 x 13.3	3 x 13.3
Total weight (approx.)	lb	740	826	900	982	1,220	1,532	2,074	2627
Weight of oil (approx.)	gal	14.7	16	16.6	17.3	21.5	24.1	30.9	37.2

* All dimensions refer to standard versions and must be confirmed with order. Other requirements affect dimensions and weights.

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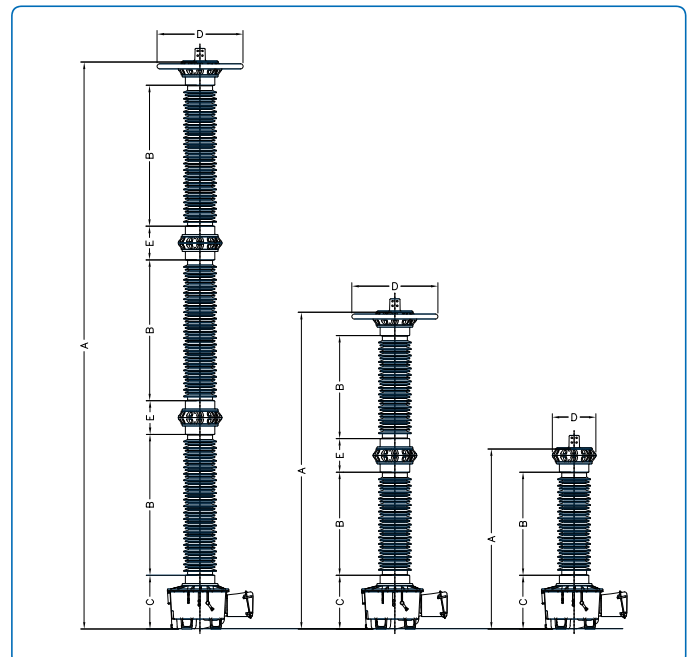
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Imagination at work