

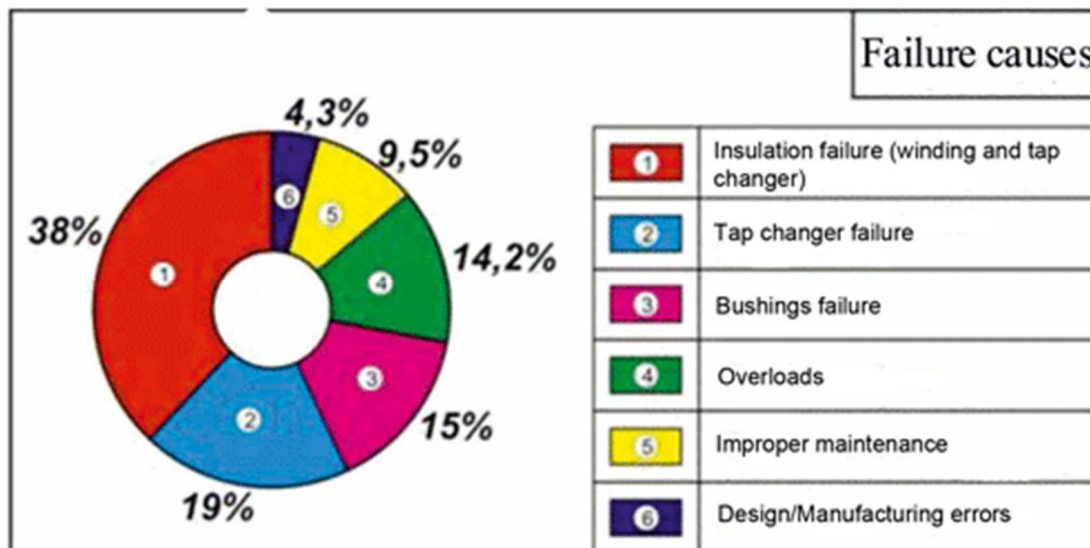
# TRANSFORMER OIL REGENERATION PLANT CMM-R CONTENTS

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## 1. GENERAL

At present, more than 40% of transformers in use by energy companies are over 25 years old. Annual transformer failure rate has been steadily rising in the past few years. Regardless of methods used to analyze failures, the results of such analysis indicate the most vulnerable part of the transformer is cellulose insulation of windings, voltage regulators, bushings and tap changers.

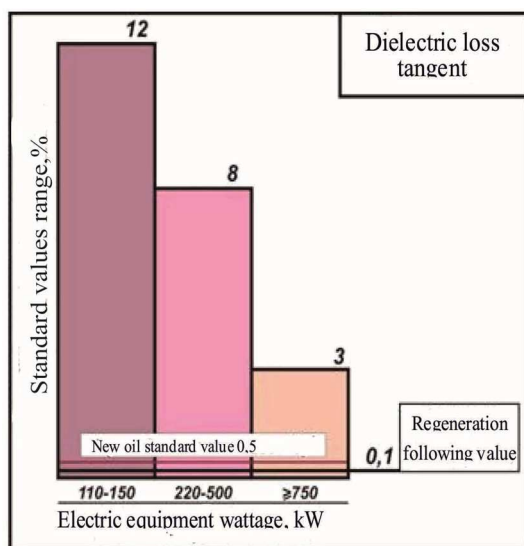


Replacement of all aging transformers is hardly possible, considering the economic realities. However, actual life time of many transformers is far from over. This life time can be extended by regeneration of transformer oil to like new conditions thus, extending the lifecycle of transformers.

CMM-R Transformer Oil Regeneration Plants are designed to improve dielectric strength and chemical composition of insulating oils. It is important to maintain an oil's properties within the recommended standards to prevent the by-products of oil degradation from weakening the cellulose insulation. Since the life of a transformer is determined by the state of its cellulose insulation, intervention is necessary to prevent sludge from destroying the chemical bonds which hold the cellulose together. Oil Regeneration will remove sludge (and sludge producing by-products such as acids, aldehydes & peroxides) from the oil, thereby improving its acidity level and decreasing its ability to dissolve gases. Comparing to older technology where Fuller's Earth is used only once and then must be disposed of together with oil and harmful contaminants, CMM-R plants utilize the principle of sorbent (Fullers Earth) reactivation and have a number of unique features:

- ❖ regenerate the oil on energized transformer
- ❖ remove sludge from cellulose insulation
- ❖ reactivate the sorbent (Fuller's Earth) allowing the sorbent to stay in the plant for 2-3 years before replacement is needed.
- ❖ oil regeneration and Fuller's Earth reactivation is fully automatic
- ❖ disposal of sorbent is environmentally friendly and safe as Fuller's Earth is free from oil and contaminants.

## 2. PRINCIPLES OF OIL REGENERATION PROCESS



Main principle of Oil Regeneration is to draw oil through the sorbent (Fuller’s Earth). During this process oil undergoes “molecular filtration” in the microporous sorbent. By-products of oil ageing are removed and stay in the Fuller’s Earth granules.

After the sorbent has accumulated certain amount of contaminants, CMM-R plant switches into sorbent reactivation mode. This unique fixture allows to regenerate oil continuously and managed by software installed on the operator’s laptop or plant’s PLC. Reactivation of the sorbent is fully automated and enables the plant to process oil using the same Fuller’s Earth up to 300 times which is equal to 2 or 3 years of operation before sorbent replacement is required. Fuller’s Earth is a clay occurring in nature and possess no environmental danger and can be disposed as a construction waste after it exhausted its absorbing properties.

System’s efficiency and reliability allows to treat any mineral transformer oil to comply with all relevant international standards (please see table below). CMM-R Plants provide better alternative to oil replacement as treated oil parameters in most cases surpass those offered by new oil. As a rule timely oil regeneration extends transformer’s life by 25 to 30 years.

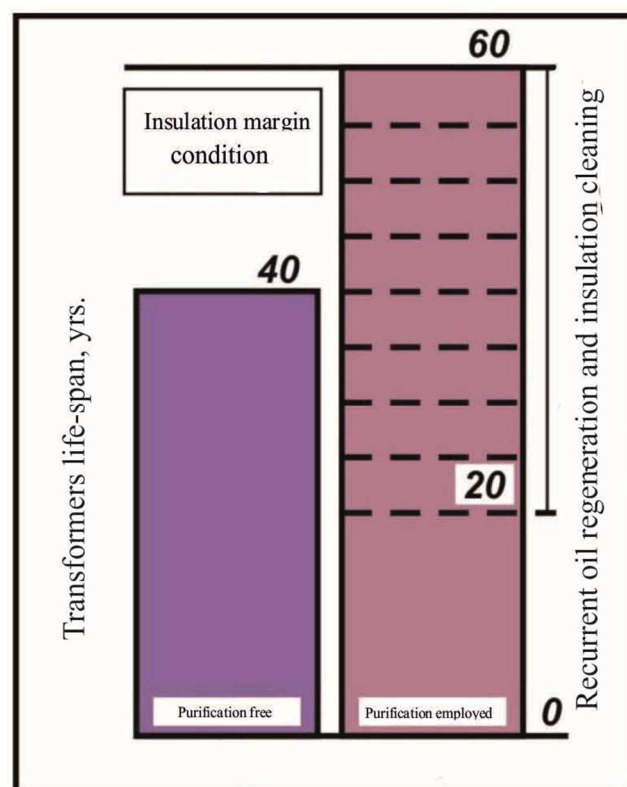
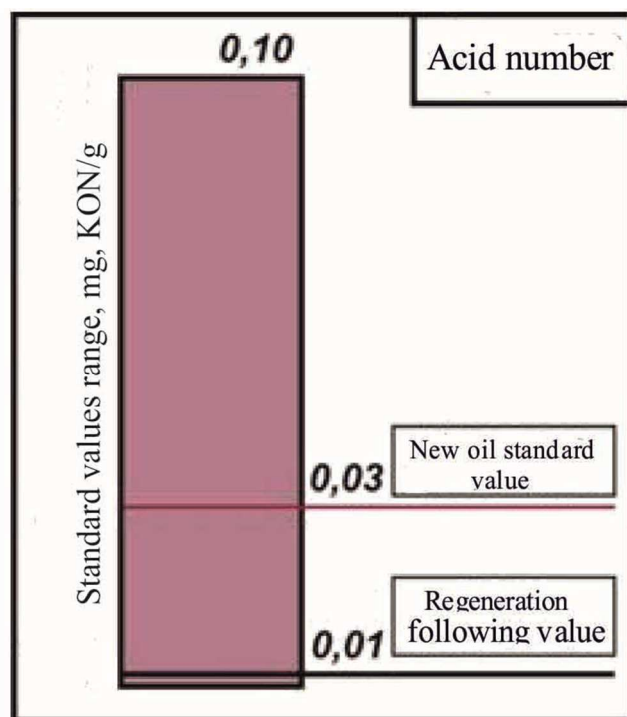


Table below shows typical oil parameters before and after treatment.

Parameter	Test Methods	Before regeneration	After regeneration
Appearance	Visual	Cloudy brown	Clear and transparent
Acid number, mg KOH/g	IEC 296; ASTM D-664	0.63	0.01
Corrosive sulfur	ISO 5662; ASTM D-1275	Present	None
Moisture content, ppm	IEC 733; ASTM D-1533	170	5
Breakdown voltage, kV	IEC 156; ASTM D-1816	11	73
Dielectric loss tangent at 90°C	IEC 247; ASTM D-924	4.0	0.001
Gas content, %	IEC 60599; ASTM D-3612	12	0.1
Surface tension, mH/m, at 25°C	ISO 6295; ASTM D-2285	22	45
Mechanical contaminants size, micron		50	5
Oxidation stability: mg KOH/g	IEC 1125A; IEC 1125B; IP-307	---	0.2

### 3. PLANT'S DESIGN AND OPERATION

CMM-R comprises degassing and regeneration units.

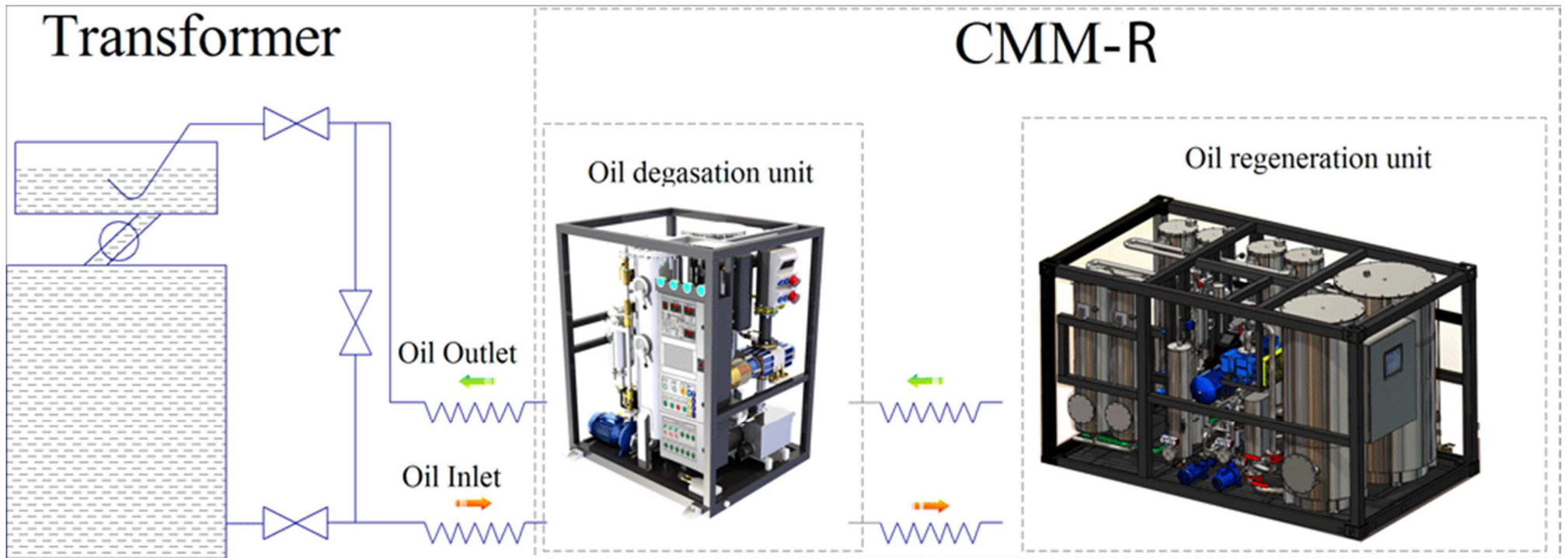
Plant's design allows for stationary as well as mobile operation when mounted on roadworthy trailer.

CMM-R is fully controlled via SCADA system from a Laptop positioned within the Operators compartment and a touchscreen on the control panel. Unit has automated mode with Air Compressor automated control system as well as manual operational mode.

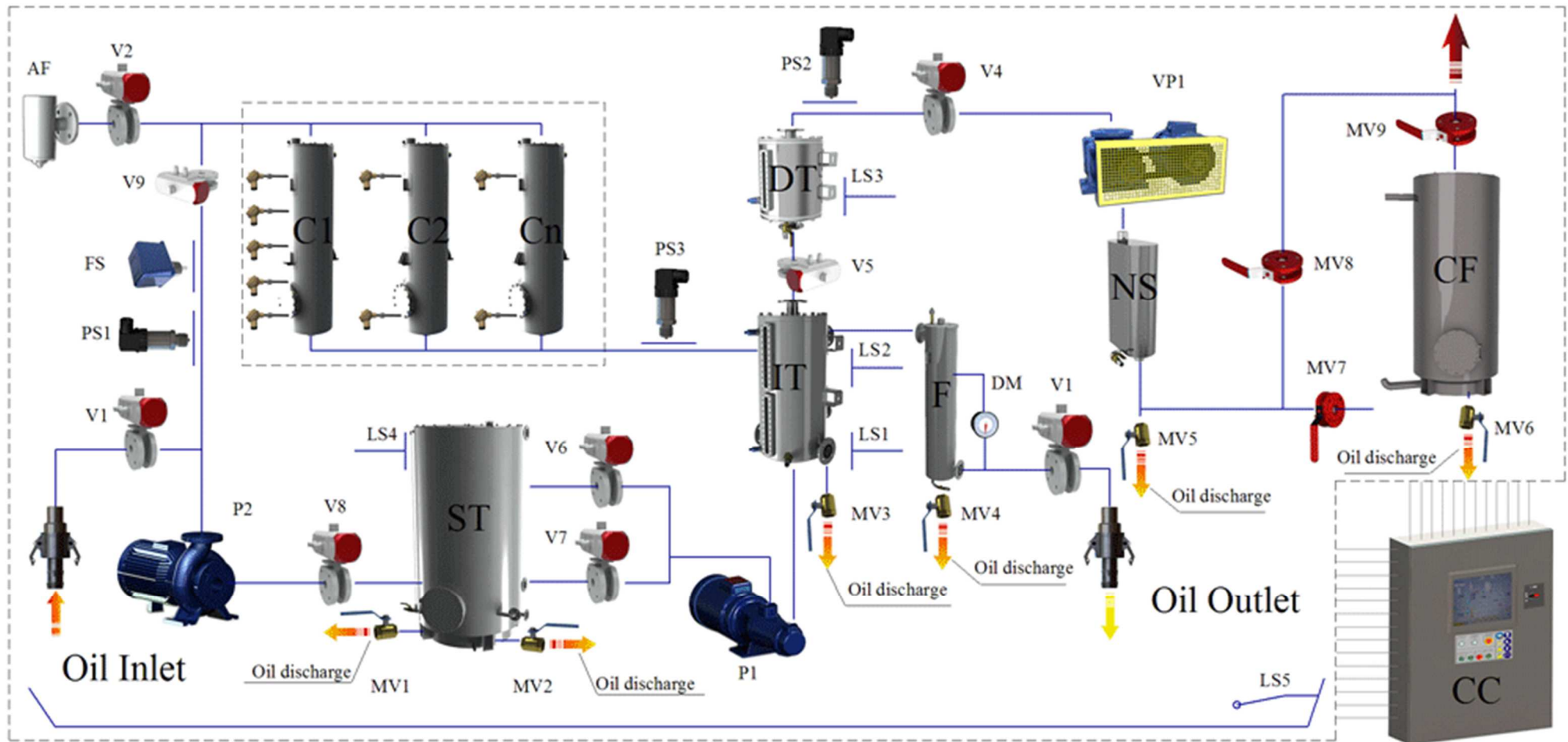
During operation degassing and regeneration units shall be connected to a transformer. Oil is drawn into degassing unit where it is heated to operational temperature and filtered. Oil is then pumped into regeneration unit and back to degasser for moisture and dissolved gasses removal.

Plant's design includes Fuller's Earth reactivation insitu for continuous reuse of Fuller's Earth. Fuller's Earth regeneration facility will allow oil processing to be carried out using 1 set of columns whilst the other set is reactivating. Alternatively oil processing or reactivation could be carried out in all columns.










## CONNECTION DIAGRAM



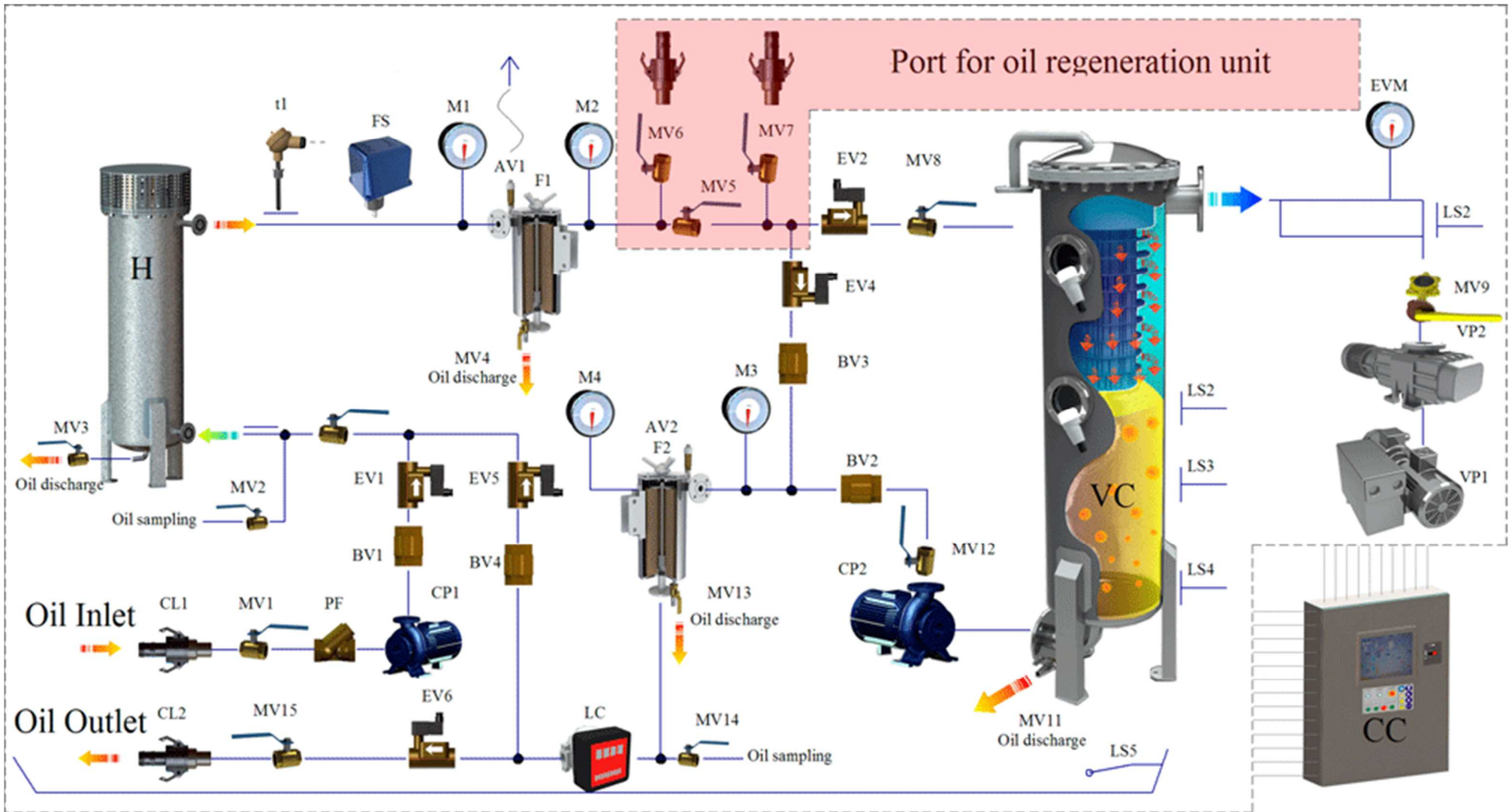
# REGENERATION UNIT FLOW DIAGRAM



C1-Cn – Fuller's Earth Column (number of columns depends on the capacity of the equipment), IT – Intermediate Tank, DT – Safety Tank (Oil Trap), NS – Noise Silencer, CF – Charcoal Filter, F – Filter, CC – Control Cabinet, ST – Oil Storage Tank, AF – Air Filter, PS1-PS3 – Pressure Transducer, VP1 – Vacuum Pump, P1 – P2 Oil Pumps, LS1 – LS4 – Level Sensors, LS5 – Leak Sensor, DM – Differential Pressure Gauge, V1 – V9 – Pneumatic Ball Valves, MV1 – MV9 – Manual Control Valve.








<b>REGENERATION UNIT MAIN COMPONENTS</b>	
	<b>FULLER'S EARTH COLUMN</b>
	Steel vessel containing cartridge with 150 kg of Fuller's Earth, sorbent heating device, filtering layer preventing column screen from clogging, and reactivation controlling temperature sensors. Number of Columns depends on Plant's capacity.
	<b>INTERMEDIATE TANK</b>
	Steel vessel sight glass and level sensors. Vessel allows for oil level control as well as for collection of impurities and subsequent disposal.
	<b>SAFETY TANK (OIL TRAP)</b>
	Serves as safety feature to prevent oil from being drawn into vacuum pump.
	<b>NOISE SILENCER</b>
	Steel vessel with sound insulation installed to reduce noise produced by vacuum system.
	<b>FINE FILTER</b>
	Fine filter installed in a steel vessel with nominal filtration fineness of 0,2 micron.
	<b>OIL STORAGE VESSEL</b>
	Steel vessel for storage of regenerated oil.
	<b>CONTROL CABINET</b>
	Control cabinet comprises electrical equipment and a touchscreen allowing to control the Plant via SCADA system.
	<b>VACUUM PUMP</b>
	Rotary vane vacuum pump used for reactivation of sorbent.
	<b>OIL PUMPS</b>
	Inlet and Outlet centrifugal pumps are utilized to draw oil into the Unit and back to transformer or external tank.

# DEGASSING UNIT FLOW DIAGRAM



VC- Vacuum Chamber; H -Oil Heater; CP<sub>1</sub> - CP<sub>2</sub> - Oil Pumps; MV<sub>1</sub>- MV<sub>16</sub> -Manual Ball Valve; BV<sub>1</sub> - BV<sub>7</sub> - Reverse Valve; F<sub>1</sub>,F<sub>2</sub> - Oil Filters; M<sub>1</sub> - M<sub>4</sub> - Pressure Gauges; EV<sub>1</sub>- EV<sub>6</sub> - Electrical Valve; LS<sub>1</sub> - LS<sub>5</sub> - Level Sensors; VP<sub>1</sub> - Vacuum Pump; VP<sub>2</sub> - Vacuum Booster; EVM - Digital Vacuum Gauge; R - Receiver; PF - Mesh Strainer; FS - Flow Relay; t<sub>1</sub>-t<sub>3</sub> - Temperature Sensor; CL<sub>1</sub> - Camlock on Inlet; CL<sub>2</sub> - Camlock on Outlet; AV<sub>1</sub> - AV<sub>2</sub> - Air Release Valve; LC - Flowmeter with Totalizer.



	<b>DEGASSING UNIT MAIN COMPONENTS</b>
	<b>VACUUM CHAMBER</b>
	<p>Vacuum Chamber Vessels and all internal parts are made of carbon steel and feature Coalescers, Sight Glass, Oil Level Controller, Foam Sensor and Vacuum Gauge. Vacuum Chamber's rigid design makes it suitable for stationary and mobile installation. Appropriate flexible connections are provided to the outlet pump and inlet pump to minimize negative effect of vibration during plant operation and transportation.</p>
	<b>OIL HEATER</b>
	<p>Oil Heater has three stage heating facility with. A low watt density heating elements (1.2 W/cm<sup>2</sup>) are used to prevent heat degradation of oil. The Heater is controlled by electronic temperature controller.</p>
	<b>OIL FILTERS</b>
	<p>A Mesh Strainer is provided to remove large particles that could cause damage to the Inlet Pump. 5 microns Coarse Filter is installed on entry to the Vacuum Chamber. Oil receives its final treatment by passing through the Fine Filter designed to remove 99.9% of particles larger than 2 microns or 1 micron (optional).</p>
	<b>CONTROL CABINET</b>
	<p>Control cabinet comprises electrical equipment and a touchscreen allowing to control the Plant via SCADA system.</p>
	<b>OIL PUMPS</b>
	<p>Inlet and Outlet centrifugal pumps are utilized to draw oil into the Unit and back to transformer or external tank.</p>
	<b>VACUUM PUMP</b>
	<p>Rotary vane vacuum pump with ultimate capability of 0.5 mbar.</p>
	<b>VACUUM BOOSTER</b>
	<p>Vacuum booster with ultimate capability of 0,01 mbar.</p>

#### 4. PLANT APPLICATION

GlobeCore’s Oil Regeneration Plants are design to carry out regeneration on energized and de-energized transformers as well as on tank to tank basis.

##### ***Regeneration of Oil in transformer***

Oil shall be taken and tested at the beginning of oil regeneration inside a transformer. The results will show duration (number of passes) required to regenerate the oil. Dissolved gas results will indicate whether transformer may be treated in energized or de-energized state.

Usually Regeneration Plant is used on 50 % to 80% of its production capacity while treating energized transformers to ensure laminar movement inside of transformer oil tank. With average oil characteristics it takes 8 to 10 passes to regenerate oil to “like new” conditions.

While treating de-energized transformers the Plant can be used on 100% of its production capacity.

##### ***Desludging***

Desludging of transformers requires oil temperature to be above aniline point usually around 80 C. Constant circulation of oil shall be maintained during desludging and oil must be new or regenerated.

This process will be more efficient on energized transformer as winding vibration and generated heat will also help to remove sludge. With average oil parameters it takes 10-20 passes to desludge energized transformer and up to 50 passes on de-energized transformer.

##### ***Tank to tank Regeneration***

After a time period when oil is left in a storage tank to settle out suspended solids and free water regeneration is carried out on 20-25% of the Plant’s production capacity to regenerate the oil to “like new” conditions in 1 pass.





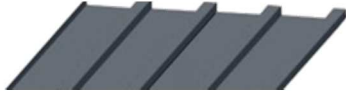
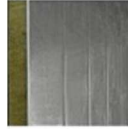




##### ***Available Models***

Model	Degassing Unit		Regeneration Unit	
	Model	Capacity l/hour	Model	Fuller’s earth amount, kg
CMM-6R/2000	UVM-3	2000	CMM-6R	800
CMM-12R/4000	UVM-4	4000	CMM-12R	1600
CMM-12R/6000	UVM-6	6000	CMM-12R	1600
CMM24R/10000	UVM-10	10000	CMM-24R	3600

*CMM-R Plants can be supplied with different from above production capacities if required. CMM-R capacities are measured in liters per hour in Degassing and Filtration modes, and in liters down through Fuller’s Earth in Regeneration mode. Capacity is calculated basing on initial oil acidity of 0,2mg KOH/g and is equal to 4 liters of regenerated oil per 1 kg of Fuller’s Earth. Amount of Fuller’s Earth required to treat oils with higher or lower acidity level will increase or decrease proportionally.*

## 5. OPTIONAL EQUIPMENT

### Mobility Options

<p>Units are built on two separate or one common open framed platform, designed suitable for installation inside a trailer or stationary indoors operations.</p> <p>Type A – Regeneration Unit Type B – Degassing Unit</p>	 <p style="text-align: center;">Type A</p>	 <p style="text-align: center;">Type B</p>
<p>Units are placed in sea freight containers.</p> <p>Type C is a 20 ft. sea freight container with steel side panels.</p> <p>Type D is a steel container with sandwich panel sides.</p>		
<p>Double Type E or single Type F doors installations are available as well as 20 ft. or 40 ft. sea freight containers. 40 ft. sea freight container comprises Regeneration and Degassing Unit and operator's, storage and laboratory compartments.</p>	 <p style="text-align: center;">Type C</p>	 <p style="text-align: center;">Type D</p>
<p>The System is mounted on a double axle roadworthy trailer and covered with tent.</p> <p>This option is available for CMM-2R and CMM-6R only.</p>	 <p style="text-align: center;">Type E</p>	 <p style="text-align: center;">Type F</p>
<p>CMM-R is mounted on triple axel semi-trailer.</p> <p>Trailer comprises Regeneration and Degassing Unit, operator's area and furniture to accommodate operator's laptop and laboratory equipment. Trailer comes with side door entrance, heater, air conditioner and aluminum staircase.</p>	 <p style="text-align: center;">Type G</p>	
		<p style="text-align: center;">Type H</p>

**System options**

***Transformer Level Monitor***

The Plant itself does not change oil level in the transformer tank. But if oil level drop in the transformer tank occurs, due to damaged pipes or seals, Transformer Level Monitor will shut down automatic valve installed at the bottom of the transformer and prevent oil drainage from the transformer.

***Generator***

Power generator provides ability to operate the plant without external power source.

***Cable Reel***

Manual or motorized cable reel with 50 m of cable is provided for ease of cable handling.


***Additive Injector***

To inject additives removed from oil during regeneration Additive Injector is provided.

***Moisture Analyser***

To continuously monitor moisture level in the treated Moisture Analyser is available with one or two probes for inlet only or for inlet and outlet. Analyser’s readings are displayed on operator’s laptop and on the control cabinet’s touchscreen. Alarms could be set for certain values to constantly monitor moisture level and alert operator if this values are higher than required.

**Consumables**

<p>Set of polypropylene coarse (5micron) and fine filters (0,2 micron) is provided as standard and sufficient for 5 years of operation.</p>	
<p>2 Sets of Spare Parts (one for Regeneration Unit and one for Degassing Unit) are supplied to ensure efficient and trouble free operation of the Plant.</p>	