

ADMIE TECHNICAL DESCRIPTION

TRANSFORMER OIL PURIFICATION & OIL REGENERATION PLANTS

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TRANSFORMER OIL PURIFICATION & OIL REGENERATION PLANTS

1. General Description

This call describes the required specifications and certifications of two plants, one mobile transformer oil purification plant and one stationary transformer oil regeneration plant. Each plant will be including all of the components required for their immediate stand-alone operation, matching the specifications described in the following paragraphs.

Candidates can provide offers for both plants but an individual offer for each plant is mandatory. Each of these two main plants can be supplied as multiple modules but the two main plants must not be supplied as a single construct, allowing the transformer oil purification plant and the transformer oil regeneration/reinhibition plant to each operate autonomously and independently. Offers that include both plants as a single sum will be disqualified.

The minimum requirements of each plant are described in the following paragraphs.

1.1 Standards

All parts and devices must be accompanied by a European declaration of conformity (CE) and, where applicable, be compliant with the following directives:

- Machinery Directive (MD) 2006/42/EC
- Low Voltage Directive (LVD) 2014/35/EU
- Electromagnetic Compatibility Directive (EMC) 2014/30/EU
- Pressure Equipment Directive (PED) 2014/68/EU
- Simple pressure vessels (SPVD) 2014/29/EU

The following standards appear in this call. The respective equipment must meet or surpass their minimum requirements and/or adhere to their testing methodology.

- ASTM D971
- IEC 60156
- IEC 60296
- IEC 60297
- IEC 60567
- IEC 60814

1.2 References

The manufacturer of the transformer oil purification plant system should be an established company, having sold at least ten similar plants during the past fifteen years

(sales list). In the case where the manufacturer does not meet the aforementioned number of sales, a recommendation letter from at least one EU-based customer who bought a similar plant during the past ten years is desired.

The manufacturer of the transformer oil regeneration system should provide at least two recommendation letters from consumers that have been using the regeneration system for at least a year.

1.3 Optional Equipment

This document describes the minimum requirements of the two plants and a few desired but optional parts. For either or for both of the two plants described in this document, candidates can attach a list of additional optional parts/features that are not mentioned in this document, such as additional safety equipment, sensors, or other features. The cost of each optional part/feature should be clearly and individually listed. Some, all, or none of these optional items may be selected to be included.

1.4 Training & Documentation

All equipment should be delivered with thorough operation and technical manuals, as well as full technical and flow diagrams. Flow diagrams should also be installed directly on the plants in the form of panels for the undemanding on-site operation of the system. A detailed maintenance manual thoroughly describing all servicing/repair procedures, as well as a list of parts, are required.

A full training programme for four individuals on the operation, servicing, and maintenance of all delivered equipment is mandatory. The training will take place at the premises of the customer. The training programme shall be submitted to the customer for approval at least one (1) month before the contractual delivery date of the equipment.

1.5 Warranty

The proper operation of all delivered parts will be guaranteed for at least a year after the delivery date.

1.6 Delivery

The equipment shall be delivered to the High Voltage Equipment Management department of the Independent Power Transmission Operator (IPTO or ADMIE) S.A., where a demonstration will take place. The department is located at Agias Annis 70, Egaleo, Athens, Greece.

2. Plant Specifications

2.1 *Transformer Oil Purification Plant*

2.1.1 Spatial Specifications

The transformer oil purification plant must be delivered in a closed frame designed for protection and transport. The plant must be capable of operating on-site and environmental conditions (i.e. rain, wind, etc.) must not compromise its safety and performance. In cases where the enclosure has wide doors, these should be lockable and capable of resisting high winds when fully open, or the unit should be capable of seamless operation with the doors fully closed.

The plant will be mounted on a trailer. The provision of a road-worthy trailer is desired but is optional and will not affect the selection process. As such, the trailer should be treated as an optional item and its cost should be listed separately. If the trailer itself is not provided or will not be selected, schematics of the plant that are required to construct an appropriate trailer must be provided. The total external dimensions of the plant, including its enclosure but excluding the trailer, should not exceed 6000 mm × 2440 mm × 3000 mm (Length × Width × Height). In case the trailer is included as an option, the maximum height of the trailer/plant assembly must not exceed 4000 mm. The dimensions of the oil regeneration plant refer to the core plant alone, with the enclosure's doors closed and readied for transport. Any additional related equipment that may be deployed during the operation of the plant, such as (but not limited to) gas burners, degassers, exhausts and/or exhaust filters, hoses, and feed pumps, are not included in that limit.

All metallic parts exposed to environmental factors shall be either hot dipped galvanized fulfilling the requirements of ISO 1461 or corrosion protected with a C4H painting/varnish system according to ISO 12944.

2.1.2 General Electrical Specifications

The input voltage of the system should be 3 ph / 400 V / 50 Hz, with a cable length of at least 5 meters. The system must have multiple oil heater power stages or electronic power control, allowing its adaptation to multiple treatment scenarios. The lowest possible power draw of the entire plant should be lower than 80 kVA, allowing its use for the treatment of small transformers where the power supply is limited.

2.1.3 Input/output Piping Specifications

The transformer oil purification plant must be equipped with two inputs and two outputs. All inputs and outputs should have two-inch or 50 mm piping couplers. Manual flow control valves must be present on all inputs and outputs.

A bypass valve between the input and the output of the transformer oil purification plant, or another method meant for emptying the connected hoses prior to disconnection from the transformer, is mandatory. The presence of a check valve at the output of the plant to prevent reverse flow in case of power cut/failure is mandatory.

The length of connection hoses shall be such that all operations described below are enabled without restrictions. Internal plant piping connections should be either welded or with flange connections. There should not be any threaded piping connections inside the oil purification plant.

2.1.4 Pump

The oil purification plant must be equipped with a vacuum-proofed pump capable of achieving an oil throughput of at least $8 \text{ m}^3/\text{h}$ during the degassing process. The input should be equipped with an automatic suction pump capable of operating without having to manually bleed the air out of the circuit. The input flow should at least be manually adjustable.

The feeding pump should be capable of operation with a distance of 40 meters and/or with a height difference of 15 meters between the oil purification plant and the transformer. The provision of an external feeding pump to support the plant in order to achieve these figures is acceptable, as long as that external feeding pump is directly connected to and controlled by the oil purification plant itself.

Automated control matching the input flow to the output flow is desirable. A sensor indicating the flow rate is required. A coarse ($\approx 30\text{-}150 \text{ }\mu\text{m}$) input filter is mandatory. The presence of an anti-clog mechanism is desired.

2.1.5 Heating system

The heating system must be equipped with heaters capable of achieving temperatures high enough for the oil purification plant to effectively purify and de-sludge the transformer's oil. The maximum power rating of the heating system must be greater than 120 kW.

Prevention of local overheating is necessary. Low watt density heaters are mandatory; the heat transfer surface should be adequate so as to prevent any chemical reactions from taking place. The maximum power density of the heaters should not exceed $1.4 \text{ W}/\text{cm}^2$. The maximum transformer oil temperature should not exceed 100 degrees Celsius at any point of the apparatus. The temperature of the oil should be monitored and controlled via a thermostat, with additional protection measures in case of a thermostat failure. Additionally, the heaters should be protected from overheating, such as in case the oil flow is not sufficient.

2.1.6 Vacuum & Degassing

The system should be equipped with a vacuum pump accompanied with a Roots vacuum booster for transformer evacuation. A secondary booster pump is desired. It is mandatory that the vacuum assembly and all associated parts to be highly resistant to volatiles and to humidity. A secondary valve for the direct connection to the transformer is required (transformer evacuation). The plant should have a pressure and a vacuum side.

It is desired that the primary vacuum line (including, if applicable, the booster pump) should have a theoretical suction capacity greater than $300 \text{ m}^3/\text{h}$. The theoretical suction capacity of the Roots pump arrangement should be greater than $1600 \text{ m}^3/\text{h}$. In real world applications, the system should be capable of achieving a pressure of at least 10^{-2} mbar in an 165 m^3 autotransformer in less than four hours of operation.

The system should be equipped with a sensor to prevent excessive foaming inside the vacuum chamber. The presence of an oil mist separator is desired. A vapors condenser is desired. A visual inspection aperture on the vacuum chamber is optional but desired.

After the degassing process, gas content should be lower than 0.3% according to the IEC 60567 standard. Water content should be decreased to less than 10 ppm, according to the IEC 60814 standard.

2.1.7 Filtering

There are no specific limitations regarding the positioning, type, and size of the transformer oil filters, as long as the filtering result after a single pass is equivalent or superior to the requirements described in this document. The filter should be equipped with a bleeder valve to allow for the air to escape prior to the filtration process. The desired particulate filter precision is $5 \mu\text{m}$. A clog sensor is mandatory.

The filter should be installed in such a way so as to prevent any oil leakage to the ground in case of accidental spillage.

2.1.8 Function

It is desired that the oil filtering plant will be capable of automated function, minimizing the possibility of human error. In this case, manual override and control functions are desirable. Any required personnel protection equipment needs to be included.

The oil purification plant should be capable of both online and offline operation, meaning that the plant should be capable to seamlessly function with the transformer operational or inoperative respectively. Oil desludging must be possible in either case. Explicitly for the case of online operation, the operation of the plant should not be hindered by the oil forced air forced (OFAF) cooling process of the transformers. The plant should be equipped with oil level monitoring systems, halting all processes if the oil level drops below a defined point for any given reason. Similarly, the vacuum chamber should be equipped with sensor reducing and/or halting the input flow according to the oil level in the chamber.

All motors should feature overload warning and protection mechanisms. In case of power loss, the plant should be capable of safely ending the process and shutting down. For safety, the plant should under no circumstances restart automatically after the power has been restored. The process should be restarted only via manual input.

2.1.9 Additional Analysis Equipment

The transformer oil purification plant should be equipped with mass moisture content sensor(s). The mass moisture content reading should be presented to the user in real time during the purification process.

The capability to measure the Dielectric Strength while the plant is operating is optional. Thermometers indicating the temperature of the oil should be present at both the input and the output of the plant.

Oil sampling valves should be present at the input and output of the oil purification plant.

2.1.10 Performance

After a single pass via the oil purification plant, the physicochemical properties of the oil should surpass the minimum acceptable figures according to both IEEE and IET standards. The following table indicates the expected performance and may be used as a reference.

Parameter	Expected Property After a Single Pass
Mass moisture content (IEC 733)	< 10 ppm
Gas content	< 0.3%
Dielectric Strength (IEC 156)	> 60 kV

2.1.11 Spare Parts

The transformer oil purification plant will be delivered alongside with consumables and spare parts to last for at least three years of service.

Indicatively, the following spare parts should be included:

- Filters (coarse & fine stages).
- Gaskets (full sets per pump).
- Ceramic vacuum pump gaskets (where applicable).
- Shaft seals, and other consumables.

2.2 *Transformer Oil Regeneration Plant*

2.2.1 Spatial Specifications

The transformer oil regeneration plant must be delivered in a chassis designed for protection, metallic, with locking doors. The plant must be capable of operating outdoors and environmental conditions (i.e. rain, wind, etc.) must not compromise its safety and performance. The plant is purported to be mainly used in stationary mode at the premises of the customer.

The total external dimensions of the plant, including its enclosure, should not exceed 6000 mm × 2440 mm × 3500 mm (Length × Width × Height).

All metallic parts exposed to environmental factors shall be either hot dipped galvanized fulfilling the requirements of ISO 1461 or corrosion protected with a C4H painting/varnish system according to ISO 12944.

2.2.2 General Electrical Specifications

The input voltage of the system should be 3 ph / 400 V / 50 Hz, with a cable length of at least 5 meters. The maximum power draw of the entire plant should not exceed 150 kVA.

2.2.3 Input/output Piping Specifications

The transformer oil regeneration system must be equipped with manual flow control valves on both the input and the output. A bypass valve between the input and the output of the regeneration system, or another method meant for emptying the connected hoses prior to disconnection from the tank, is mandatory. The presence of a check valve at the output of the plant to prevent reverse flow in case of power cut/failure is mandatory.

2.2.4 Pump

The oil regeneration plant must be equipped with a vacuum-proofed pump capable of achieving an oil throughput of at least $1 \text{ m}^3/\text{h}$. The input should be equipped with an automatic suction pump capable of operating without having to manually bleed the air out of the circuit. The input flow should at least be manually adjustable. A sensor indicating the flow rate is required. A coarse ($\approx 30 \text{ }\mu\text{m}$) input filter is mandatory. Automated control matching the input flow to the output flow is desirable. The presence of an anti-clog mechanism is desired.

2.2.5 Heating system

The heating system must be equipped with heaters capable of achieving temperatures high enough for the oil purification plant to effectively purify the treated oil. Prevention of local overheating is necessary. Low watt density heaters are mandatory; the heat transfer surface should be adequate so as to prevent any chemical reactions from taking place. The maximum transformer oil temperature should not exceed 90 degrees Celsius at any point of the apparatus. The temperature of the oil should be

monitored and controlled via a thermostat, with additional protection measures in case of a thermostat failure. Additionally, the heaters should be protected from overheating, such as in case the oil flow is not sufficient.

2.2.6 Vacuum & Degassing

The system must be equipped with a vacuum pump. The presence of a vacuum booster is optional. It is mandatory that the vacuum assembly and all associated parts to be highly resistant to volatiles and to humidity. The system should be equipped with a sensor to prevent excessive foaming inside the vacuum chamber.

After the degassing process, gas content should be lower than 0.03% according to the IEC 60567 standard. Water content should be decreased to less than 10 ppm, according to the IEC 60814 standard.

2.2.7 Filtering

There are no specific limitations regarding the positioning, type, and size of the transformer oil filters, as long as the filtering result after three passes is equivalent or superior to the requirements described in this document. The filter should be equipped with a bleeder valve to allow for the air to escape prior to the filtration process. The desired particulate filter precision is 5 μm . A clog sensor is mandatory.

The filter should be installed in such a way so as to prevent any oil leakage to the ground in case of accidental spillage. The presence of an appropriate exhaust air filter and/or a gas burner is mandatory so as to prevent air pollution while the plant is operating, taking into account that the plant will operate inside a residential urban site.

2.2.8 Fuller's Earth

The oil regeneration plant's capacity of Fuller's Earth adsorbent should be greater than 1000kg. The diameter of each adsorbent column should not be greater than 400 mm. There is no limitation regarding the number of columns. In any case, the dimensioning of the absorbent columns (diameter and number) is in the full responsibility of the manufacturer, in order to achieve optimized performance in terms of heat transfer, as well as to ensure the longevity of the adsorbent and the system as a whole.

The plant must be capable of reactivating the adsorbent at least 150 times before saturation. After its end of serviceable life, the adsorbent must not be a dangerous waste and its disposal should be environmentally friendly.

2.2.9 Oil Losses

The oil losses during the regeneration process should not be greater than 6%, whereas the waste oil should not be greater than 3% of the total oil processed.

2.2.10 Function

It is desired that the oil regeneration plant will be capable of semi-automated function, requiring minimal human inputs. Ideally, the operation of the regeneration plant

after a regeneration cycle begins should be completely unattended. In the case of automated operation, manual override and control functions are desirable. Any required personnel protection equipment needs to be included.

All motors should feature overload warning and protection mechanisms. In case of power loss, the plant should be capable of safely ending the process and shutting down. For safety, the plant should under no circumstances restart automatically after the power has been restored. The process should be restarted only via manual input.

2.2.11 Performance

After three passes via the regeneration plant, the physicochemical properties of the oil should surpass the minimum acceptable figures according to both IEEE and IET standards. The following table indicates the expected performance of the two systems assuming an input oil acidity of 0.2 mg KOH/g and may be used as a reference. After regeneration, CCD (IEC 62535) and ECD (IEC 62697-1) analyses must indicate that there is no corrosive sulfur in the oil.

Parameter	Expected Property After a Single Pass
Interfacial tension (ASTM D971)	> 32 dynes/cm
Acidity (IEC 296)	< 0.04 mg KOH/g oil
Oxidizing Steadiness	Fully recovered
Tan Delta (90 IEC 297)	< 0.006
Mass moisture content (IEC 733)	< 10 ppm
Gas content	< 0.3%
Dielectric Strength (IEC 156)	> 60 kV
Mud	< 0.1% (% mass)
Color	Pale or Sparkling Yellow

2.2.12 Spare Parts

All equipment will be delivered alongside with consumables and spare parts to last for at least three years of service.

Indicatively, the following spare parts should be included:

- Filters (coarse & fine stages).
- Gaskets (full sets per pump).
- Ceramic vacuum pump gaskets (where applicable).
- Shaft seals, and other consumables.
- Fuller's earth columns.

3. APPENDIX A

All candidates are required to fill the following form and attach it alongside with their detailed offer:

3.1 *Transformer Oil Purification Plant*

1 Input pump manufacturer(s)

2 Input pump(s) rated capacity (m³/h)

3 Heater power stages (quantity & kW)

4 Vacuum pump(s) manufacturer

5 Vacuum pump(s) rated capacity (m³/h)

6 Roots pump(s) manufacturer

7 Roots pump(s) rated capacity (m³/h)

8 Maximum oil output temperature (°C)

9 Oil temperature thermostat mechanism (description)

10 Foaming sensor type

11 Flow sensor(s) type

12 Oil filter(s) type

13 Expected maintenance cycles & consumables (description)

14 Length of warranty

3.2 *Transformer Oil Regeneration Plant*

1	Input pump manufacturer(s)	_____
2	Input pump(s) rated capacity (m ³ /h)	_____
3	Heater power stages (quantity & kW)	_____
4	Vacuum pump(s) manufacturer	_____
5	Vacuum pump(s) rated capacity (m ³ /h)	_____
6	Sorbent capacity (kg)	_____
7	Sorbent regeneration cycle (hours)	_____
8	Expected sorbent lifetime (reactivation cycles)	_____
9	Oil overheating safety mechanism (description)	_____
10	Foaming sensor type	_____
11	Flow sensor(s) type	_____
12	Oil filter(s) type	_____
13	Expected maintenance cycles & consumables (description)	_____
14	Length of warranty	_____