

User Manual

Python program and its interface for transformer oil analysis
based on IEEE Standard C57.106-2015

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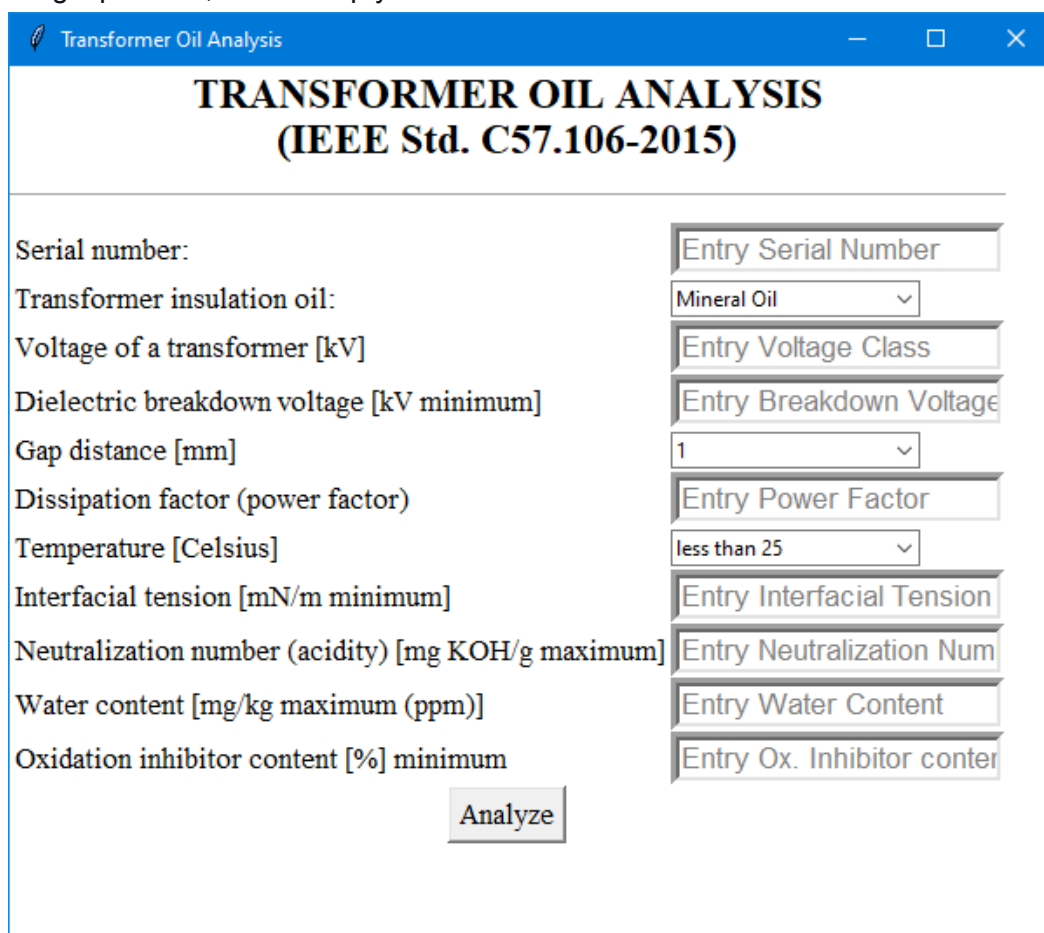
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1. Program Interface

The GUI python program was developed for transformer oil analysis based on IEEE Standard C57.106-2015. The main purpose is to get several parameters of transformer oil, check its current state condition and give the recommendations, when it is needed. The condition assessment uses suggested limits for continued use of in-service mineral oil (Table 3 of the Standard). The program can evaluate the condition of transformers in different voltage classes. The voltage classes are divided into three main groups:

- under 69 kV;
- between 69 and 230 kV;
- above 230 kV.

When the program has launched, an user can see the initial frame, which is shown in the Fig.1, for receiving input data, where empty entries are commented.



The screenshot displays the 'Transformer Oil Analysis' window. The title bar is blue with the text 'Transformer Oil Analysis' and standard window controls. The main content area has a white background with the title 'TRANSFORMER OIL ANALYSIS (IEEE Std. C57.106-2015)' in bold black text. Below the title, there are ten input fields arranged in two columns. The left column contains labels for each parameter, and the right column contains the corresponding input boxes. The parameters and their input types are: Serial number (text entry), Transformer insulation oil (dropdown menu with 'Mineral Oil' selected), Voltage of a transformer [kV] (text entry), Dielectric breakdown voltage [kV minimum] (text entry), Gap distance [mm] (dropdown menu with '1' selected), Dissipation factor (power factor) (text entry), Temperature [Celsius] (dropdown menu with 'less than 25' selected), Interfacial tension [mN/m minimum] (text entry), Neutralization number (acidity) [mg KOH/g maximum] (text entry), Water content [mg/kg maximum (ppm)] (text entry), and Oxidation inhibitor content [%] minimum (text entry). At the bottom center, there is an 'Analyze' button.

Parameter	Input Type
Serial number:	Entry Serial Number
Transformer insulation oil:	Mineral Oil (dropdown)
Voltage of a transformer [kV]	Entry Voltage Class
Dielectric breakdown voltage [kV minimum]	Entry Breakdown Voltage
Gap distance [mm]	1 (dropdown)
Dissipation factor (power factor)	Entry Power Factor
Temperature [Celsius]	less than 25 (dropdown)
Interfacial tension [mN/m minimum]	Entry Interfacial Tension
Neutralization number (acidity) [mg KOH/g maximum]	Entry Neutralization Num
Water content [mg/kg maximum (ppm)]	Entry Water Content
Oxidation inhibitor content [%] minimum	Entry Ox. Inhibitor conter

Analyze

Fig.1. The initial frame for input data

Some of the inputs require clarification, namely:

Serial number. It is the serial number of the transformer to be tested. The entry can accept both symbols and numbers as input data. It serves as a distinction between one transformer and another.

Transformer Insulation Oil. It is an insulating oil type of the transformer. The goal of the project was to test a mineral oil of transformers, so, currently, only "Mineral Oil" can be selected as an input. If another parameter is selected, then an information window gives the warning message in the Fig.2.

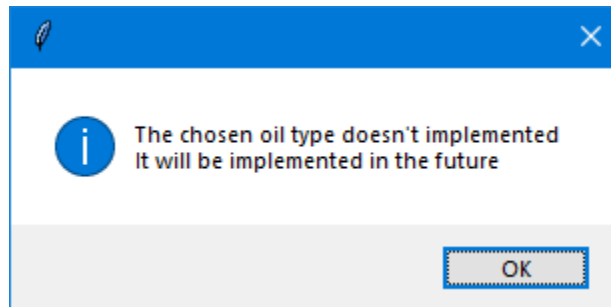


Fig.2. Warning message about insulating oil type.

Voltage of a transformer. It is an operating voltage of the transformer. The voltage value is entered in kilovolts. Besides, the window takes values in rational numbers, so, for example, values of 0.4 kV or 0.220 kV are also accepted.

Gap distance. According to the method of measuring the breakdown voltage of the dielectric of insulating liquids, the standard implies the use of spherically-shaped electrodes. The "Gap distance" is the distance between the electrodes. The user can choose between "1" or "2" cell or type their numbers. For the mineral oil type, only these numbers are available. The gap distance beyond 1 or 2 mm can be used for other insulating oil types beyond this course project.

Temperature. It is the measured temperature of the insulating oil of the transformer at the time of the test. It can be remained with the choice "more than 25" or "less than 25". Also, the user can type their number on it.

All the input parameters, except for the serial number, must be entered using numbers. Both integers and floats are accepted. In the case of using inappropriate values (for example, letters or signs), an information window appears with the message in the Fig.3.

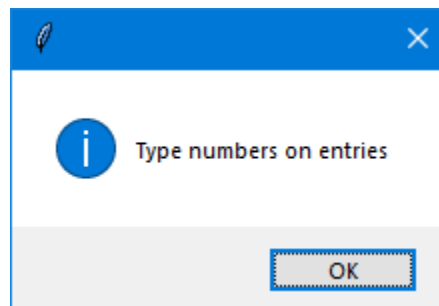


Fig.3. Warning message about wrong entry.

2. Test runs

According to the IEEE Standard C57.106-2015, after each parameter is checked, there are 3 possible outcomes of the recommendations. Each recommendation case is checked below.

The program can be tested with the parameters typed in the Fig.4.

Parameter	Value
Serial number:	0XSD-3034-DW78
Transformer insulation oil:	Mineral Oil
Voltage of a transformer [kV]	11
Dielectric breakdown voltage [kV minimum]	25
Gap distance [mm]	1
Dissipation factor (power factor)	0.2
Temperature [Celsius]	less than 25
Interfacial tension [mN/m minimum]	27
Neutralization number (acidity) [mg KOH/g maximum]	0.15
Water content [mg/kg maximum (ppm)]	25
Oxidation inhibitor content [%] minimum	0.09

Analyze

Fig.4. The program interface with the input parameters from test 1.

The program's operation for the Fig. 4 is shown in the Fig.5, where time and general information are presented, each parameter is checked and a recommendation is given. If a parameter is within a limit, then it is marked with a green color. If it is out of the limit, then it is marked with a red color. If a recommendation is positive, then it is marked with green. If a recommendation is negative, it is marked with red. The Fig.5 demonstrates that all parameters are within the limits and gives the first recommendation outcome after classifying the mineral oil with the class 1. Thus, they are marked with the green color.

Transformer Oil Analysis	
ANALYSIS RESULTS	
Date: 14/04/2021 Time: 19:00:44 Serial Number: 0XSD-3034-DW78 Insulation Material: Mineral Oil Voltage of a transformer [kV]: 11.0	
Parameters' states	
Dielectric breakdown voltage is in satisfactory condition	
Dissipation factor is in satisfactory condition	
Interfacial tension is in satisfactory condition	
Neutralization number is in satisfactory condition	
Water content is in satisfactory condition	
Oxidation inhibitor content is in satisfactory condition	
Recommendations:	
Class I mineral oil Mineral oil is in satisfactory condition.	

Fig.5. The result of the Fig.4.

If the dielectric breakdown voltage is decreased to 20kV as revealed in the Fig.6, then the program classifies the mineral oil with the class 2 and gives the second possible recommendation outcome, which is presented in the Fig.7. The dielectric breakdown voltage is out of the preferred range, so it is marked with red. The importance of this recommendation is, also, marked with the green color.

Transformer Oil Analysis

TRANSFORMER OIL ANALYSIS (IEEE Std. C57.106-2015)

Serial number:	0XSD-3034-DW78
Transformer insulation oil:	Mineral Oil
Voltage of a transformer [kV]	11
Dielectric breakdown voltage [kV minimum]	20
Gap distance [mm]	1
Dissipation factor (power factor)	0.2
Temperature [Celsius]	less than 25
Interfacial tension [mN/m minimum]	27
Neutralization number (acidity) [mg KOH/g maximum]	0.15
Water content [mg/kg maximum (ppm)]	25
Oxidation inhibitor content [%] minimum	0.09

Analyze

Fig.6. The modified dielectric breakdown voltage from the Fig.4.

Transformer Oil Analysis

ANALYSIS RESULTS

Date: 14/04/2021
Time: 19:03:06
Serial Number: 0XSD-3034-DW78
Insulation Material: Mineral Oil
Voltage of a transformer [kV]: 11.0

Parameters' states

Dielectric breakdown voltage is not in satisfactory condition

Dissipation factor is in satisfactory condition

Interfacial tension is in satisfactory condition

Neutralization number is in satisfactory condition

Water content is in satisfactory condition

Oxidation inhibitor content is in satisfactory condition

Recommendations:

Class II mineral oil
Mineral oil needs to be reprocessed by mechanical filtration such as filter pressing, vacuum dehydration or similar technique.

Fig.7. The result of the Fig.6.

When the dissipation factor from the Fig.6 is increased from 0.2 to 0.6 in the Fig.8, the third outcome highlights the violation of the constraint and importance of the recommendation for the class 3 mineral oil with the red color. They are presented in the Fig.9.

Transformer Oil Analysis

TRANSFORMER OIL ANALYSIS

(IEEE Std. C57.106-2015)

Serial number:

0XSD-3034-DW78

Transformer insulation oil:

Mineral Oil

Voltage of a transformer [kV]

11

Dielectric breakdown voltage [kV minimum]

20

Gap distance [mm]

1

Dissipation factor (power factor)

0.6

Temperature [Celsius]

less than 25

Interfacial tension [mN/m minimum]

27

Neutralization number (acidity) [mg KOH/g maximum]

0.15

Water content [mg/kg maximum (ppm)]

25

Oxidation inhibitor content [%] minimum

0.09

Analyze

Fig.8. The modified dissipation factor from the Fig.6.

Transformer Oil Analysis

ANALYSIS RESULTS

Date: 14/04/2021

Time: 19:04:33

Serial Number: 0XSD-3034-DW78

Insulation Material: Mineral Oil

Voltage of a transformer [kV]: 11.0

Parameters' states

Dielectric breakdown voltage is not in satisfactory condition

Dissipation factor is not in satisfactory condition

Interfacial tension is in satisfactory condition

Neutralization number is in satisfactory condition

Water content is in satisfactory condition

Oxidation inhibitor content is in satisfactory condition

Recommendations:

Class III mineral oil

Mineral oil should be reclaimed using Fuller's earth or an equivalent method.

Fig.9. The result of the Fig.8.