"Bodh", BPIT's International Journal of Technology & Management

ISSN: 2454-8421, Volume 1, Issue 1, July-Dec, 2015. *Page 19-27*

BBIJTM

HEALTH INDEXING OF POWER TRANSFORMERS

KUSHAGRA GUPTA,

Bhagwan Parshuram Institute of Technology, EEE 3 YEAR,

Rohini, New Delhi.

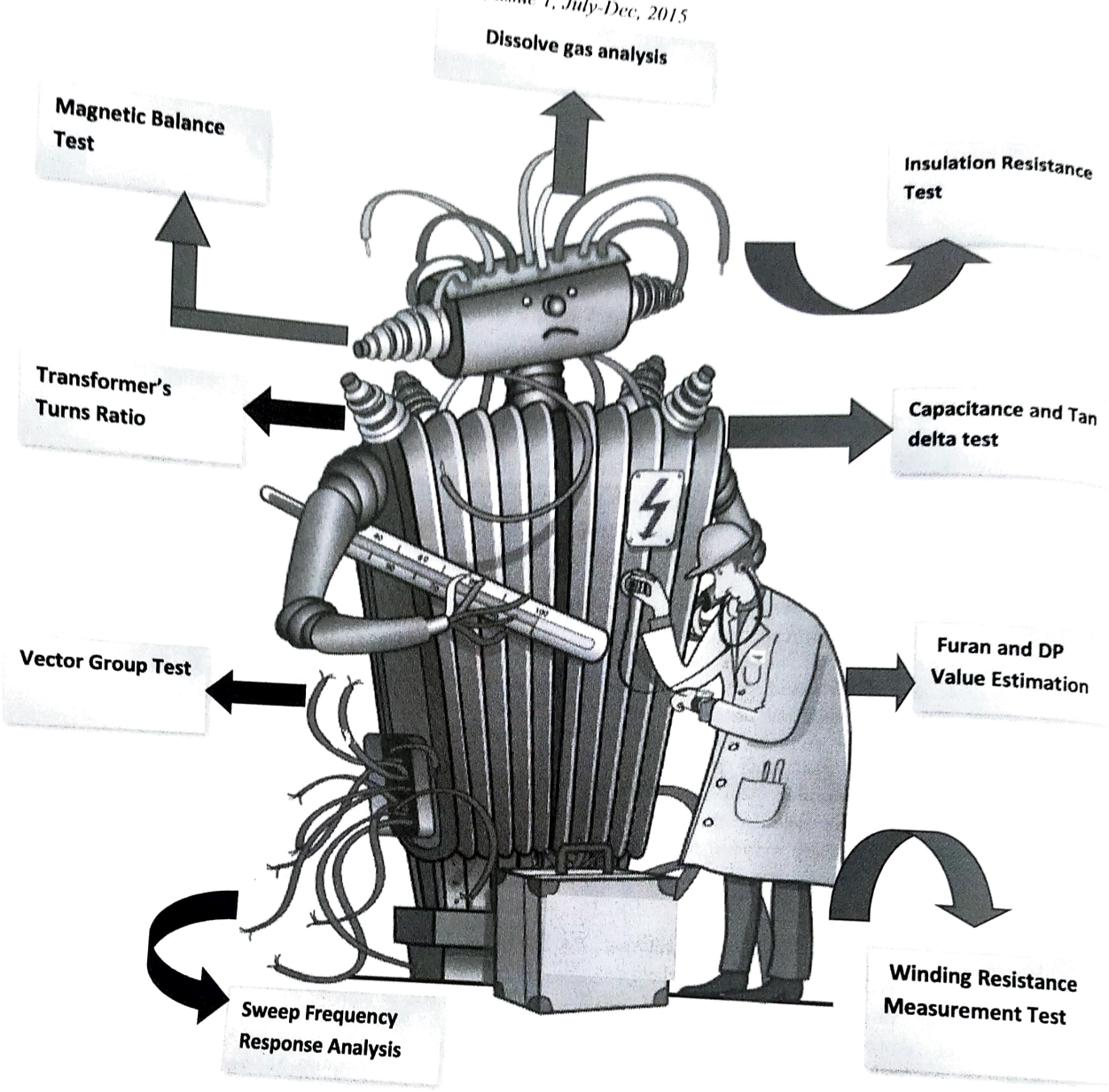
ABSTRACT

Power transformer is the major asset of any power system. Transformers represent **extensive investment** in any power delivery system, and because of the notable effect of a transformer outage on system reliability, **careful management** of this type of **asset** is **critical**. In many cases, **unexpected transformer outages can be catastrophic** and cause both direct and indirect costs to be incurred by industrial, commercial, and residential sector. So it becomes **mandatory to assess** the **health and remaining lifetime** of a **working power transformer**. This information plays a very important role in the planning strategies of power delivery systems and in the avoidance of the potentially appalling effects of unexpected transformer outages.

This paper presents different condition monitoring methods and condition assessment techniques which include various electrical tests and oil analysis of power transformer. Finally the **flowchart** for health indexing and evaluation of remaining life of a power transformer **considering the year of its manufacturing is presented taking into consideration the cumulative effect of the tests performed.**

It is a **new approach** to health indexing and estimating its percent residual life. **Traditionally** health indexing is done on the basis of results of **one or two tests** which may give **false results**. Now it is proposed that transformer should be **monitored** for two to three months **according to the flowchart** before taking it out from the network for maintenance.

INTRODUCTION: Health index is a practical tool that combines the results of routine inspections, and site and laboratory testing to estimate the aging or health condition of power transformers. It can be defined as number from 0 to 100 or in the form of zones as **red**, **yellow** and **green** depending upon the aging condition of a power transformer. Tests necessary for **health Indexing** and estimating percent residual power transformer are: Insulation resistance test, dissipation factor test, dissolve gas analysis, furan test and DP value estimation, SFRA.



VARIOUS TESTS PERFORMED ON POWER TRANSFORMER

Absorption index (AI) = (IR value after 60 seconds) / (IR value after 15 seconds)

Polarization index (PI) = (IR value after 600 seconds) / (IR value after 60 seconds)

LIMITATION OF I.R. TEST:

When IR value is greater than 5 Giga ohms then PI may not be the indicator of the insulation condition and is therefore not recommended as the life assessment tool for the transformer.

Source: IEEE standard no. 43-2000

HEALTH INDEXING BY POLARISATION INDEX (PI) CRITERION Table 1.3

Serial no.	PI limits	Health zone	Remarks
1.	<1	RED	Insulation has reached its life
2.	1.0-1.3	YELLOW	Accelerated aging. Conduct test frequently
3.	1.3-2.0	GREEN	Normal aging. Continue testing at regular defined frequency
4.	>2	GREEN	Healthy

PERMISSIBLE TAN DELTA (DISSIPATION FACTOR) VALUES: Table 2.1

Serial no.	Age of transformer in years	Tan delta limit (DF %)
1.	0-4	<0.8
2.	5-10	0.8-1.0
3.	>10	1.0-2.0

*allowance of 100 % is provided in case of older transformers (reference TPDDL testing manual)

Table 2.2

Serial no.	Case	Remarks
1.	Tan delta value in UST mode exceeds limit	Problem in oil insulation. Confirm by oil analysis.
2.	Tan delta value in GST L-guard mode exceeds limit	Problem in HV winding insulation. Confirm by IR test and Furan test
3.	Tan delta value in GST H-guard mode exceeds limit	Problem in LV winding insulation. Confirm by IR test and Furan test
4.	Tan delta values in limit for all the modes.	Transformer is healthy. Continue testing at regular defined interval.

Note:

1. After test if tan delta value(s) exceed limits it is recommended that test should be performed again after inductive heating of transformer because moisture in oil can largely affect the tan delta values.
2. If the tan delta values exceed limits even after inductive heating then we can conclude that there is problem in oil or paper insulation.
3. Any further comment on the health or residual life of insulation can only be made after oil analysis, Furan and DP value estimation.
4. No doubt the correction factor table for dissipation factor is given but it is recommended to perform the test at temperature around 20 degrees Celsius only.

HEALTH INDEXING ON THE BASIS OF ROGER'S RATIO TEST RESULTS Table 3.5

Serial no.	Roger's ratio result	Health zone	Remarks
1.	In limits	GREEN	Transformer is healthy
2.	CH4/H2 ratio violates limit	YELLOW	Retesting required within 2 mo
3.	C2H2/C2H4 ratio violates limit	RED	Maintenance required (onsite o offsite accordingly)
4.	CH4/H2 and C2H2/C2H4 ratios violate limits	RED	Maintenance required (onsite o offsite accordingly)

ACCEPTANCE LIMITS OF DISSOLVED GASES Table 3.1

Sr.no	P.TRANSFORMER AGE → / TYPE OF GAS ↓	0-4 years	5-10 years	More than 10 years
1.	H2	150	300	500
2.	CH4	30	80	130
3.	C2H2	15	30	40
4.	C2H4	30	50	150
5.	C2H6	30	50	110
6.	CO	300	500	700
7.	CO2	4000	5000	10000

DETECTION OF FAULT ON THE BASIS OF ROGER'S RATIO TEST RESULTS (Table 3.3)

Case	Characteristic fault	C2H2/C2H4	CH4/H2	C2H4/C2H6
PD	Partial discharge	NS	<0.1	<0.2
D1	Discharge of low energy	>1	0.1-0.5	>1
D2	Discharge of high energy	0.6-2.5	0.1-1.0	>2
T1	Thermal fault T< 300	NS	>1	<1
T2	Thermal fault 300<T<700	<0.1	>1	1.0-4.0
T3	Thermal fault T>700	<0.2	>1	>4

PERMISSIBLE LIMITS OF ROGER'S GAS RATIOS (Table 3.4)

Roger's ratio	0-4 years	5-10 years	More than 10 years
C2H2/C2H4	<0.50	<0.60	<0.27
CH4/H2	>0.20	>0.27	>0.27

Sr. no.	Gas	Generation rate of gas limit (ppm/month)
1.	H2	10
2.	CH4	8
3.	C2H2	3
4.	C2H4	8
5.	C2H6	8
6.	CO	70
7.	CO2	700

RATE OF GAS GENERATION LIMITS: table (3.6)

HEALTH INDEXING ON THE BASIS OF FURAN CONTENT AND DP VALUE

Table 4.1

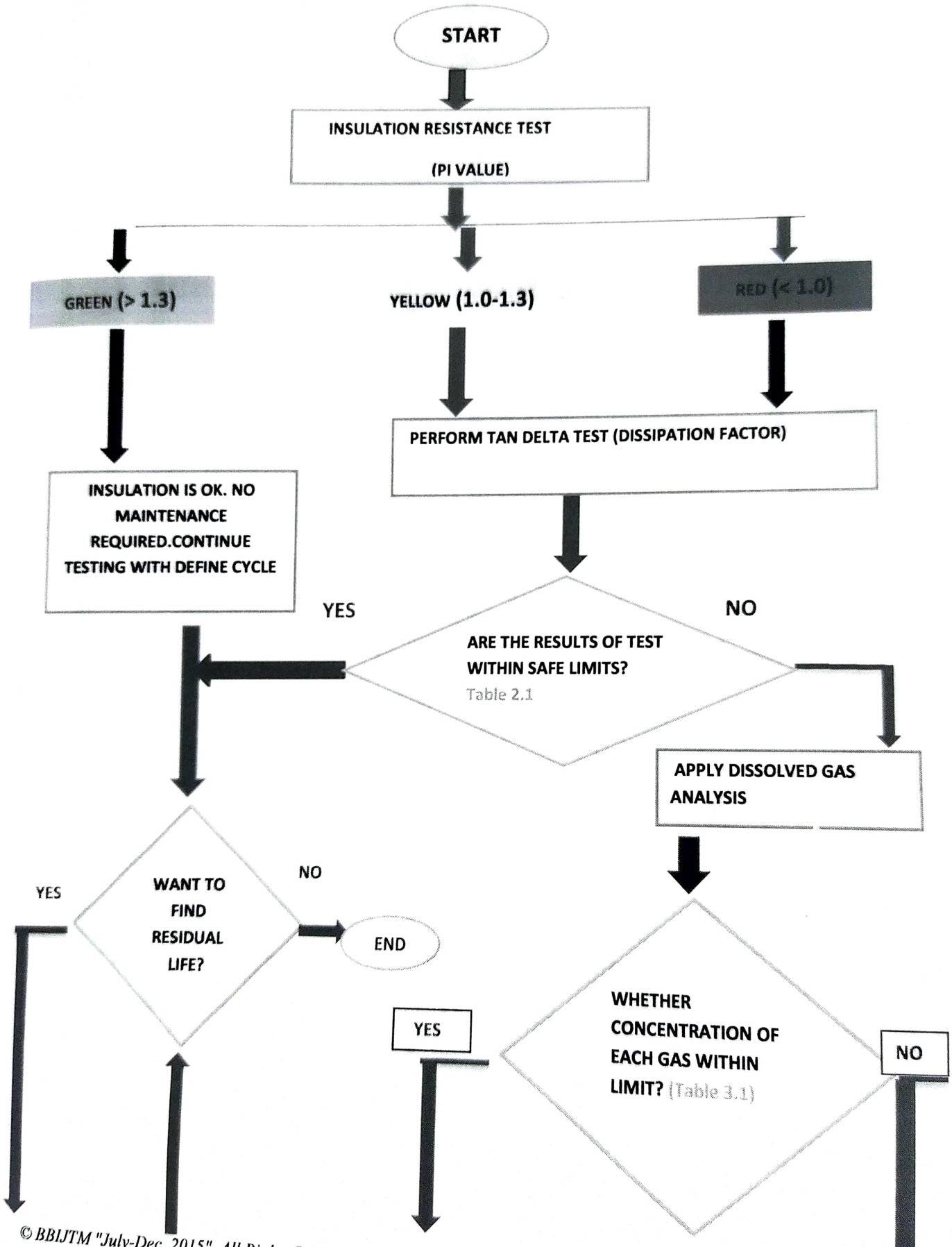
2-FAL(ppb)	DP value	Health zone	Remarks
50-500	>600	GREEN	Healthy
500-2000	350-600	GREEN	Normal aging. Continue testing at define cycle of 1 year
2000-4000	200-350	YELLOW	Excessive aging. Do testing within 6 months.
>4000	<200	RED	Transformer should be sent for repair

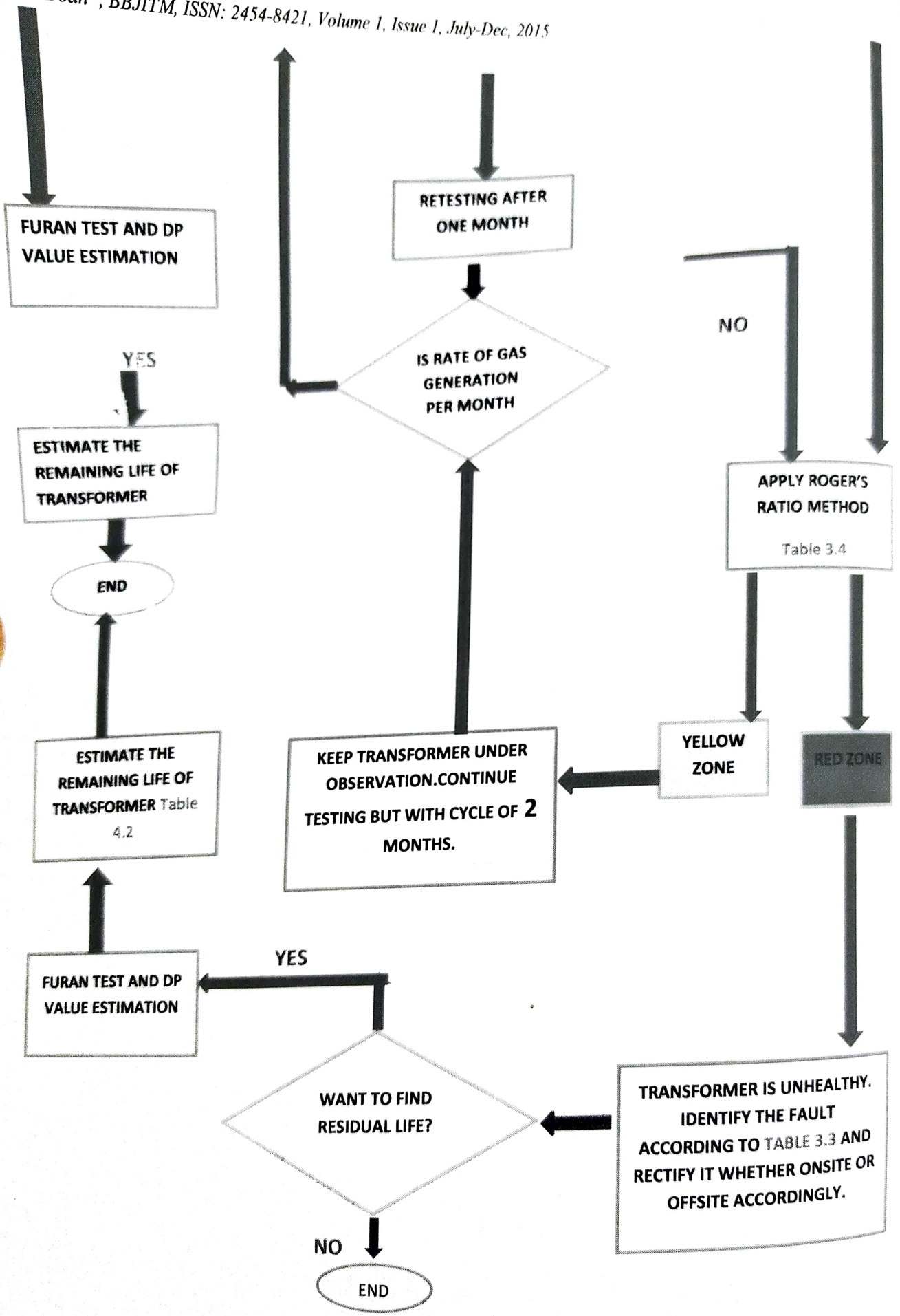
REMAINING LIFE ESTIMATION ON THE BASIS OF FURAN CONTENT AND DP VALUE:

Table 4.2

2-FAL(ppb)	DP value	Estimated % remaining life	Interpretation
50-300	>600	100-70	Normal aging
350-2000	500-350	70-40	Accelerated aging rate
2000-3000	340-300	40-24	Excessive aging (danger zone)
3000-4500	300-250	25-20	High risk of failure
>5000	<200	<1	End of expected life

*2-FAL is 2-Furaldehyde compound





REFERENCES:

- Source of table 1.3 : according to Appendix A.1.2 IEEE
- Source of table 3.6 - "Comparative Study and Analysis of DGA Methods for Transformer Mineral Oil," IEEE Lausanne Power Tech pp. 45-50, 2007
- Source of table 4.2 "An Introduction to the Hal-Century Transformer" by the Transformer Maintenance Institute, S.D.Meyers Co. 2002.
- Table 3.1, 3.3, 3.4, and 3.6 according to CPRI standards.