TRANSFORMER MAINTENANCE

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Deliberation Domain

Transformer types and constructions

Transformer main components

Maintenance Aspects

Transformer Types

A1: Single Phase

A2: Three Phase

B1: Shell Type

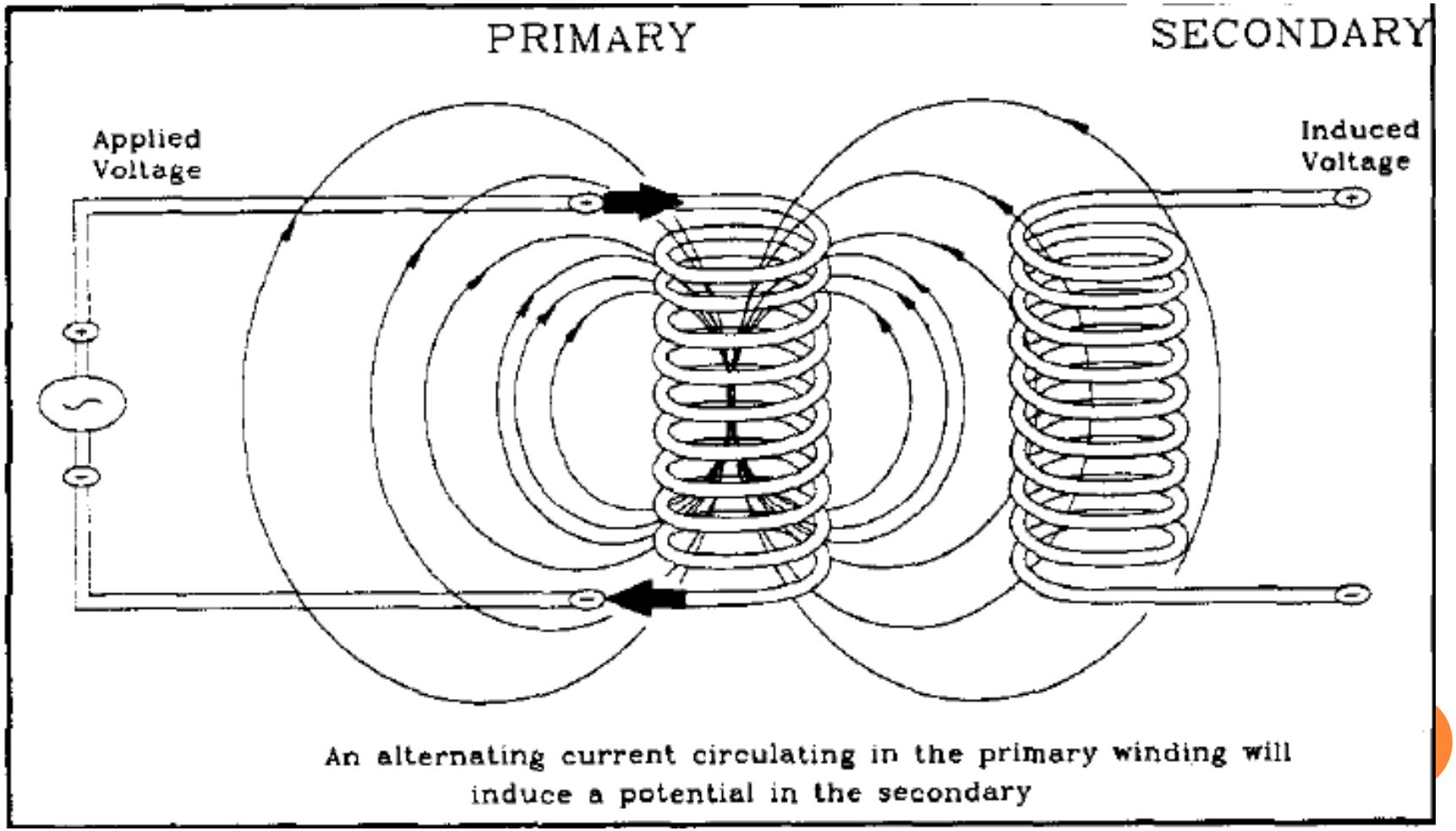
B2: Core type

C1: Two winding

C2: Three or more Windings

D: Special type transformers

TRANSFORMER BASICS

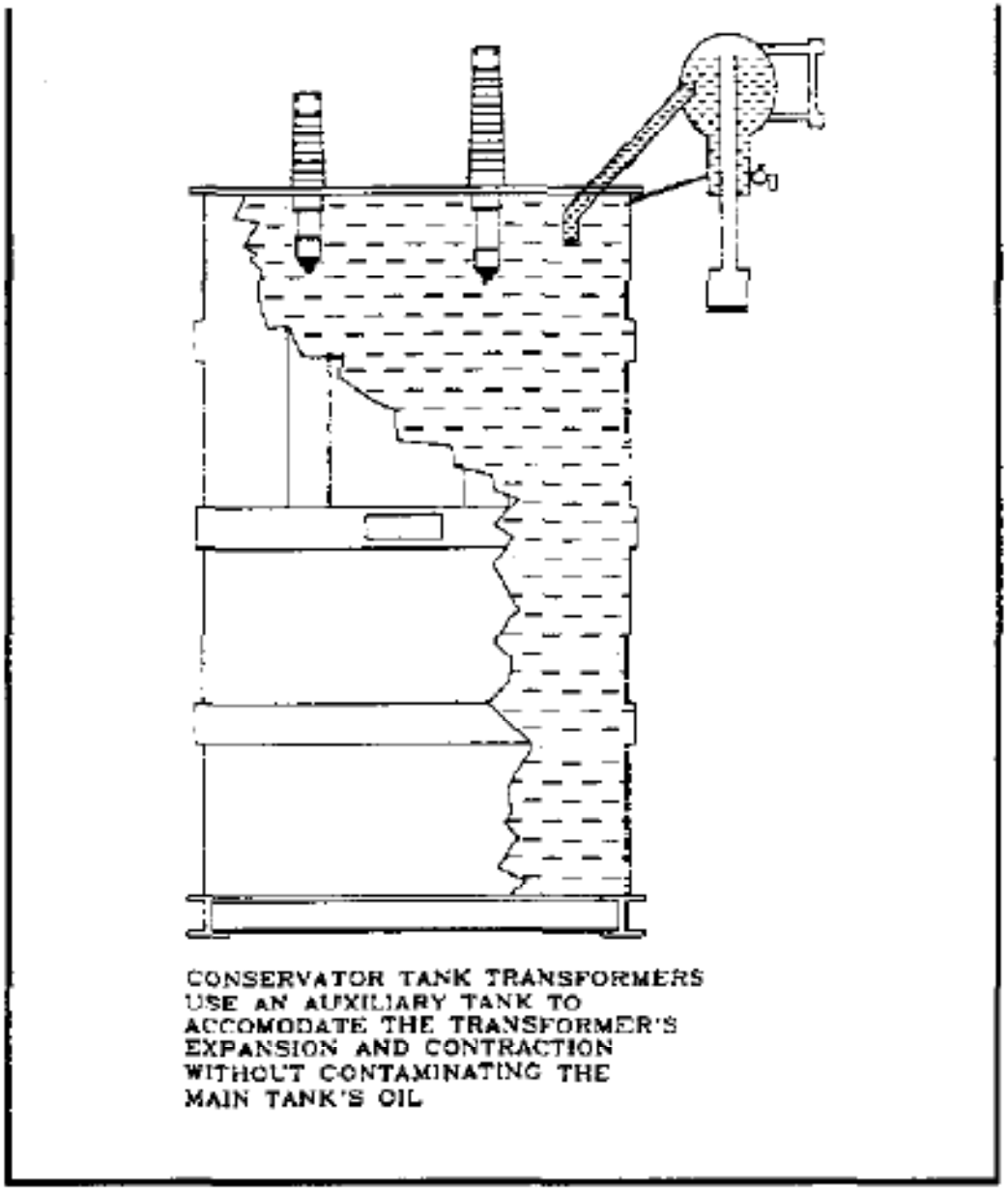


An alternating current circulating in the primary winding will induce a potential in the secondary

Transformer Types

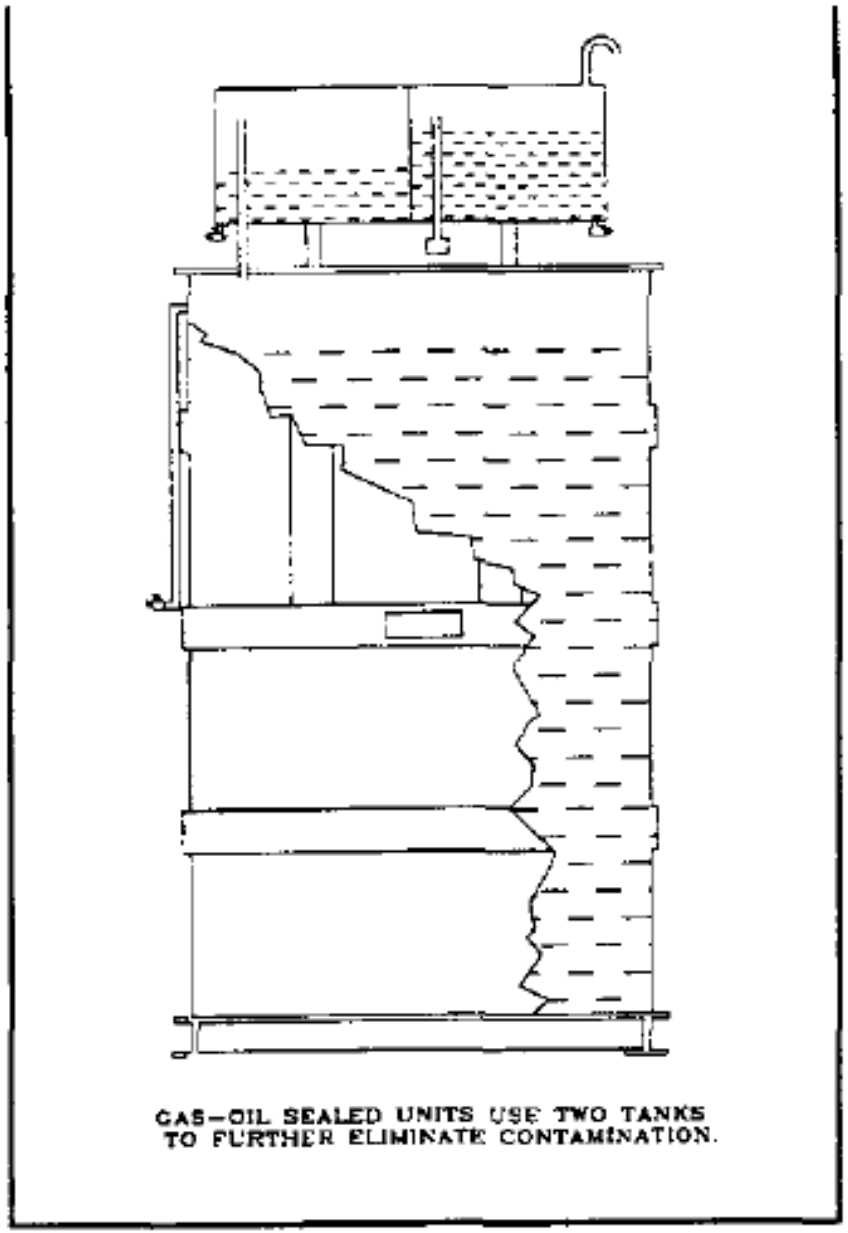
- 1 : Dry type
- 2: Oil filled
  - A: Air breathing
  - B: Gas Oil sealed
  - C: Gas sealed

Air breathing



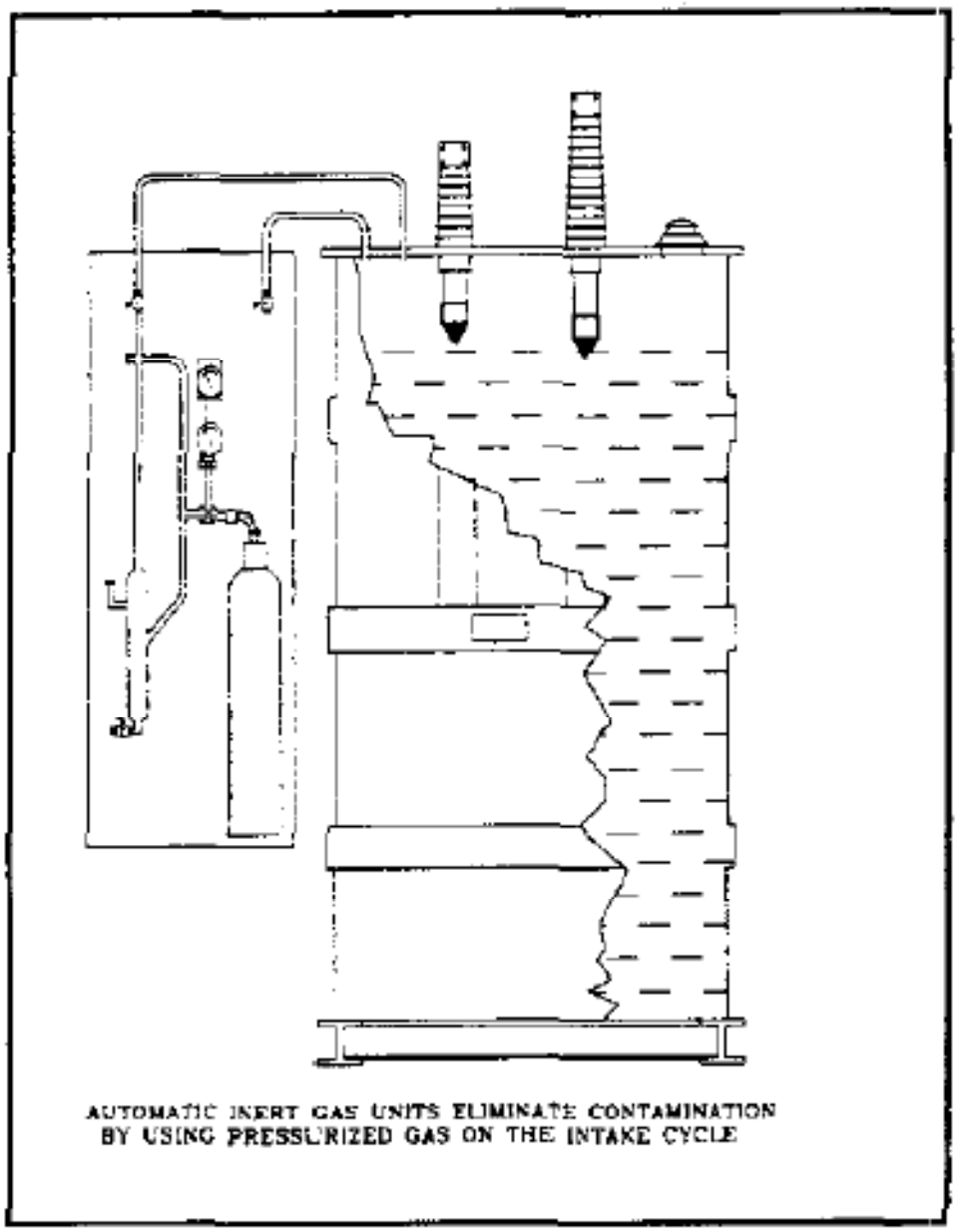
CONSERVATOR TANK TRANSFORMERS USE AN AUXILIARY TANK TO ACCOMODATE THE TRANSFORMER'S EXPANSION AND CONTRACTION WITHOUT CONTAMINATING THE MAIN TANK'S OIL

Gas-Oil Sealed



GAS—OIL SEALED UNITS USE TWO TANKS TO FURTHER ELIMINATE CONTAMINATION.

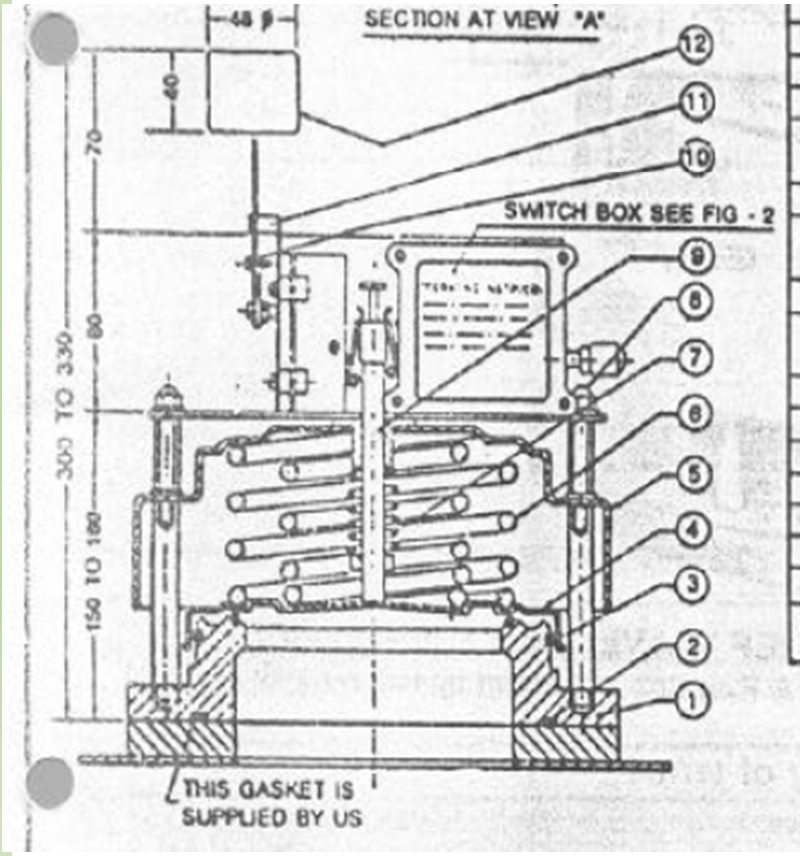
Gas Sealed

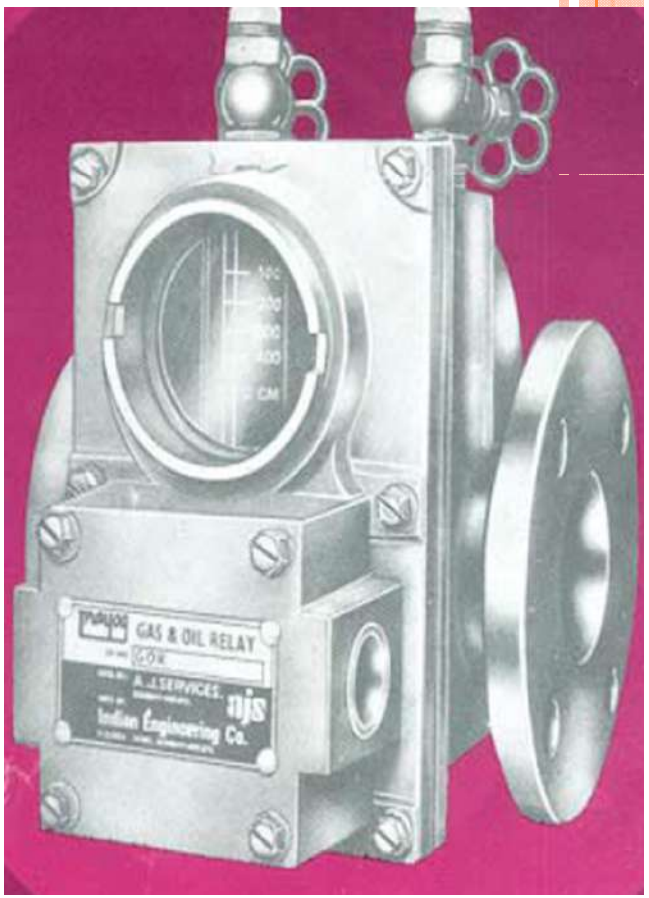


AUTOMATIC INERT GAS UNITS ELIMINATE CONTAMINATION
BY USING PRESSURIZED GAS ON THE INTAKE CYCLE

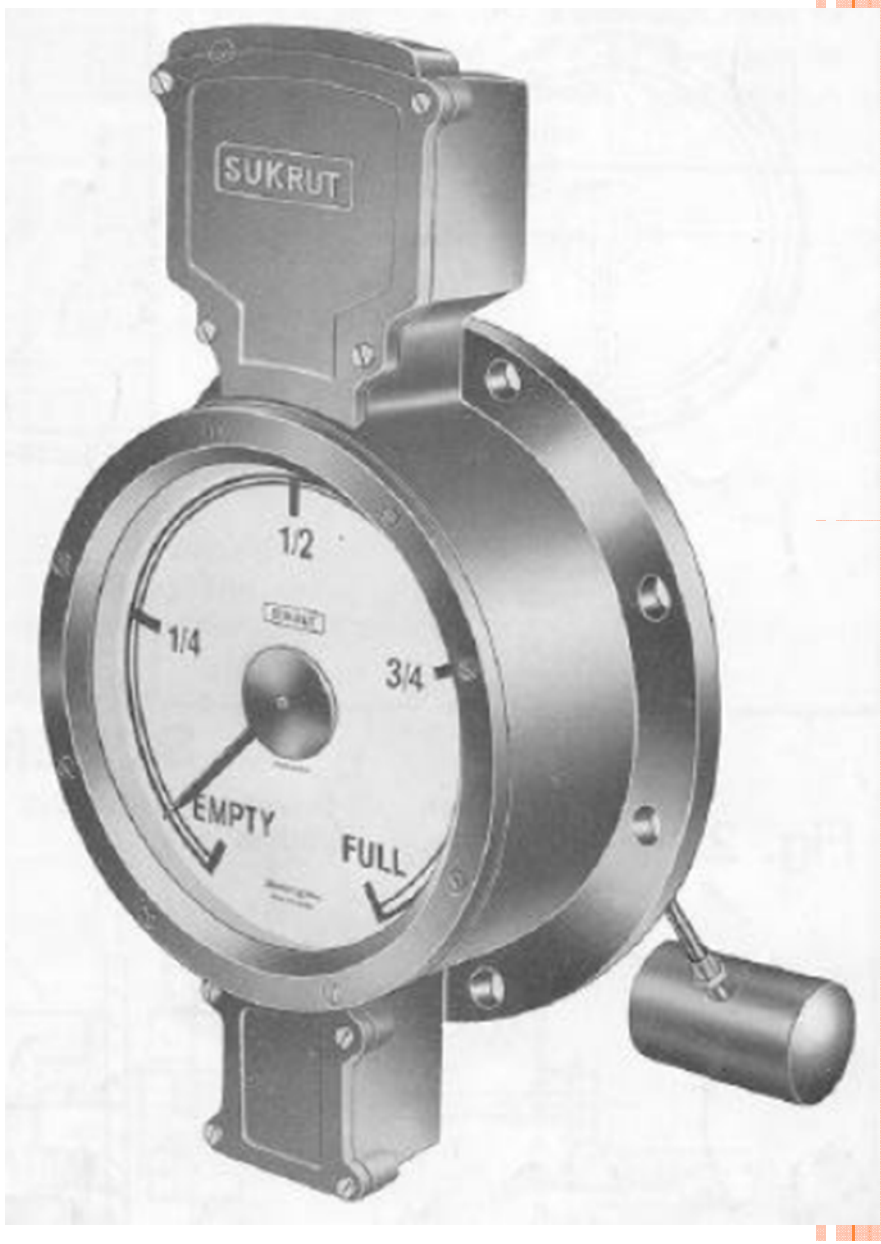
Transformer Accessories

- PRV
- Buchholz Relay
- Oil Surge Relay(for OLTC)
- Fans
- Oil Pumps
- Air cell/air bag
- Bushings
- Oil Gauge

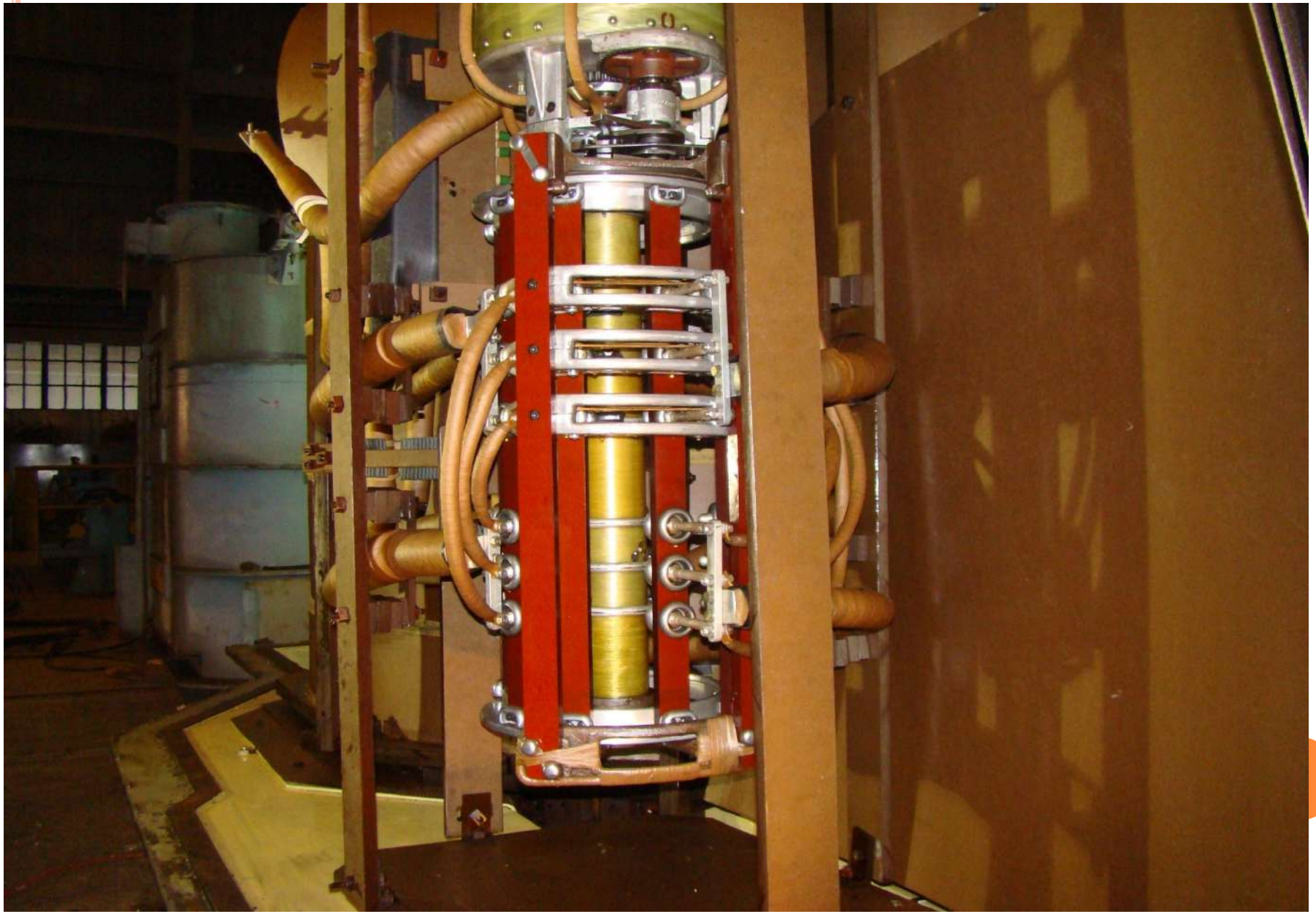

SECTION AT VIEW "A"
48
40
70
80
150 TO 180
300 TO 330
12
11
10
SWITCH BOX SEE FIG - 2
9
8
7
6
5
4
3
2
1
THIS GASKET IS
SUPPLIED BY US


GAS & OIL RELAY
Indian Engineering Co.

transformer temperature



OLTC Selector switch



Maintenance of oil filled transformer

- Breakdown Maintenance
- Periodic Maintenance
- Condition Based Maintenance
- Proactive Maintenance

Break down MTC: Root Causes

- Fans problem
  - Bearing wornout/damaged
  - Winding burnt
- Control circuit problems
  - Contactor burnt
  - Over heated connections
  - Incorrect BMR setting
- Entry of moisture
  - Into buchholz, PRV
  - Fans, pumps
- Oil Leakages
  - Gasketted joints
  - Welded joints

Periodic MTC: Basic Test

- Winding ratio
- Winding resistance
- Magnetising current
- Capacitance and Tan delta
  - Bushings
  - Windings
- Leakage reactance
- Core insulation
- Insulation resistance
- Dissolved gas analysis
- Furfural/furan analysis

- Winding ratio
  - Used to detect interturn faults
  - Open circuits
- Winding resistance
  - High resistance
  - Loose connections
- Magnetising current
  - Short turns
  - Magnetic circuit problems

- C and Tan delta
- Capacitance of winding changes with the change in geometry
  - Between winding and ground
  - Between core and tank
  - Bushings
  - Tan delta changes due ingress of moisture and other foreign material/dust

LEAKAGE REACTANCE

- Short circuit impedance of transformer measured.
- It indicates the integrity of the total windings
- Must be measured carefully.
- Variation from previous reading should not be more than 5%

Core Insulation and Insulation measurement

- Core and Yolks are separately grounded at one point only
- Multiple ground causes localised circulation of current and thus creating hot spots.
- Ensuring good insulation resistance is mandatory. (Generally tested with 500V)
- IR value of transformer winding for EHV transformers is being carried out at 5kV
- IR values to be measure between
  - HV to LV
  - HV to earth
  - LV to earth

Condition based Mtc Tools

- Dissolved Gas analysis
- Partial discharge measurement
  - Electrical
  - Acoustic
- Thermal scanning
- FRA
- Furan/furfural measurement
- Frequency domain spectroscopy

DISSOLVED GAS ANALYSIS

- Helps in ascertaining the type of fault in transformer
- Severity of fault
- Main fault gases
  - Hydrogen- indicates partial discharge
  - Ethelene (C_2H_4)- Thermal heating of joints/core etc
  - Acetylene (C_2H_2)- presence of arcing in the transformer
  - CO/CO_2 with above gases: Indicate involvement of paper insulation

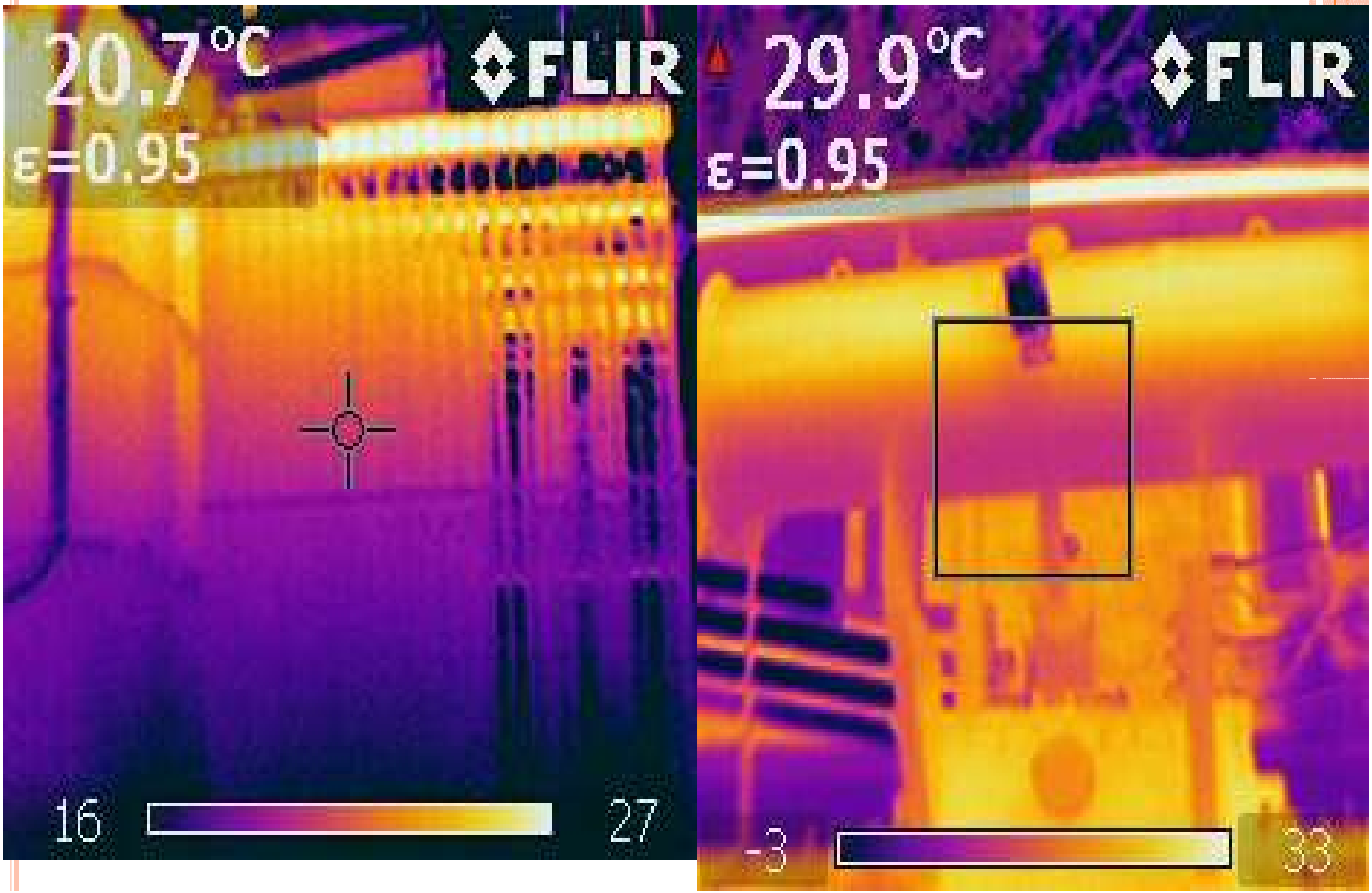
Troubleshooting Chart	
Detected Gases	Interpretations
a) Nitrogen plus 5% or less oxygen	Normal operation, good seals
b) Nitrogen plus 5% or more oxygen	Check seals for tightness
c) Nitrogen, carbon dioxide, or carbon monoxide, or all	Transformer overloaded or operating hot causing some cellulose breakdown. Check operating conditions
d) Nitrogen and hydrogen	Corona, discharge, electrolysis of water, or rusting
e) Nitrogen, hydrogen, carbon dioxide and carbon monoxide corona discharge involving cellulose or severe overloading	
f) Nitrogen, hydrogen, methane with small amounts of ethane and ethylene	Sparking or other minor fault causing some breakdown of oil
g) Nitrogen, hydrogen, methane with carbon dioxide, carbon monoxide and small amounts of other hydrocarbons; acetylene is usually not present	Sparking or other minor fault causing breakdown of oil
h) Nitrogen with high hydrogen and other hydrocarbons including acetylene	High energy arc causing rapid deterioration of oil
I) Nitrogen with high hydrogen, methane, high ethylene and some acetylene j) same as (I) except carbon dioxide and carbon monoxide present.	High temperature arcing of oil but in a confined area; poor connections or turn-to-turn shorts are examples same as (I) except arcing in combination with cellulose

Examples of faults detectable by DGA

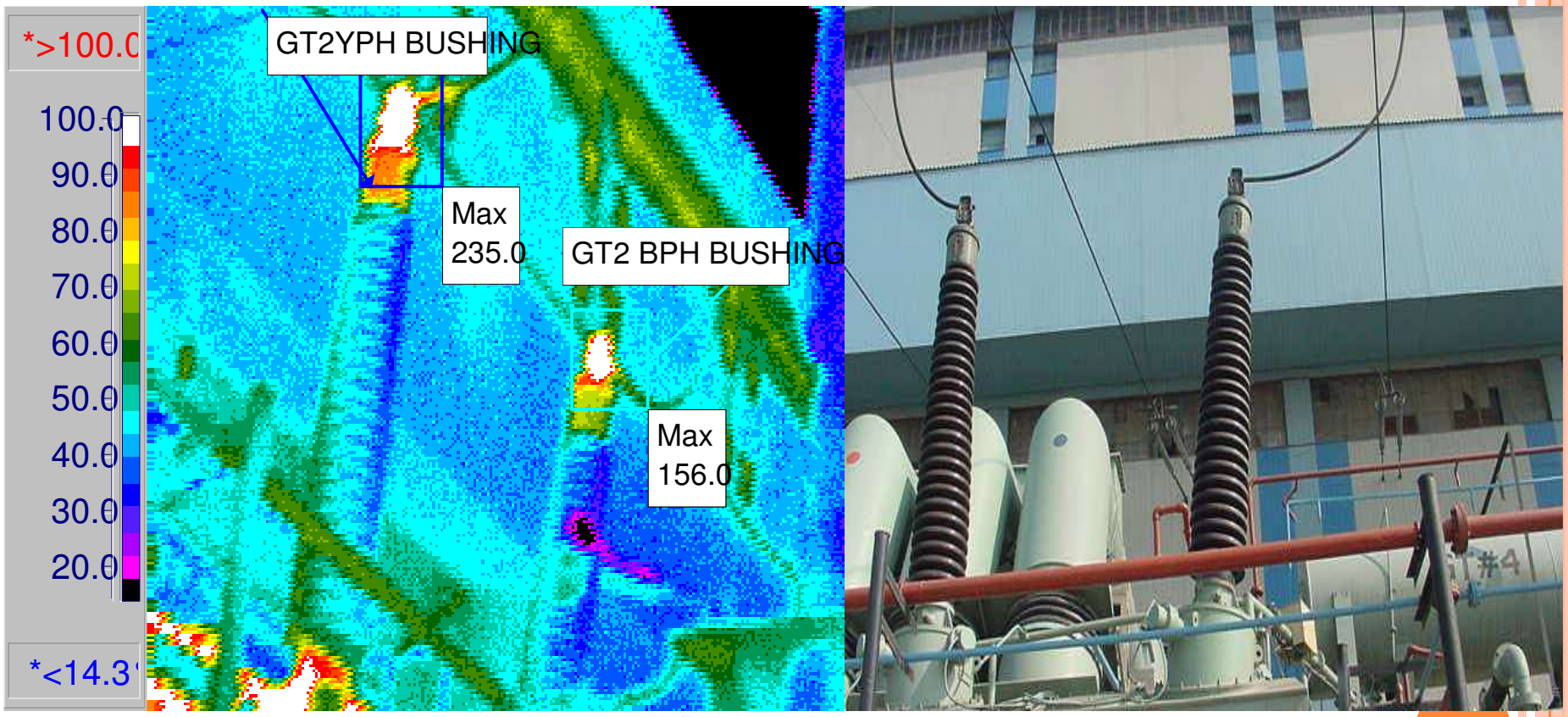
Symbol	Fault	Examples
PD	Partial discharges	Discharges of the cold plasma (corona) type in gas bubbles or voids, with the possible formation of X-wax in paper.
D1	Discharges of low energy	Partial discharges of the sparking type, inducing pinholes, carbonized punctures in paper. Low energy arcing inducing carbonized perforation or surface tracking of paper, or the formation of carbon particles in oil.
D2	Discharges of high energy	Discharges in paper or oil, with power follow-through, resulting in extensive damage to paper or large formation of carbon particles in oil, metal fusion, tripping of the equipment and gas alarms.
T1	Thermal fault, T <300 °C	Evidenced by paper turning brownish (> 200 °C) or carbonized (> 300 °C).
T2	Thermal fault, 300 <T<700 °C	Carbonization of paper, formation of carbon particles in oil.
T3	Thermal fault, T >700 °C	Extensive formation of carbon particles in oil, metal coloration (800 °C) or metal fusion (> 1000 °C).

THERMAL SCANNING

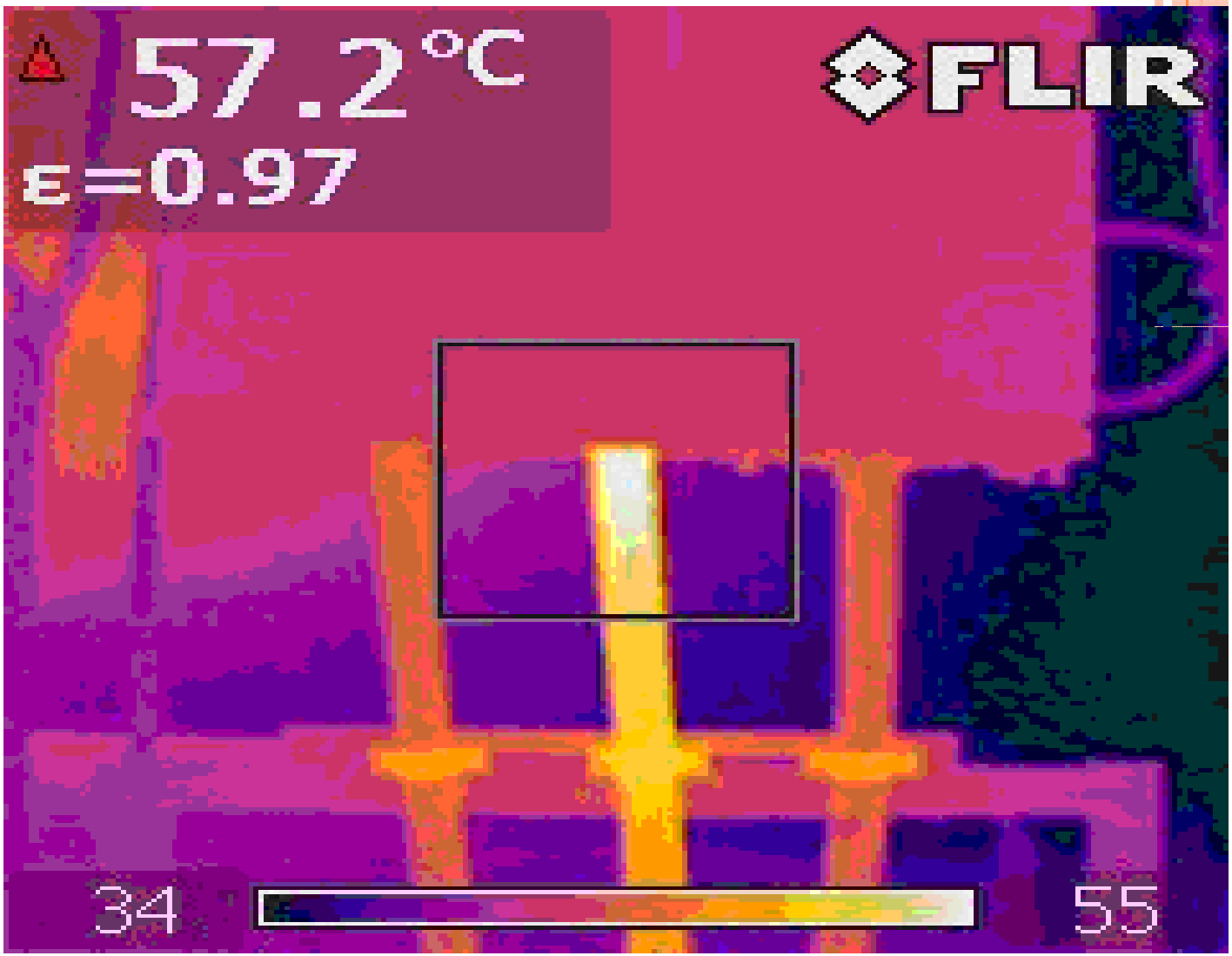
- Indicate presence of Hot spots at various connections
- Indicates the effectiveness of cooler banks
- Indicated the uniform flow of oil inside transformer-in case forced oil cooled
- Used to detect the hot spots in the Tank specifically at the entry/exit point of LV windings through bushings


20.7°C
FLIR
ε=0.95
16
27
29.9°C
FLIR
ε=0.95
-3
33

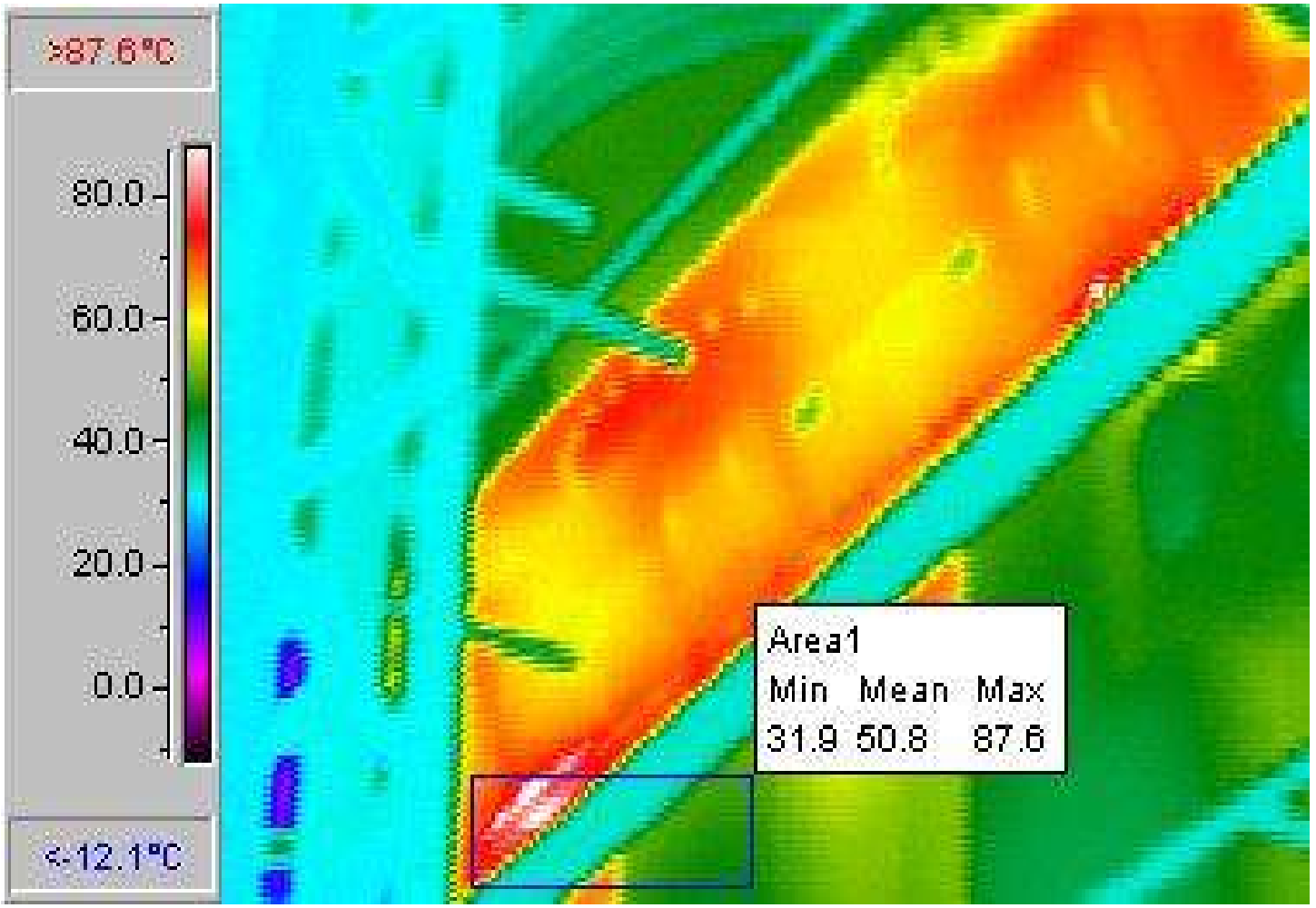
GT-2 220 KV BUSHING HOT SPOT.THE BUSHING WERE FOUND DEFECTIVE AND WAS REPLACED



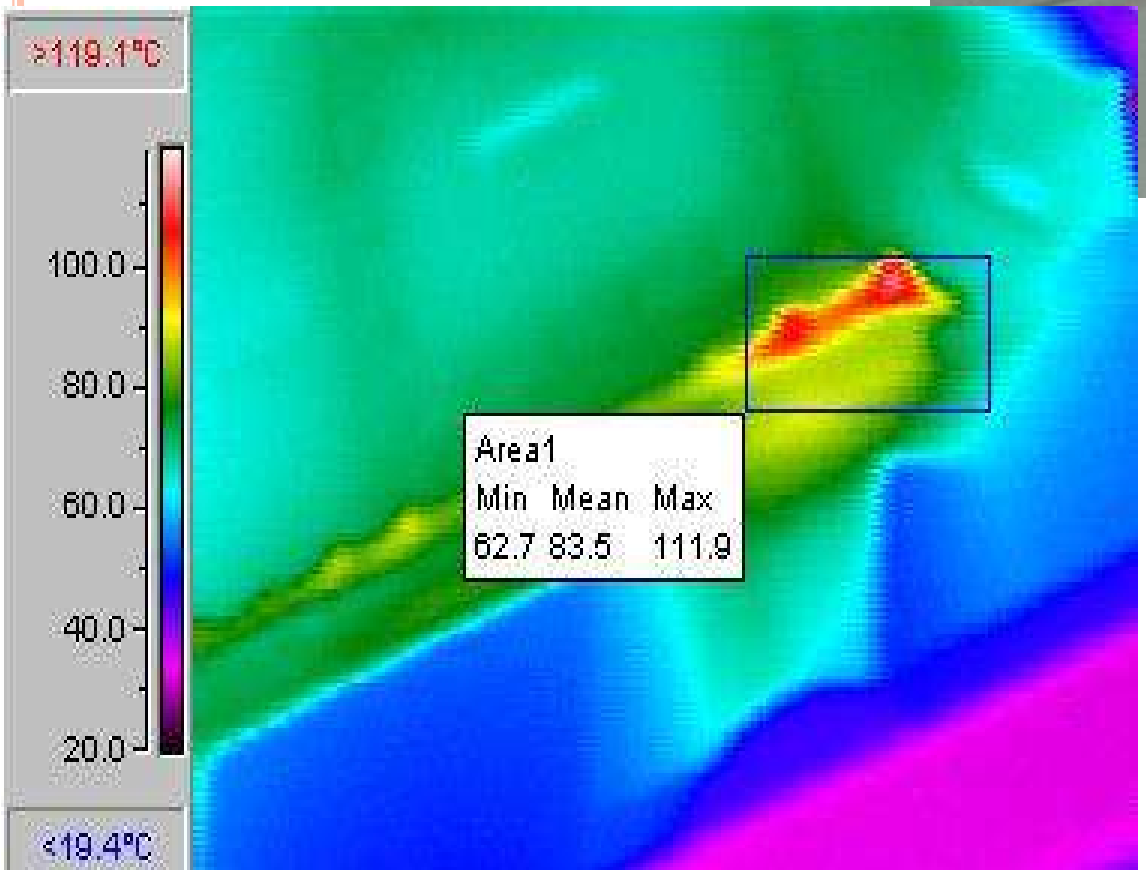
Cable connections



GT1 LV TURRET



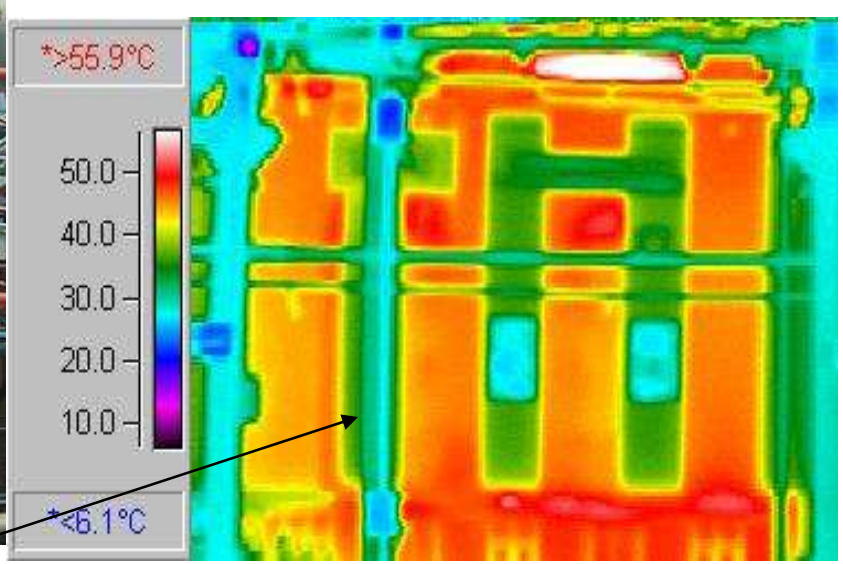
GT2 LV TURRET



TRANSFORMER

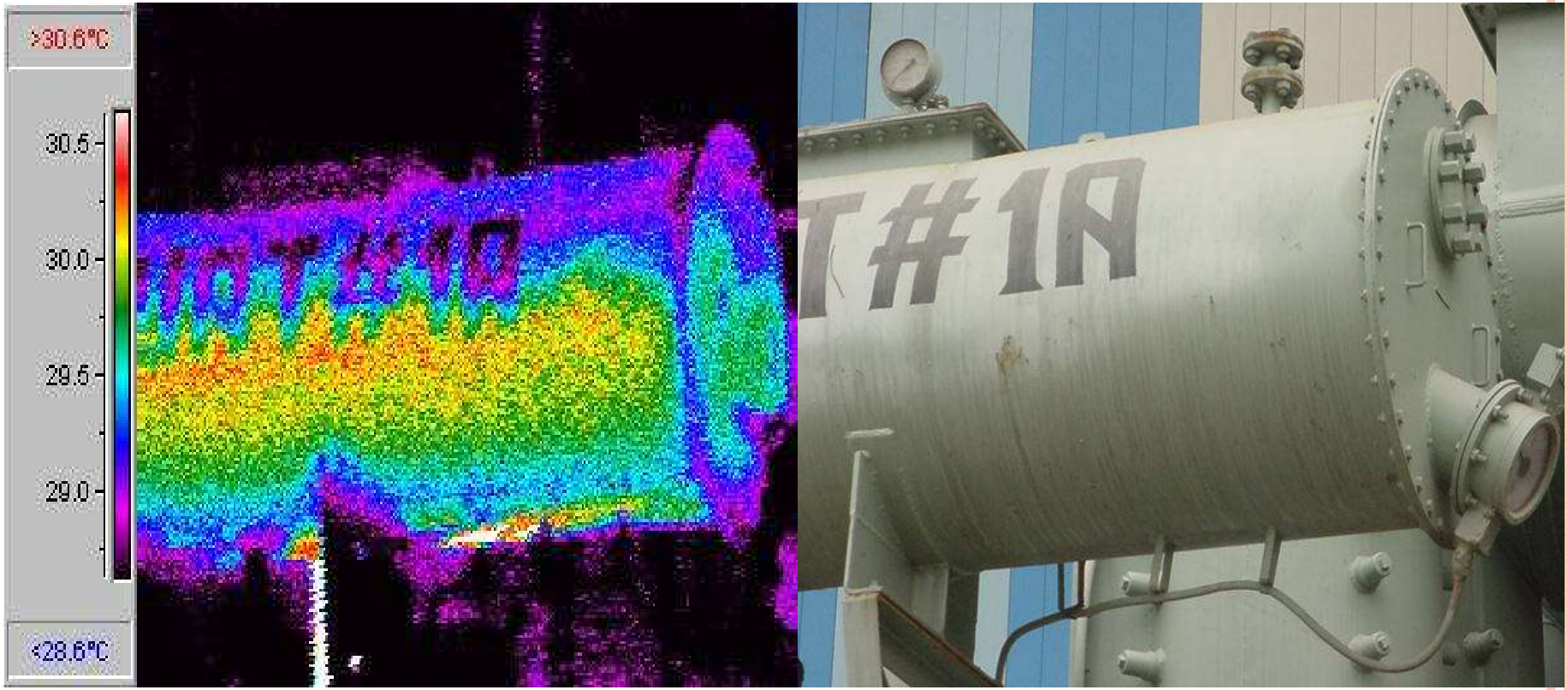
BUSHING

LIGHTENING ARRESTER



TANK

MONITORING OF OIL LEVEL OF CONSERVATOR



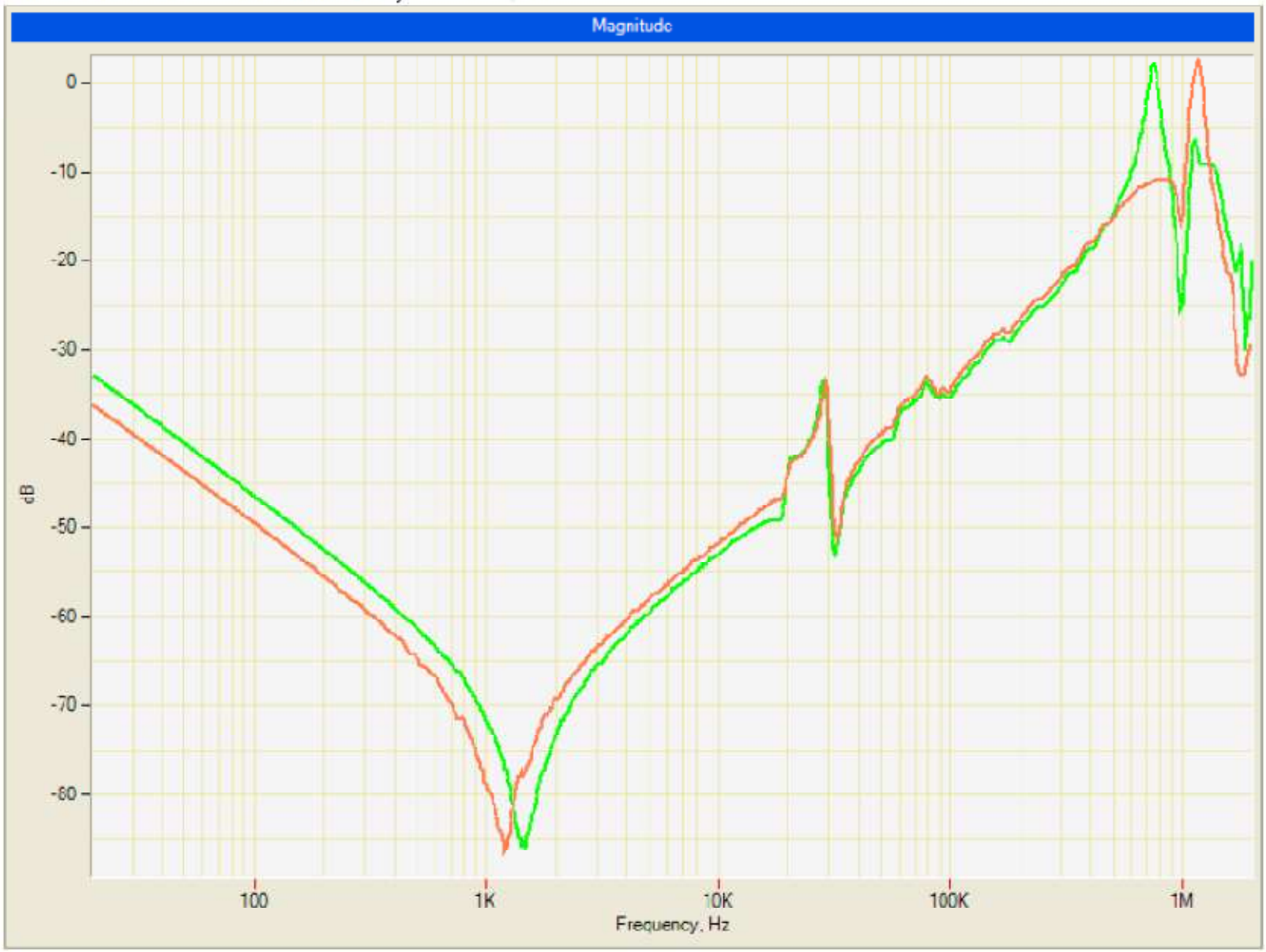
FRA- Frequency response analysis

Transformer: Manufacturer: Bharat Heavy Electricals, Ltd.

N-HV_2012-03-14_10-17-17 - Manufacturer: Bharat Heavy Electricals, Ltd.Serial Number: 6006569Date: 14/03/2012 10:17:17
LTC: TAP NO 6DETC: as found - make noteMVA Maximum: 200KV: 400/21

1U-1V(1N)_2012-01-17_17-00-23 - Manufacturer: Bharat Heavy Electricals, Ltd.Serial Number: 6006565Date: 17/01/2012 17:00:23
LTC: extreme raiseDETC: TAP NO 6MVA Maximum: 200KV: 400/21

Transformer: Manufacturer: Bharat Heavy Electricals. Ltd.

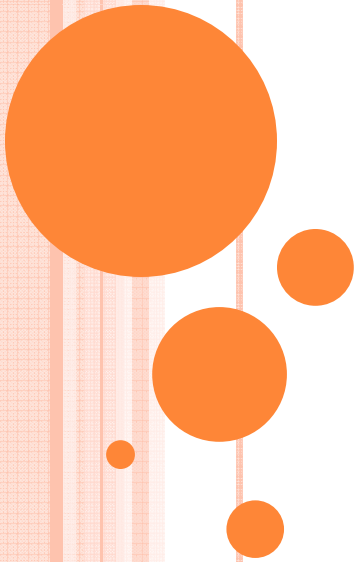


N HV_2012 03 11_10 02 38 Manufacturer: Bharat Heavy Electricals, Ltd.Serial Number: 6006569Date: 11/03/2012 10:02:38
LTC: TAP 6DETC: as found - make noteMVA Maximum: 200KV: 400/21

1U-1V(1N)_2012-01-17_16-54-59 - Manufacturer: Bharat Heavy Electricals, Ltd.Serial Number: 6006565Date: 17/01/2012 16:54:59
LTC: extreme raiseDETC: TAP NO 6MVA Maximum: 200KV: 400/21

FRTEQUENCY DOMAIN SPECTROSCOPY (FDS)

- Used for measurement of moisture content in bushing (OIP)
- For measurement of moisture in paper insulation of windings
- It measured by applying varying frequency and measuring the response. By using complex algorithms moisture content is determined.



THANKS

BUSHING FAILURE OF ICT#SPARE

- In Feb 2003, after attending hotspots in 220kV side, transformer was energised, after 10minutes, 400kV Bushing failed.
- Cause of failure could not be established.

FAULT GASES IN ICT#SPARE

- After replacement of 400kV Bushing, fault Gas C2H4 generation started with traces of C2H2. Phenomenon was load dependent.
- In situ Internal inspection carried out, found nothing abnormal

INTERNAL INSPECTION AFTER DETANKING.

- Internal inspection after detanking carried out, found nothing abnormal.
- Core coil assembly lifted from tank. Found sole plate bolt head overheated.


K