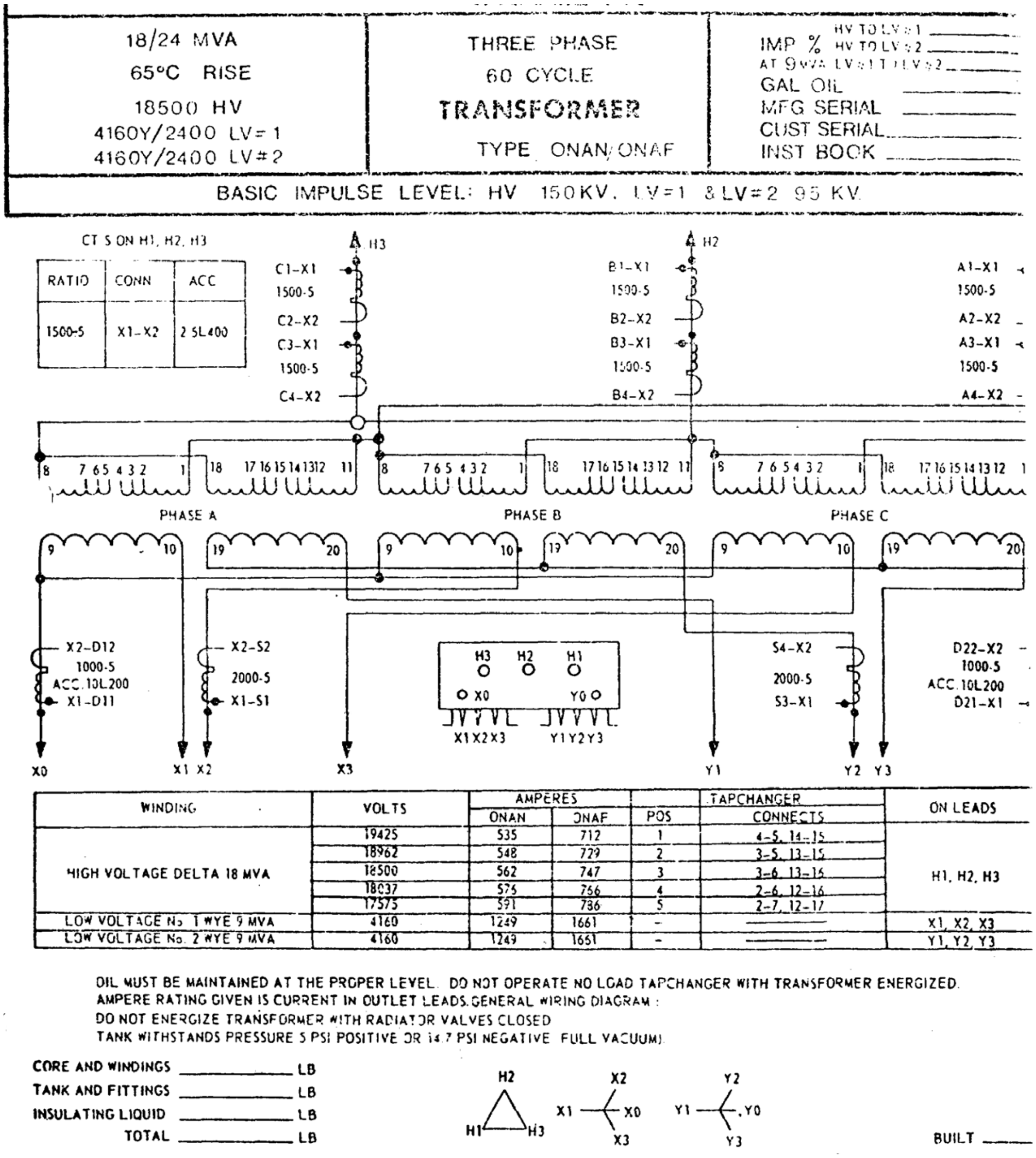

18/24 MVA
65°C RISE
18500 HV
4160Y/2400 LV=1
4160Y/2400 LV#2

THREE PHASE
60 CYCLE
TRANSFORMER
TYPE ONAN/ONAF

IMP % HV TO LV#1
HV TO LV#2
AT 9 MVA LV#1 TO LV#2
GAL OIL
MFG SERIAL
CUST SERIAL
INST BOOK

BASIC IMPULSE LEVEL: HV 150KV. LV=1 & LV=2 95 KV.

CT S ON H1, H2, H3

RATIO	CONN	ACC
1500-5	X1-X2	2.5L400

WINDING	VOLTS	AMPERES ONAN	AMPERES ONAF	POS	TAPCHANGER CONNECTS	ON LEADS
HIGH VOLTAGE DELTA 18 MVA	19425	535	712	1	4-5, 14-15	H1, H2, H3
	18962	548	729	2	3-5, 13-15	
	18500	562	747	3	3-6, 13-16	
	18037	575	766	4	2-6, 12-16	
	17575	591	786	5	2-7, 12-17	
LOW VOLTAGE No. 1 WYE 9 MVA	4160	1249	1661	-	———	X1, X2, X3
LOW VOLTAGE No. 2 WYE 9 MVA	4160	1249	1661	-	———	Y1, Y2, Y3

OIL MUST BE MAINTAINED AT THE PROPER LEVEL. DO NOT OPERATE NO LOAD TAPCHANGER WITH TRANSFORMER ENERGIZED.
AMPERE RATING GIVEN IS CURRENT IN OUTLET LEADS. GENERAL WIRING DIAGRAM :
DO NOT ENERGIZE TRANSFORMER WITH RADIATOR VALVES CLOSED
TANK WITHSTANDS PRESSURE 5 PSI POSITIVE OR 14.7 PSI NEGATIVE (FULL VACUUM)

CORE AND WINDINGS ______ LB
TANK AND FITTINGS ______ LB
INSULATING LIQUID ______ LB
TOTAL ______ LB

BUILT ______

Figure 3-14- Example 8: Transformer nameplate information

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Purchaser

Test APRIL 1973 Purchaser's Order No. ______ G.O. ______ S.O. No. 3-S-7248

ONAN/ONAF Phase 3 Cy. 60 Insulating Fluid OIL L.Spec. ______ Polarity SUBT

Winding H.V.	Winding L.V. #1	Winding L.V. #2
Kva 18000/24000	Kva 9000/12000	Kva 9000/12000
Voltage 18500 DELTA	Voltage 4160 WYE	Voltage 4160 WYE

RESISTANCES, EXCITING CURRENT, LOSSES AND IMPEDANCE – Based on normal rating, unless otherwise stated. Losses and regulation are based on wattmeter measurements. For three-phase transformers the resistances are the sum of the three phases in series. Pos. #1

SERIAL NO.	RESISTANCE IN OHMS AT 75°C WINDINGS H.V.	LV#1	LV #2	% EXCITE CURRENT AT 100% RATED VOLTAGE	NO LOAD LOSS WATTS AT 100% RATED VOLTAGE	18.5 Kv TO 4.16 * Kv 18000 Kva LOAD LOSS WATTS 75°C	% IMP 75°C	18.5 Kv TO 4.16* Kv 24000 Kva LOAD LOSS WATTS 75°C	% IMP 75°C	TO ______ LOAD LOSS WATTS 75°C	% IMP 75°C
A-3-S-7248	0.359	0.0108	0.01087	0.69	16500	80000	6.7	143800	8.9	*LV#1 & LV#2	
						Total Loss	% Imp 75°C	Total Loss	% Imp 75°C	Total Loss	% Imp 75°C
AVERAGE					16500	96500	6.7	160300	8.9		
GUARANTEE					18000	108000	6.5	178000			

REGULATION AT 75°C		100% PF	% PF	80% PF	% PF
	AVERAGE				
	GUARANTEE				

TEMPERATURE RISES – Average rise in degrees C., corrected to instant of shutdown, of transformer.

Serial No. A-3-S-7248 with windings connected and loaded as follows:

HV Winding 17.575 Kv 591 Amp.: LV.#1 Winding 4.16 Kv 1249 Amp.

LV#2 Winding 4.16 Kv 1249 Amp. until constant temperature rise was reached.

	RISE OF WINDINGS BY RESISTANCE H.V.	L.V.#1	L.V.#2	GUARANTEE	TOP FLUID RISE	AMBIENT TEMP. INGOING WATER	IDLER OR ROOM	WATER RISE	GALLONS PER MIN.	POUNDS PRESSURE
ONAN	51	59.0	47.8	65	49.3					
ONAF	54.9	60.3	55.8	65	45.6					

INSULATION TESTS	WINDING	VOLT RATING	TEST VOLTAGE APPLIED IN Kv	DURATION OF TEST IN SECONDS
APPLIED POTENTIAL TESTS (Voltage applied between each winding and all other windings connected to core and ground.)	H.V.	18500	50	60
	L.V.#1	4160	26	60
	L.V.#2	4160	26	60

INDUCED POTENTIAL TEST: Two times rated voltage ~~across full winding~~; ______ Kv from ______ Kv Line terminal to ~~ground~~ line; at 180 cycles per second for 7200 cycles

REMARKS NAMEPLATE #206P454

% IMPEDANCE BETWEEN H.V.-L.V.#1 = 6.45
H.V.-L.V.#2 = 6.50
L.V. #1 - L.V. #2 = 12.78
} based on 9 MVA

We hereby certify that this is a true report based on factory tests made in accordance with the latest Transformer Test Code C57.2 of the American Standards Association and that each transformer withstood the above insulation tests.

Signed ______ Date May 22, 1973 Approved ______

Page ____ of ____ Pages

Figure 3-15- Example 8: Transformer test results

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Table 3-7- Information Required for Modelling the Transformer of Example 8

Item	Transformer Parameter	Symbol	Values
General			
1	Transformer ONAN Ratings	MVA_{ONAN}	18 MVA
2	Winding Voltages (primary, secondary, …)	V_H, V_X, V_Y, … V_P, V_S, … V_1, V_2, …	18.5kV/2.4kV/2.4kV
3	Connection type	-	Dyy
4	Tap range	t_1, t_2, …	± 30%
5	Number of tap steps	-	5 (OCTC)
6	Winding with an adjustable tap	-	Primary (high) side
7	Phase angle of windings	θ_1, θ_2, θ_3…	30°,30°
No Load Loss Test Results			
8	No-load loss test MVA	$MVA_{NL\ Test}$	-
9	No-load loss	P_{NL}	16.5 kW
10	Excitation current	$\%I_{exc}$	0.69 A
11	Tap setting for no-load loss test	t_{NL}	Nominal
Load Loss Test Results			
12	Load loss test MVA	$MVA_{SC\ Test}$, …	(H-X+Y @ 18MVA)
13	Load loss	$P_{SC,}$ $P_{LL\_HX, …}$	80 kW
14	Impedance (Voltage)	I_Z, or Z_{HX}, …	6.7%
15	Reactance	I_X, or X_{HX}, …	Not reported
16	Tap setting for load loss test	t_{SC}	Nominal (13)
17	Positive-sequence impedance between Pair Windings	H-X, H-Y, X-Y @MVA	6.45%, 6.50%, 12.78% @ 9MVA
Zero-Sequence Test Results			
18	Zero-sequence open circuit test results	Z_1, Z_2	-
19	Zero-sequence short circuit test results	Z_3	-
20	Zero-sequence T-model parameters	Z_{H0}, Z'_{X0} Z_{M0} for the T-model	-
21	Zero-sequence impedances between Pair Windings	$Z_{H\text{-}X\ 0}$, $Z_{H\text{-}Y\ 0}$, for the T-model	-
22	Grounding configuration	Windings neutral point grounding method	Solidly grounded
23	Grounding Impedance	Z_{GX}, Z_{GY}, …	0 Ω reactance

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Table 3-8- Example 8: Generic Model Parameters of the Transformer

Type	Parameters in Per Unit	Parameters in SI Units[1]
Windings' leakage impedance	$z_H = \frac{z_{H-X}+z_{H-Y}-z_{X-Y}}{2} = 0.0017$ $z_X = \frac{z_{H-X}-z_{H-Y}+z_{X-Y}}{2} = 0.1273$ $z_Y = \frac{-z_{H-X}+z_{H-Y}+z_{X-Y}}{2} = 0.1283$ @ 18MVA	$Z_b = \frac{V_{rated}^2}{S_b} = \frac{18.5^2}{18}$=19.014 Ω $Z_H = z_H \times Z_{Z_{H-base}} = 0.0323\Omega$ $Z'_X = z_X \times Z_{H-base} = 2.42\Omega$ $Z'_Y = z_Y \times Z_{Z_{H-base}} = 2.44\Omega$ Verification: $Z_{H-X\|\|Y} = Z_H + Z'_X\|\|Z'_Y = 1.2473\ \Omega$ From full load-losses test: $Z_{H-X\|\|Y} = 1.274\ \Omega$
Magnetizing branch admittance	$y = \%I_{exc.}/100 = 0.0069$ *pu*	$Y_H = \frac{I_{OC}}{V_{OC}} = 3.63E-4$ ℧ or
No-Load losses equivalent conductance	$g = \frac{P_{NL}}{MVA_{NL\,Test} \times 1000} = 0.00092$ *pu*	$G_H = \frac{P_{OC}}{V_{OC}^2} = \frac{P_{NL}}{V_{H\,rated}^2} = 4.821E-5$ ℧
Magnetizing branch susceptance	$b = -\sqrt{y^2 - g^2} = -0.0068$ *pu*	$B_H = -\sqrt{Y_H^2 - G_H^2} = -3.6E-4$ ℧
Zero-Sequence parameters (Based on assumptions)	$z_{H0} = 0.85 \times z_H$ $z'_{X0} = 0.90 \times z'_X$ $z'_{Y0} = 0.90 \times z'_Y$ $z_{M0} = \infty$	

3.7 Three-Winding Transformers with Delta Primary, Wye Secondary, and Delta Tertiary

The tertiary winding in this type of connection is not provided to supply a considerable amount of load; it might be used for a local small load such as substation lighting. In practice, if the VA rating of the delta-connected tertiary winding is significantly less than the VA rating of the other windings it cannot be considered as a single winding in modelling. Even in practice, it is not recognized as a three-winding transformer by practical engineers. However, the zero-sequence current can flow through this winding. Therefore, the tertiary winding should withstand the zero-sequence fault current if one of the other windings is a grounded Y connection. For example, Figure 3-16 shows the nameplate information of a D-y-d-connected transformer. It is a 5.76 MVA 20 kV/900 V distribution transformer. This transformer does not have a test results report, but the impedances have been provided on the transformer nameplate. These parameters can be used to obtain the positive-sequence equivalent circuit. The zero-sequence equivalent circuit of this transformer depends on whether the neutral point of the secondary winding is grounded or not. If it has been grounded, the zero-sequence equivalent circuit is only one impedance from the secondary terminal and is an open circuit from the other terminals (See line 24 in Table 1-2). Since the zero-sequence test results are not available, the transformer can be considered as a two-winding transformer with Delta-wye connected (See Section 2.7)

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