SECONDARY UNIT SUBSTATION TRANSFORMERS

Liquid-Filled (Oil or Askarel) for Load Center Application

Standard Design, Preferred Ratings

APPLICATION

Liquid-filled substation transformers are applied in indoor or outdoor locations to step down distribution system voltages for utilization near the load concentration. These units are designed to be coordinated with primary and secondary equipment to form "Secondary Unit Substations" in accord with NEMA Publication No. 210-213 and ANSI C57.12.00.

STANDARD RATINGS:

Three phase, 60 Hertz, 65°C rise (55°C optional addition)

KVA (Self-Cooled)	500, 750, 1000, 1500, 2000 and 2500 KVA.
HIGH VOLTAGES	2400, 4160, 4800, 6900, 7200, 8320, 12,000, 12,470, 13,200 or 13,800 volts with standard 2 ± 2-1/2% taps.
LOW VOLTAGES	208Y/120 or 240 volts delta through 1000 KVA, 480 volts delta or 480Y/277WYE all KVA ratings.

USER BENEFITS INCLUDE:

Unique cover bushing transition arrangement:

- Eliminates insulating liquid leakage around bushings.
- Allows transformer removal without disturbing adjacent substation components.
- Reduces substation length and floor space required.

Sheet wound secondary windings:

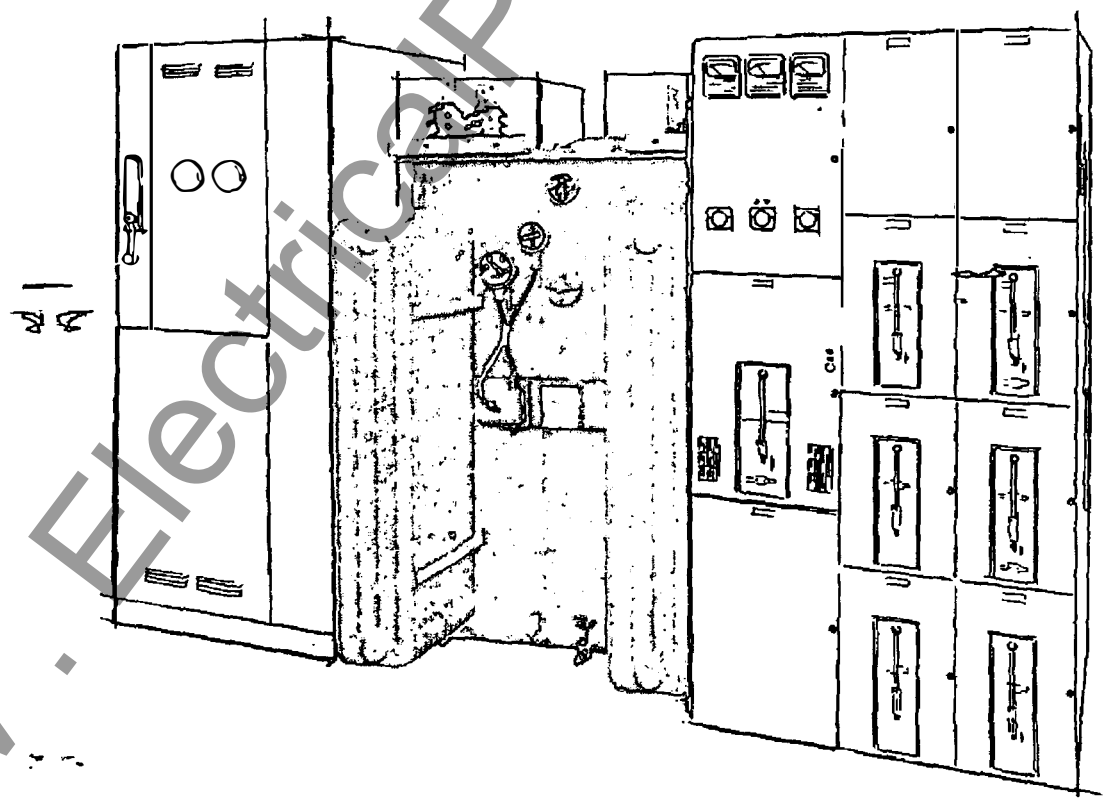
- Exceptional short circuit withstand capability.

Front-grouping of accessory devices:

- Indicators, gauges and no-load tap changer readily accessible from floor level in common area.

Sealed-tank construction with welded-on cover:

- Eliminates major gasketing problems.
- Minimal maintenance and care required.
- Preserves insulating liquid.



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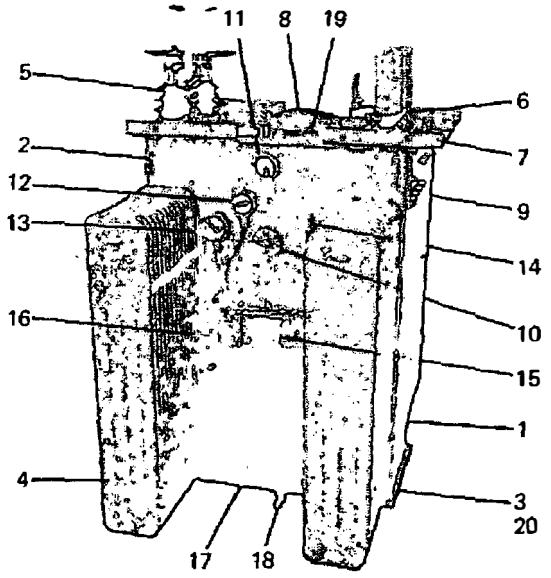


GENERAL DESIGN FEATURES:

1. **Tank**

   High quality welded steel plate, reinforced rectangular tank with welded-on cover provides permanently sealed construction. Vibration damage during shipment and service is minimized by sturdy construction.

   After completion, the tanks are grit blasted (inside and out) and pressure tested for leaks. After successful completion of this test, zinc chromate primer is flow-coated on all surfaces. Two finish coats of alkyd base paint of ANSI No. 61 light grey for indoor or No. 24 dark grey for outdoor units complete the high-quality paint finish.

2. **Lifting Provisions**

   Four sturdy hooks for lifting transformer are strategically located near each corner of cover.

3. **Jacking and Towing Provisions**

   Jacking can be accomplished at the four corners of the base. Towing provisions are accessible at four points at base of tank.

4. ***Radiators***

   Panel-type, sheet steel coolers provide increased cooling surface and highly efficient performance. Radiators are welded to tank.

5. **High Voltage Bushings**

   Cover mounted, porcelain, draw-lead bushings are normally supplied.

6. **Low Voltage Bushings**

   Cover mounted epoxy molded bushings eliminate leakage around bushings and are externally clamped to non-magnetic plate on cover.

7. **Transition Throat Adapter**

   Primary and secondary "hood" arrangements (when required) are bolted to this adapter. Slotted holes in adapter allow adjustment for minor misalignments.

8. ***Pressure Relief Device***

   In accordance with ANSI standards, relief devices are standard for non-flammable liquid (askarel) units only. Indoor units utilize (as shown) a rupturing diaphragm device. Outdoor units are furnished with a mechanical automatically resealing type. Alarm contacts (optional) are available with the resealing device only. Relief devices are mounted on handhole cover. Outdoor oil filled units can be supplied with the self-resealing device (optional addition).

9. **Access Ports (Both Ends)**

10. **Tap Changer Handle (De-energized Operation)**

    Externally operated handle is located at a convenient location at front of unit and can be padlocked in any tap position.

11. **Pressure-Vacuum Gauge**

    Indicates positive or negative pressure in gas space above liquid and is conveniently located with other gauges, etc. in accessible area at front of unit.

12. **Liquid-Level Gauge**

    Float position is transmitted magnetically to gauge pointer. Liquid or gas do not come in contact with dial. Alarm contacts are optional.

13. **Dial-Type Thermometer**

    Indicates top liquid temperature. Magnetically resettable high temperature pointer included. Alarm contacts and fan contacts are optional.

14. **Top Sampling Device (Askarel Only)**

    Rotating-type sampler allows top liquid maintenance check for contamination.

15. **Diagram and Rating Plate**

    Stainless steel nameplate located conveniently (satin finished with black etched data).

16. ***Terminal Box (When Required)***

    All contacts terminated from accessory devices.

17. **Ground Pad**

    Provision for connector to ground tank to station ground.

18. **Drain Valve**

    One inch valve for combination lower filter press connection, complete drain and provision for sampling (top filter press connection on tank cover).

19. **Filling Connection and Top Filter Press Connection**

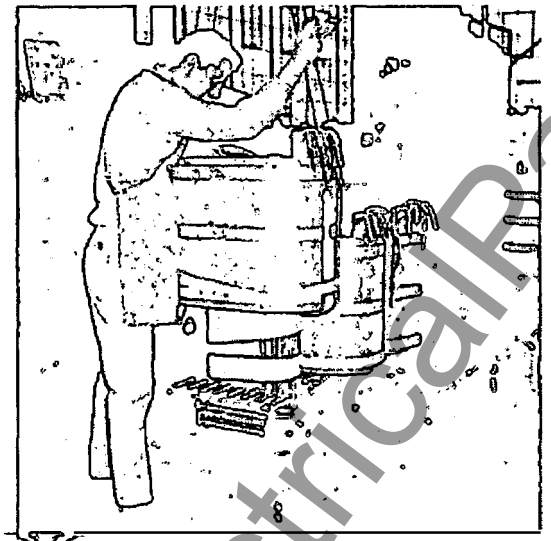
20. **Base**

    Tank base is suitable for rolling in two directions.

CORE CONSTRUCTION

The three-legged, stacked core is of the square cut, butt joint design and utilizes precision cut, burr-free, non-aging, grain-oriented, silicon steel providing low-loss characteristics. Laminations are coated on both sides with inorganic insulating material which is not affected by high temperatures.

Unique core clamping design affords complete elimination of bolts through the core legs and yokes which ensures a uniform flux path and eliminates danger of core bolt insulation failures. Leg laminations are securely held by special tape; yoke laminations by fabricated steel clamps. Clamps are lined with resilient packing to obtain uniform pressure and minimize sound and vibration transmission. Vertical tie bars between top and bottom clamps are designed to withstand all axial short circuit forces and lifting stresses.



Placing Coil on Core Leg

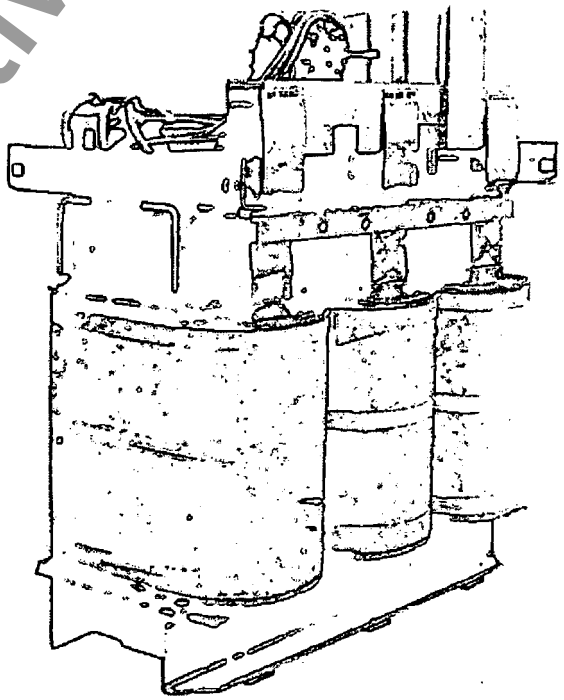
Placing Top Yoke Core Steel in Position

COIL CONSTRUCTION

The overall coil design results in a transformer of exceptional short circuit withstand strength attributable to its compact, rectangular configuration and utilization of low voltage sheet windings.

The low-voltage winding utilizes full coil-width sheet aluminum. The high-voltage aluminum wire winding is arranged in concentric layers with taps brought out so as to optimize magnetic balance on all ratios resulting in constant impedances.

The LV and HV coils are wound progressively on one mandrel into a solid, compact assembly and incorporates a substantial HV to LV barrier. Liberal vertical cooling ducts enhance coolant flow.



Typical Core and Coil Construction Viewed from Low Voltage Side

CORE AND COIL ASSEMBLY

The completed core and coil assembly presents a compact, long-life unit. This assembly is oven dried and after being placed in its tank is vacuum filled while hot to eliminate any possibility of moisture being absorbed by the insulation system.

All low-voltage bar conductors and high-voltage tap leads are strategically supported and spaced by kiln dried maple, or impregnated, pressure-laminated beechwood to maintain electrical clearances.

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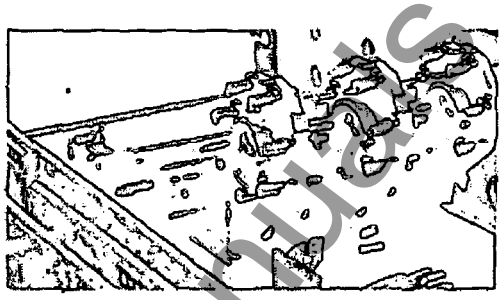
TAP CHANGER – Externally Operated (De-energized Operation)

All transformers (500 KVA and above) are equipped with a rotary snap-action tap changer mounted on the top core clamp. The three phases are gang-operated by a common insulating shaft that holds the spring-loaded contact rings. The rotating rings make high-pressure contacts with the terminal posts and produce a positive snap-action preventing an "open" tap position. Stationary posts are molded into the resin bases for added strength and rigidity.



Externally Operated Tap Changer

INSULATION SYSTEM

The insulation system is an optimum coordination of materials and is designed for 65° C temperature rise (average temperature rise by resistance), with ambient not to exceed 40° C and an average ambient temperature for any 24-hour period not to exceed 30° C.

Thermally up-graded, coordinated insulating materials are utilized on wire and between inter-turn sheet conductors.

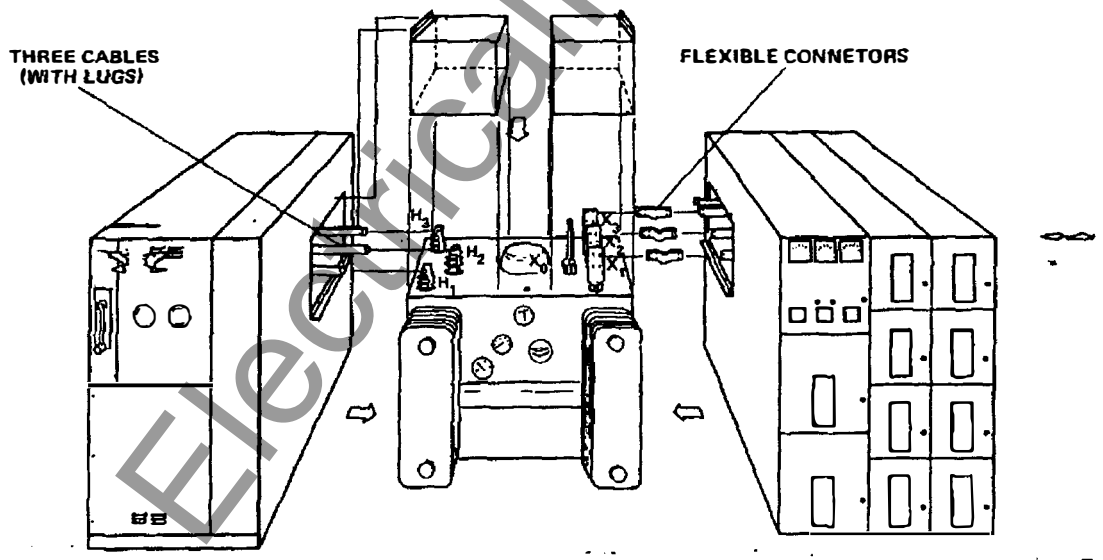
Optional 55° C units are designed to provide 12% additional capacity at 65° C temperature rise without loss of life expectancy.

Suitable quantity of high-grade oil (normally for outdoor applications) or Askarel liquid is shipped within each transformer.

The oil contains inhibitors to resist oxidation and has a low-viscosity and pour point to facilitate cooling and circulation. It is free from acids, alkalis and corrosive sulphur and will not attack finish on transformer coils. The oil is particularly resistant to sludging and emulsification with water.

Askarel liquid is a non-flammable coolant with insulating characteristics similar to those of transformer oil. It is a synthetic, non-sludging liquid and permits application of transformers indoors without vaults.

Either liquid provides high dielectric and heat transfer capabilities.



As Shown in Exploded Schematic Drawing, Overhead Transitions Save Floor Space, Increase Flexibility

BUSHINGS

Cover mounted bushings for high and low voltage terminals are used. Bus transitions and connection to incoming and outgoing switchgear sections are accomplished in the space above the transformer. Transformer bushings brought out at the top eliminate sidewall mounted bushings and throat transition sections. A steel enclosure fits over each set of transformer bushings, providing metal-enclosed construction for protection and appearance. Because transition sections are at the top, close coupling of the incoming, transforming and outgoing sections reduces overall length and conserves floor space.

This tank-top arrangement inherently permits installation or removal of the transformer without disturbing the incoming or outgoing sections or their cable connections. The bushings are conveniently located to facilitate bolting to the bus connections. Steel enclosures gasketed at the switchgear, are provided for outdoor units.

STANDARD ACCESSORIES

Listed below are the accessories furnished for standardized transformers.

Description	Oil-Filled	Askarel-Filled
	500 through 2500 KVA	
De-energized tap changer, manually operated, external	X	X
Combination drain and filter valve and sampling device	X	...
Combination drain and filter valve	...	X
Filling plug in cover (& filter press connection)	X	X
Thermometer (dial type – without alarm contacts)	X	X
Liquid level gauge (without low level alarm contacts)	X	X
Provision for lifting	X	X
Jack provisions	X	X
Towing provisions	X	X
Pressure relief device	...	X
Ground pad	X	X
Top sampling device	...	X
Diagram and rating plate	X	X
Pressure vacuum gauge	X	X
Welded-on main tank cover	X	X

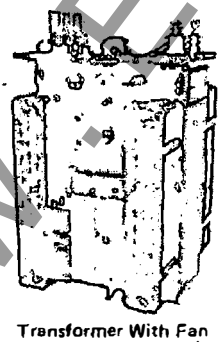
OPTIONAL ACCESSORIES (Addition)

FORCED-AIR COOLING

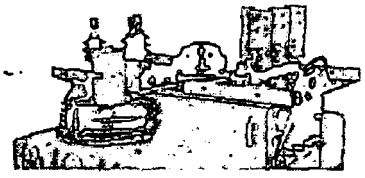
To provide additional transformer capacity, equipment can be supplied to give the following OA/FA ratings. Fan motors are controlled from the top liquid thermometer contacts. Fans are located on top of rear radiators. Note fan control box at front.

Standard fan motor voltage is 230 volts, single phase.

65C Rise Unit 3 Phase KVA		55/65C Rise Unit 3 Phase KVA			
~~OA~~	FA	OA (55C)	OA (65C)	FA (55C)	FA (65C)
500	–	500	560	–	–
750	862	750	840	862	965
1000	1150	1000	1120	1150	1288
1500	1725	1500	1680	1725	1932
2000	2300	2000	2240	2300	2576
2500	3125	2500	2800	3125	3500



Transformer With Fan Cooling (Front View)



View of Fan Cooling Installed on Top of Rear Radiators

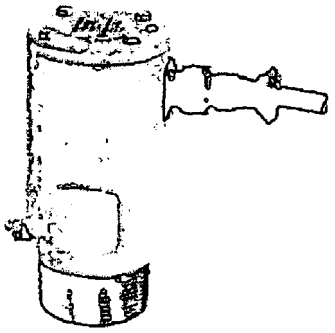
ALARM CONTACTS

Alarm contacts may be added to the thermometer, liquid level gauge and pressure relief device (resealable type only).

SUDDEN PRESSURE RELAYS

Severe arcing in a transformer liquid such as that caused by a major fault will generate a high volume of gas in a relatively short period of time. A sudden pressure relay to detect a rapid rise in pressure within the transformer tank is supplied as an optional extra. Several types are available, but each is designed to detect pressure increases in excess of established safe limits. By initiating an electrical signal for circuit breaker operation (or an alarm) the extent of damage to equipment under the conditions described can be limited and the hazard to operating personnel reduced accordingly.

A typical unit is the Series 910 Qualitrol Rapid Pressure Rise Relay as shown. It features high sensitivity and repeatability with temperature compensation for consistent performance over wide temperature variations. Momentary contacts only are available.



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STANDARD RATINGS

Insulation Levels

KV	Induced Test 120 Hertz	Applied Test-60 Hertz	BIL
1.2		10	30
2.5	Twice	15	45
5.0	Times	19	60
8.6	Normal	26	75
15.0		34	95

High Voltage Taps

Rated High Voltage Winding: Volts	Rated KVA High Voltage Taps: Volts			
2,400	2,520,	2,460,	2,340,	2,280
4,160	4,365,	4,260,	4,055,	3,950
4,800	5,040,	4,920,	4,680,	4,560
6,900	7,245,	7,075,	6,730,	6,555
7,200	7,560,	7,380,	7,020,	6,840
8,320	8,730,	8,520,	8,105,	7,900
12,000	12,600,	12,300,	11,700,	11,400
12,470	13,095,	12,780,	12,160,	11,845
13,200	13,860,	13,530,	12,870,	12,540
13,800	14,490,	14,145,	13,455,	13,110

Temperature Guarantees

(Altitudes not to exceed 1000 meters or 3300 feet)

	Ambient ①	Rise ②	Hotspot Rise
Standard	30°C	65°C	80°C
Optional	30°C	55°C	65°C

① 30°C average ambient temperature of cooling air not to exceed 40°C max. over any 24-hour period.

② Degree rise is the average winding temperature rise by resistance.

AUDIO SOUND LEVELS

When energized at rated voltage and frequency at no load and under standard test conditions and measurement procedure, the average sound level in decibels will not exceed the following limits.

KVA Self-Cooled	Sound Level (Decibels)	
	Without Fans	With Fans Running
500	56	—
750	58	67
1000	58	67
1500	60	67
2000	61	67
2500	62	67

Impedances*

KVA	Liquid-filled
500	5.0%
750	5.75%
1000	5.75% ①
1500-2000-2500	5.75%

*Subject to NEMA tolerance of plus or minus 7-1/2%.

① or 8% at 480 volt delta or wye.

STANDARD TESTS

1. The following tests, all made in accordance with the latest revision of the American Standard Test Code for Transformers, will be made on all transformers except as specifically noted. The sequence of listing does not necessarily indicate the sequence in which the tests will be made.
   a. Exciting current at rated voltage on rated voltage tap connection.
   b. Impedance and load loss at rated current on the rated voltage tap connection of each unit and on the tap extremes of one unit only of a given rating on an order.
   c. No load loss at rated voltage on the rated voltage tap connection.
   d. Polarity and phase relation on the rated voltage tap connection.
   e. Potential Tests.
      (1) Applied.
      (2) Induced.
   f. Ratio tests on all tap connections.
   g. Resistance measurements of all windings on the rated voltage tap connection of each unit and on the tap extremes of one unit only of a given design.
   h. Temperature Tests.
      (1) Temperature test will be made only when there is not available a record of a temperature test, in accordance with ANSI Standards, of an essentially duplicate unit. Test will be made in accordance with ANSI Standards and will be made on one unit only of a given rating on an order.
      (2) When a transformer is supplied with auxiliary cooling equipment to give more than one KVA rating, tests will be made on all nameplate KVA ratings, subject to the conditions outlined in (1) above.
2. The following additional tests may be performed: (at additional cost)
   a. Audio sound test.
   b. Impulse tests.
   c. Temperature tests, special.
   d. Zero sequence impedance tests.

DIMENSIONS AND WEIGHTS (APPROXIMATE)

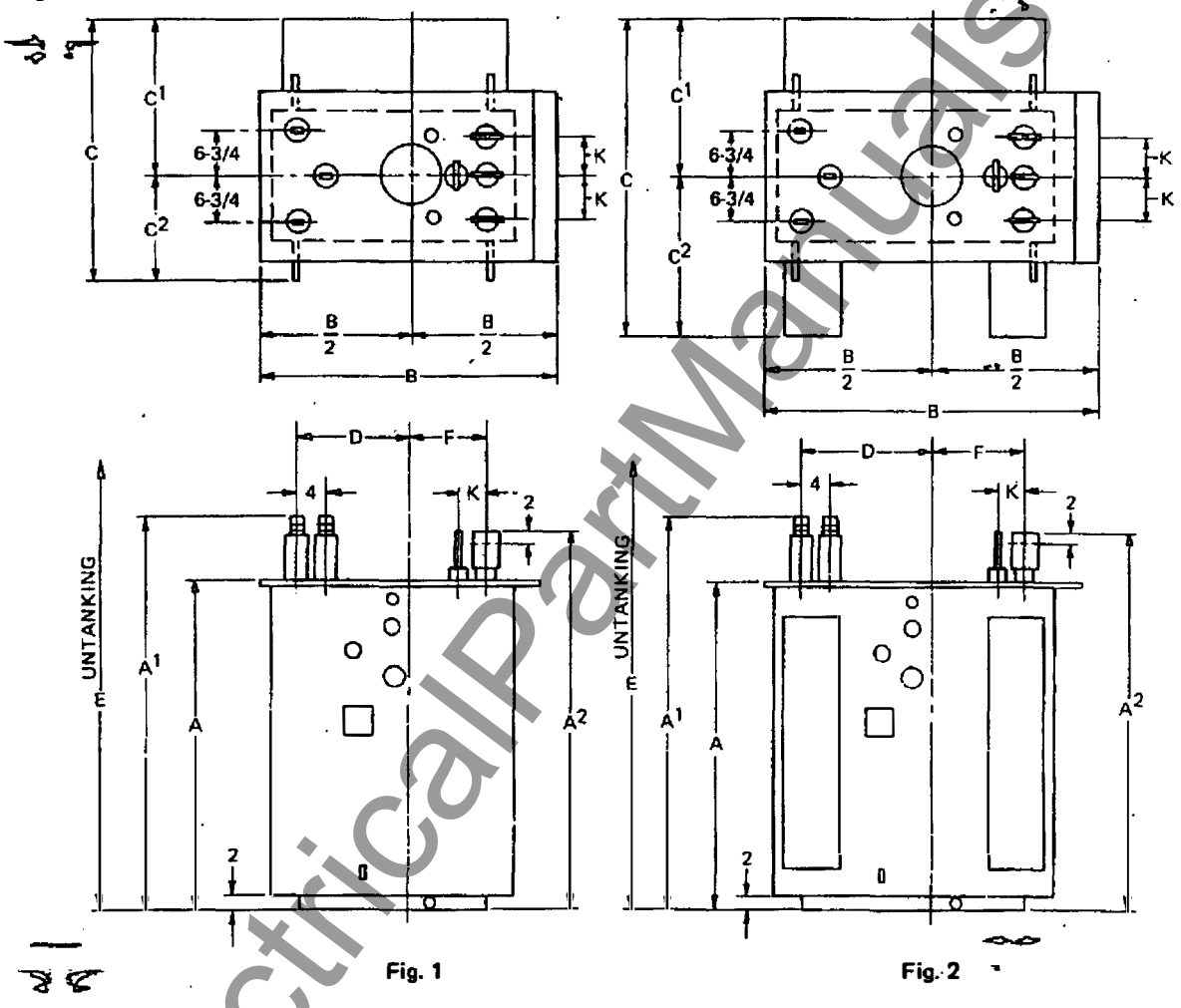

Fig. 1 Fig. 2

Elevation and plan views show high voltage termination at left, low voltage at right.

KVA	High Voltage Rating Delta	°C	Low Voltage Rating	Fig. No.	Overall Approximate Dimensions											Total Weight	
					A	A1	A2	B	C	C1	C2	D	E	F	K	Oil	Askarel
500	2400	65	480Y/277-4 Wire	1	56-1/4	67-1/2	69-5/8	49	41-3/4	24-1/4	17-1/2	19-1/2	105	18-3/4	6-1/4	4700	5600
750	thru		480Δ	2	60-1/4	71-1/2	69-5/8	52	50	25-3/4	24-1/4	21	105	16-1/4		5300	6200
1000	13,800				67-1/4	78-1/2			55	27-1/2	27-1/2		130			6200	7350
1500								56	61	29-3/4	31-1/4	23		18-1/4		8400	9800
2000								64	59-3/4	30-3/4	29	24	132	19-1/4		9700	11,300
2500	4160 thru 13,800				71-1/4	82-1/2	80-5/8	66	68	34-3/4	33-1/4	25		22	7	12,000	13,800

1. All dimensions are in inches.
2. Dimensions are approximate and are not to be used for construction.
3. Dimensions cover 65° C rise units only. "C" dimensions increase for 55° C rise units.
4. For outdoor substation units, add 6" to elevation dimensions.
5. Cover centerlines shown.

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SPECIFYING A LIQUID-FILLED SUBSTATION TRANSFORMER

Information is to be selected by purchaser and denotes alternates, options and specific information.

The ☐ *Each* ☐ 3 phase transformer will be rated:

Capacity

_____KVA, self-cooled
_____KVA, forced air-cooled
_____KVA, future forced air-cooled

Frequency

_____Hertz

Impedance

5.75% Standard ☐
8.0% (1000 KVA) ☐
(Special) ☐

Type

Outdoor ☐ *Indoor* ☐

Coolant

Oil ☐ *Askarel* ☐ *liquid*

Temperature Rise

65 degrees centigrade ☐
55/65 degrees centigrade ☐

High Voltage

_____volts delta

Low Voltage

_____volts *delta,* ☐
_____volts *wye,* ☐ *with neutral brought out* ☐

Tests and Electrical Characteristics

Transformer(s) will be tested and provided with electrical characteristics as set forth in the latest ANSI and NEMA standards for standard insulation levels, tests and impedances.

Tap Changer (De-energized Operation)

Four (4) approximately 2-1/2% full capacity taps will be provided. Two (2) taps will be above and two (2) will be below the rated voltage.

Transformer Tank

Sealed tank construction, with welded-on cover will be furnished.

Terminals

High and low voltage terminals will be provided for direct connection to the incoming line and secondary switchgear sections. Low voltage terminals will be on the *left* ☐ *right* ☐ *when facing the front (accessory side).*

Option ☐

The transformer(s) will be equipped with forced-air cooling equipment to give _____ KVA capacity. The equipment will include the necessary fans, conduit enclosing wiring, motor starters and top liquid thermometer for fan control.

Option ☐

Provision will be made for the future addition of forced-air cooling equipment to give _____ KVA capacity. The transformer bushings, leads and other components will be designed to carry the increased load. A top liquid thermometer for control of the future fans will be furnished. Provision for future mounting of fans, addition of conduit enclosing wiring and terminal box will be furnished.

Standard Accessories

The following standard accessories will be furnished:

- Drain and filter connection.
- Filling and top filter press connection.
- Top sampling device. (Askarel liquid only.)
- Pressure-vacuum gauge.
- Dial type thermometer *(with alarm contacts* ☐*)*
- Magnetic liquid level gauge, *(with alarm contacts.* ☐*)*
- Pressure relief device, *(with alarm contacts.* ☐*)* (Askarel liquid only.)
- Ground connection pad.
- Provision for jacking.
- Provision for lifting.
- Provision for towing.
- Diagram and rating nameplate.

HELPFUL TRANSFORMER APPLICATION DATA:

COMPARISON OF TYPICAL CHARACTERISTICS OF SECONDARY UNIT SUBSTATION TRANSFORMERS

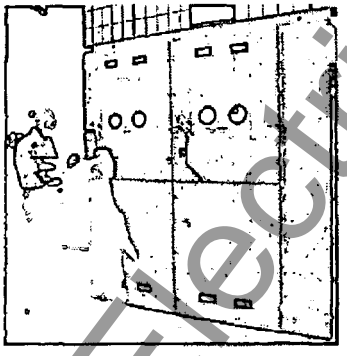
1000 kVA, 13.8 kV to 480 Volts, Oil-Immersed Transformer as Base

Characteristics	Liquid-Immersed 65° C Rise		Ventilated-Dry 150° C Rise	Sealed-Dry 150° C Rise
	Oil	Askarel	Air	Gas
Impulse Strength	95 kV	95 kV	50 kV	95 kV
Losses @ operating temp (20° C Ambient)				
No Load	100%	100%	160%	120%
Full Load	100%	100%	130%	110%
Temperature Ratings:				
Average Rise°, C	65	65	150	150
Hottest Spot Rise°, C	80	80	180	180
Sound Level – Decibels	60	60	65	64
Weights	100%	116%	98%	166%
Dimensions: Floor Space	100%	100%	120%	125%
Application: Indoor, Outdoor	Indoor (vault only) Outdoor	Indoor Outdoor	Indoor (Limited)	Indoor Outdoor
Fire, Explosion Resistant	No	Yes	Yes	Yes
Toxic Resistant	No	No	Yes	Yes
Maintenance: Liquid Cleaning	Yes	Yes	No	No
Internal	No	No	Yes	No
External	Normal	Normal	Occasionally	Normal
Cost	100%	125%	125%	200%

Note: Values stated are approximate average and subject to variation with kVA size, kV rating, etc.

For additional information to complete your "Secondary Unit Substation" specification refer to:

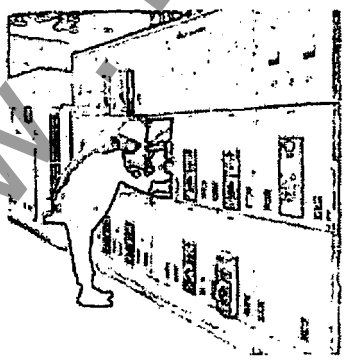
1) For primary switching and protective equipment – Descriptive Bulletin SG4.1a (18c 9022-05) "Type LBS-SE Load Break Switch, Stationary Mounted" covering Allis-Chalmers air switches, fused or unfused, indoor or outdoor, three pole, two position (with optional two line selector switch – non load break) pre-stored manual operator with quick make, quick break feature.



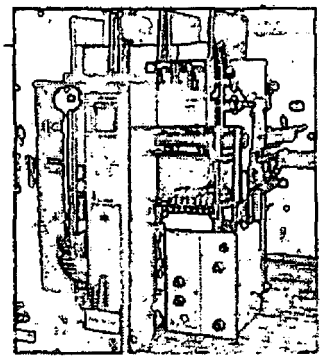
LOAD BREAK AIR SWITCH RATINGS

KV		AMPERES				BIL
Nominal	Maximum	Cont.	Int.	Momentary	Fault Closing	KV
4.16	4.76	600	600	60,000	61,000	60
4.16	4.76	1200	1200	60,000	61,000	60
13.8	15.0	600	600	60,000	61,000	95
13.8	15.0	1200	600	60,000	61,000	95

2) For secondary metal-enclosed switchgear (600 volts max.) – Descriptive Bulletin SG1.1a (18c 1170-04) "Low Voltage Metal-enclosed Switchgear" featuring "STATIC TRIP II" solid-state overcurrent tripping system.



Indoor Switchgear Application



Low Voltage Drawout Power Circuit Breaker with Static Trip Device At Lower Right

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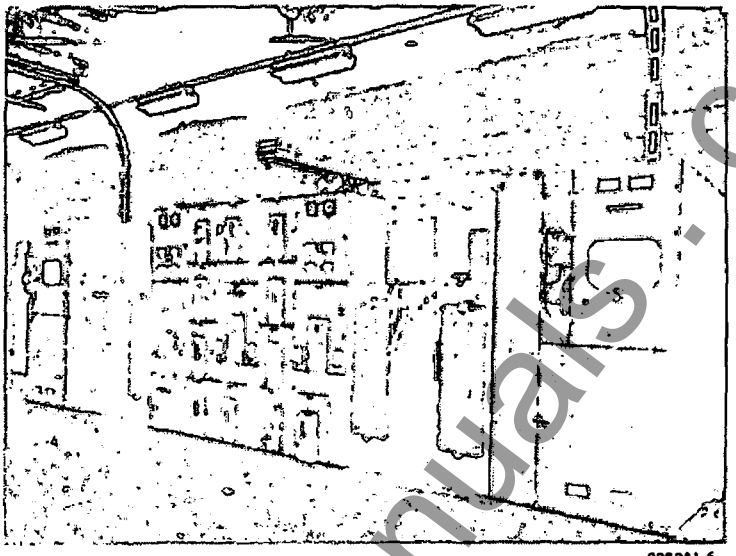

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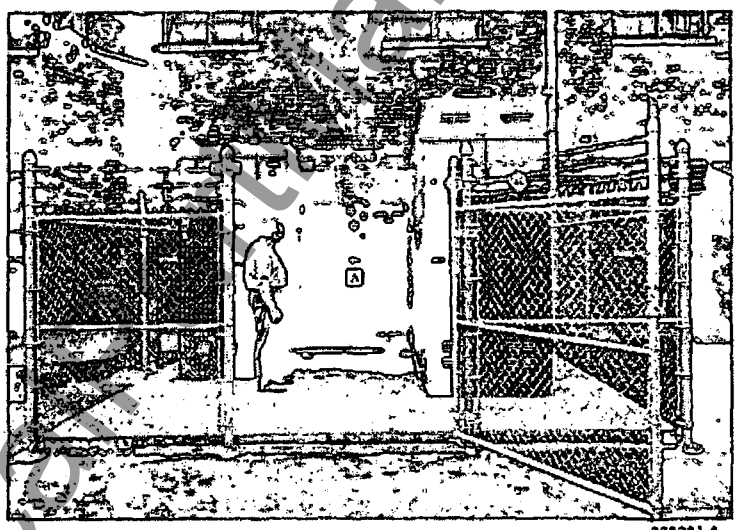
TYPICAL INSTALLATIONS using LIQUID-FILLED TRANSFORMERS



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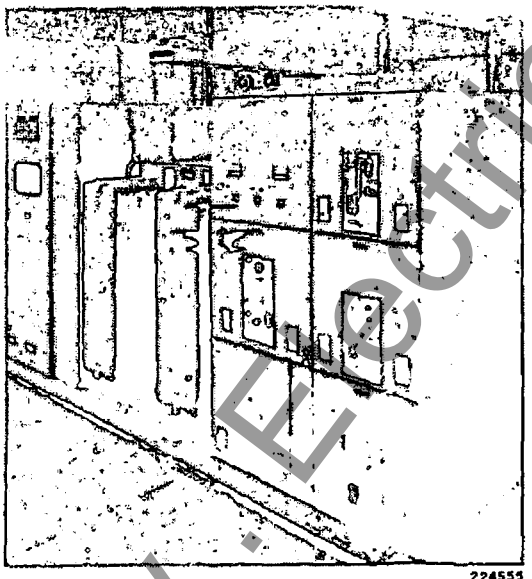

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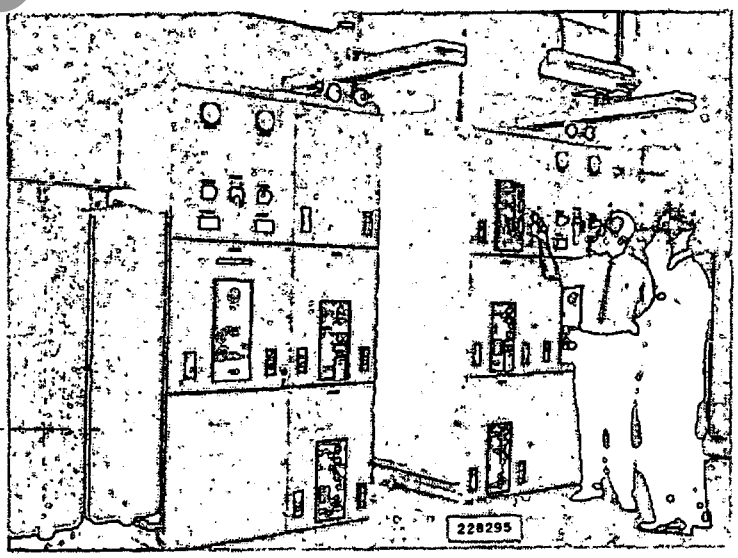

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ALLIS-CHALMERS

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