Today's transformers offer top reliability and higher efficiency

Transformers get a heavy play in the industrial plant for primary and secondary substations, changing voltage at individual machines, matching lighting needs (p 123). They're broadly classed as *wet* or *dry*. In wet types the liquid, oil or askarel, serves as a primary heat-transfer medium and insulator. Dry types use air or inert gas in place of liquid. Askarel and dry types are being used increasingly in unit substations.

Transformer Design. Trend is toward greater safety, dependability, sleek appearance, and to higher voltages and ratings for single units. In large transformers, tap-changing under load is now well established (pp 82, 83). Impulse testing as the manufacturer's "proof test" of design has contributed much to growing dependability. Grain-oriented steels in cores have raised flux densities.

Field experience has confirmed manufacturers' belief that the four available oil-preservation methods (POWER, June 1952, p 79) will maintain oil in serviceable condition. Even so, mineral oil is now available with inhibitors aimed to cut oxidation and sludging. Portable oil reclaimers are being used while transformers are energized, to sandwich in *maintenance* operations during regular work hours.

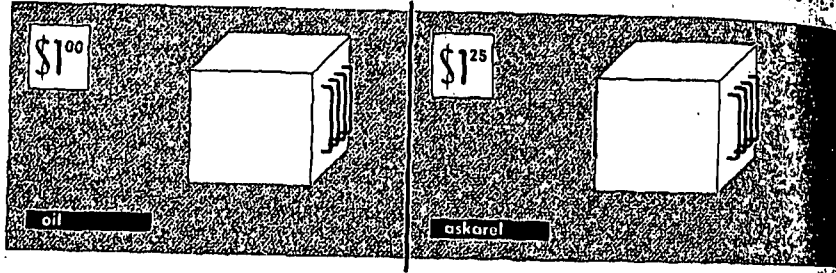
Improved steels have been a big factor in reducing physical size for a given rating. Further squeezing may come with improved insulations. But pendulum may swing in the other direction if use of aluminum grows; for given current rating, more aluminum cross-sectional area is required. Some manufacturers are now turning out aluminum-wound units.

Another *factor in size reduction* that also cuts cost is the single 3-phase unit, now used in place of three single units. Considering top reliability of today's transformers there's little *justification* for leaning on more costly open-delta plan.

Insulation. As more is learned about the true limits of each insulation, the amount is generally reduced. Greater dependence is placed on arresters to cope with overvoltages rather than insulation bulk. Sealed tanks and modern oil-preservation methods have helped to stretch insulation life.

Tomorrow's insulations will grow out of synthetics rather than organic materials. Typical today is class H (p 114). Vented dry types are now available with class H; this permits operation in humid atmospheres without using space heaters during shutdowns.

Oil- and askarel-filled units offer highest impulse levels while



Biggest kva volume of transformers is oil-filled, generally limited to today's outdoor primary substations. Fireproof vault is needed if put indoors. Water-spray or CO_2 extinguishing systems, manual or automatic, are used for important units. Water spray is insulator (POWER, Oct. 1950, pp 110-113) and protects adjoining bays. CO_2 is good for vaults.

Free-breathing units are largely superseded by conservator type and sealed-nitrogen units to hold absorption of oxygen and moisture to a minimum. Newer designs employ an oil-conditioning unit, built into transformer tank wall.

Askarel, a nonflammable liquid, side-steps oil's fire hazard yet retains high impulse level. Use only in transformers specifically designed for it, indoors or out. If indoors above 15 kv, keep in vaults for high-voltage protection.

Chlorine gas is generated if arcing occurs in tank. So units over 25 kva have (1) pressure-relief vent leading to outdoor flue, or (2) gas absorber installed on transformer case. Engineers lean toward gas absorber to avoid running flue. In some plants, especially well-ventilated ones, local inspector may permit vent alone, minus flue or absorber.

Fan cooling or a larger transformer? Here are the factors to check before deciding

A forced-air cooled transformer with two sets of fans may have three ratings: (1) self cooled (2) with one set of fans (3) with all fans. This is a triple-rated unit. High-velocity fans can boost top rating of large liquid-filled transformers to 1.67 times self-cooled rating. Dry-type units usually benefit greatly from fans because cooling air comes in direct contact with windings.

Pros and Cons. Fans are often specified on industrial transformers since they are one of the few means of increasing rating of an existing installation (POWER, June 1952, pp 76, 77). But because fans increase rating by a percentage of the self-cooled rating, benefit is small on small units. Cost of fans and controls is relatively fixed, so many engineers can't see their value for transformers below 500, or even 750, kva. But at 1500-2000 kva and up, fans often prove quite economical.

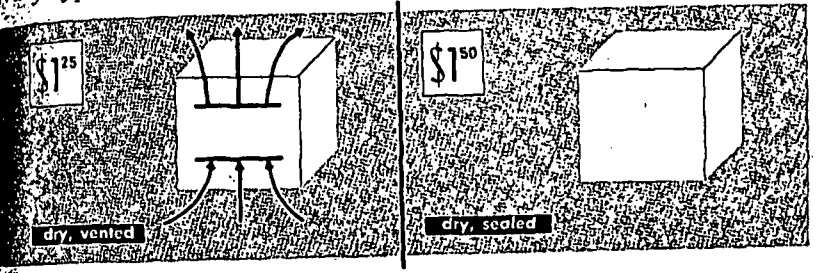
Consider transformer losses when operating at higher ratings with fans. Other factors are noise and maintenance—often higher for fans and controls than for unit itself. So carefully evaluate whether fans, or next larger transformer, is best long-run bet.

Using Fans. Forced-air cooling may be used to: (1) provide additional capacity for peaks, with normal loads handled by natural circulation (2) lower oil and copper temperatures where ambient is high and unit couldn't carry full rated load without exceeding recommended temperatures (3) *carry larger* continuous load than the self-cooled rating would allow.

This last scheme often leads to selecting a smaller transformer than is really needed. Power engineers frown on it as shortsighted. Best use of fans is for peaks or to provide for future loads. In latter case, arrange for cooling when you buy the unit, then you can easily add fans later if capacity is needed.

askarel and dry types are moving ahead for indoor installation

dry types boast light weight, greater simplicity of installation



These are getting a big bid in industry today. They eliminate maintenance of liquids, yet present new problems of their own. Dirt accumulates within housing so side plates must be removed occasionally and the unit blown out.

Avoid installation in production areas of textile and chemical plants; lint and fumes are trouble sources. Consider locating in well-ventilated, separate room in such plants. With some insulations you may run into moisture-absorption problem during shutdown in seasonal plants. Power engineers are licking this with built-in electric heaters.

Here is newest addition to transformer family. Although premium priced, it offers absolute sealing with inert gas at slight positive pressure. This *keeps air*, contaminants and moisture from windings. There is no maintenance other than occasional inspection. And this design is *less noisy* than vented dry type—an important angle in some installations.

Being submersible, there's no need for a special location when installing. But if serious flooding is a possibility, give thought to additional anchoring. Future: Power engineers will last see its advantages and lustily added cost.

Power engineers lean toward newer sealed dry type for wet, dirty or hot locations

Looking into the past, we can see the now-retired air-blast transformer used *for street-railway work as the forerunner* of today's dry type. Modern designs, made their formal bow in the early 1930's. Some 12 years ago, sealed units came in, and with them inert gases.

Vented Designs. Vented dry types with class B insulation have been used for years, usually in clean, dry surroundings. But they've fared well even under tough ambients. During World War II *many were exposed to moisture, lint, dust* and sometimes corrosive fumes. That they stood up under these nonrecommended conditions, even though for relatively short periods, is a tribute to modern transformer design.

Newer sealed designs would have been a better choice. When specifying sealed units, power engineers consider their many advantages: (1) Little maintenance is needed. (2) Transformers can be installed in dirty locations provided periodic checks are made on bushings and gas pressure. (3) Units can be used indoors, outdoors, even where flooding is a possibility. (4) Contaminants can't get at insulation to decrease voltage strength. (5) Minimum oxidation means longer insulation life.

Today's Sealed Units. These fall into one of two groups, based on insulation used: class B or class H. (Both insulations are also available in vented units.) Right now, class H is highest in cost. Some engineers, basing their thinking on field tests, feel a nitrogen-sealed unit with *class B insulation will operate* in class H temperature zone without material effect on life.

But majority looks to the class-H-insulated unit, preferably sealed in nitrogen, as the one to select for holding tomorrow's maintenance costs in check. It is being installed where extremes in load, temperature and atmospheric conditions must be met successfully.