Open enclosures handle most of industry's current requirements

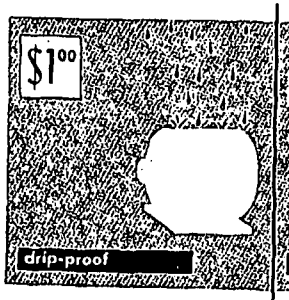
For virtually all motor types a wide variety of enclosures are available. These aim to protect against different ambient conditions, reduce maintenance, increase reliability and safety.

Open motors draw outside air through vent openings. It passes over and around windings, cooling them. So use open motors only where air contains nothing that would harm insulation. A certain amount of "normal" dirt can be tolerated.

All open motors have some form of enclosure, varying in size, location and shape of vent openings. Drip-, splash- and weather-protected motors discussed below are most popular of many types. In these, the enclosure design is intended to protect the motor and its windings.

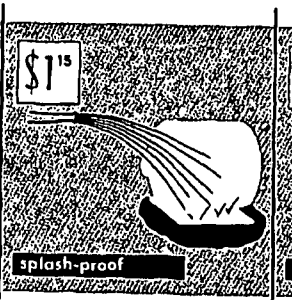
In a "guarded" motor, the vent openings are restricted and located to prevent accidental insertion of hand or fingers into working parts. In a "semi-guarded" motor, restrictions apply only to part of openings, usually on top half of motor.

Textile industry fights against its lint problem by using totally enclosed nonventilated designs in smaller ratings. For larger ratings, many plants now use "textile motors" – specially designed open units with smooth surfaces and well-rounded corners to allow lint to pass through the machine without collecting in the vent passages. Some users put screens over the vent openings of standard open motors, but this can cause trouble unless screens are inspected regularly and kept clean.



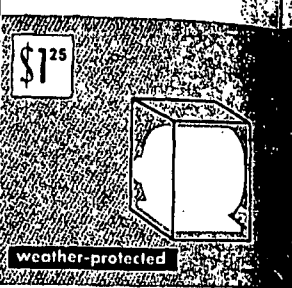
Today's common industrial motor is of open design with drip-proof enclosure. This is defined by NEMA as one with vent openings so constructed that drops of liquid, or solid particles, falling on the machine at any angle not greater than 15 deg from the vertical cannot enter the machine directly, or by striking and running along horizontal or inclined surfaces.

Least expensive, drip-proof construction is suitable for clean indoor areas – elevator penthouses, etc.



For more protection, splash-proof enclosure is designed so drops of liquid or solid particles falling on the unit, coming toward it on a straight line, or at any angle less than 100 deg from vertical cannot enter directly, or by striking and running along surfaces.

This design is intended for motors operating under fairly severe moisture conditions. Manufacturers have offered them, and some plants have used them, for outdoor operation, but trend now is to weather-protected enclosure.



This low-cost open design for outdoor operation has side openings through which air travels up into space above stator. Rotor fan draws air from this chamber through motor windings. Heated air discharges through stator vents and out through screened, baffled openings in the base. This tortuous air path keeps dust, rain, snow out of windings, even when winds are high.

These units have been used down to –40 F with thermostatically controlled immersion heaters in oil reservoir.

Weather-protected units prove highly satisfactory answer for outdoor installations

Growth of outdoor installations in chemical and petroleum industries, and in power plants, brought need for a motor that would lick weaknesses of splash-proof type and yet be less expensive than enclosed designs. The weather-protected enclosure is the answer; experience to date is good.

Ambient air flows through windings to carry away heat, as in other open types, but designers have skillfully combined baffles, sharp turns, vertical and low-velocity travel so air reaching windings doesn't carry rain or snow.

Many on-the-job tests show these units stand up well, even against rain and snow driven directly into openings by high winds. Engineers now apply them for vertical as well as horizontal mounting; both types are available.

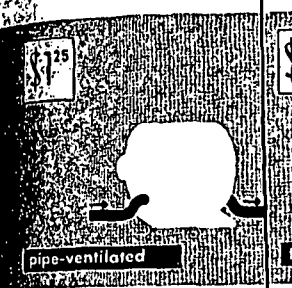
Is the weather-protected enclosure the last word for outdoor jobs? Probably for most. But ambient air does pass over windings, so corrosive atmospheres can cut life. And where hazardous conditions are met, an enclosed motor must be used – pipe-ventilated or explosion-proof.

Totally enclosed designs cut maintenance, meet tough ambients

In most industries, trend is to a greater degree of enclosure to: (1) assure maximum motor life by protecting insulation (2) cut down motor maintenance. **Standardization.** Many plants standardize to some extent on TEFC motors. But there's no agreement on whether it pays to settle on one motor enclosure, across the board. A majority seems to feel that economics calls for matching enclosure to particular need. Most plants thus wind up with at least several of available types. The exceptions, notably automotive plants, find standardization cuts maintenance and vastly reduces stock of spares needed.

Widely used "enclosed" types are discussed below. A number of special types are also of interest: (1) The water-cooled enclosed motor, with water-to-air heat exchanger, handles problems of high ambient temperatures. (2) The sanitary motor, totally enclosed, nonventilated and water-proof, has a smooth, crevice-free exterior that can be easily cleaned of germ-bearing dirt. (3) The *chemical* motor is a TEFC design with special emphasis on impregnation and insulation of windings, etc.

"Price tags" below show relative costs of several enclosure types, taking the common drip-proof as $1.00. Comparison is for 1000-hp 900-rpm 2300-v 60-cycle 3-phase motor. Values change in smaller sizes, where, for example, weather-protected and pipe-ventilated types aren't widely used. In the 50-hp range, splash-proof would be $1.10, TEFC $1.65, and explosion-proof $1.85 (using same base).



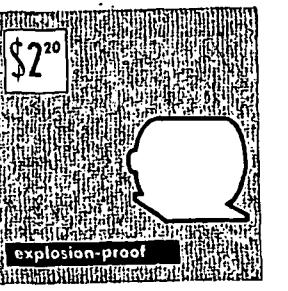
A pipe-ventilated machine is totally enclosed except for inlet and outlet duct openings. Connecting ducts admit and discharge ventilating air, which is circulated by a fan within the motor enclosure, or, in many cases, by an external blower.

This separate- or forced-ventilated type is applied if surrounding conditions don't supply enough clean, cool air. This type of application is of growing importance in the petroleum and chemical industries.



The totally enclosed fan-cooled motor (TEFC) has a fan at end of motor shaft to circulate air around its totally enclosed motor frame. Cooling efficiency is increased by placing fins on exposed side of the inner frame. Then an outer shroud is placed around complete motor and fan, enclosing all but the necessary vent openings.

This type is becoming more and more popular; in many cases, lower maintenance and greater reliability more than offset higher first cost.



This totally enclosed type is designed and constructed to withstand internal explosion of a specified gas or vapor and to prevent ignition of any gas or vapor surrounding the motor.

In applying explosion-proof motors, refer to the National Electrical Code, Article No. 500, Hazardous Locations Class I, Group A, B, C and D.

This enclosure is costly, so today's engineers try to avoid need for it, either by changing motor location, or by using a pipe-ventilated enclosure.

Pipe-ventilated motors find economical application in industry's hazardous areas

In a never-ending search for lower-cost methods, engineers now seek to avoid heavy cost of explosion-proof enclosures, particularly for large units. The pipe-ventilated design, pioneered in the petroleum industry and now used by others, looks like a good answer. Right now, for example, 800- to 1000-hp pipe-ventilated units smack in the heart of chemical or hazardous areas are working with cooling air brought to them through ducts from a source of clean air. Cost comparisons must include ducts and blowers. Where source of clean air isn't too far away, this scheme pans out economically.

Another possible answer is the totally enclosed gas-filled induction motor. Basic idea of this type is to keep gas within enclosure at a pressure slightly higher than the surroundings. This insures against explosive gases seeping into enclosure. A recent example of such an installation is a 3000-hp 1800-rpm 2300-v 3-phase unit driving an oil-refinery centrifugal compressor. Keep this scheme in mind as a possible lower-cost solution to problems of hazardous or corrosive atmosphere.