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still being formulated. Until that time, electrical transformer manufacturers and customers are hesitant to make full commitments to a particular fluid because of insurance ratings.

National Electrical Manufacturers Assn. commissioned Factory Mutual to study flammability of the fluids, and results are not expected until about the end of this year.

"Factory Mutual seemed the dominant group to make judgments on substitutes," explains John H. Motherway, power equipment division manager of NEMA. The contract covers "very specific questions of flammability: tests for standards of flammability and for the evaluation by Factory Mutual into their system of insurability," he says.

Covered in the tests: the manner of heat release, large-scale burn tests. Motherway says final evaluations of the data are now underway, with Factory Mutual seeking to establish the criteria required for insurability and for standards for testing substitutes in the future.

Until the standards are set up, Factory Mutual has given the various candidate fluids interim acceptance for use in transformers.

Taking Over: Technically, PCBs are not yet officially banned. Monsanto voluntarily halted production (*see sidebar, p. 29*), but EPA's hearings last week were another step toward regulations prohibiting production. Manufacturers of electrical equipment can use existing stocks of the product until June 30, 1979, and can import stocks through the end of this year. After that, PCBs cannot be used—except for certain small applications (e.g., small capacitors), for a period of five years.

Nevertheless, the handwriting is on the wall, and manufacturers of electrical equipment have been working with replacement fluids for some time.

For example, Westinghouse began a development program in 1974 with Dow Corning with silicone fluid in small, power transformers, moved the products into commercial use in late 1976.

Playing on Age: Silicone producers are

CW PHOTO: Charles E. Garb

TRANSFORMERS (behind trees) in residential areas need fire-resistant dielectric fluids.

Seeking way out of PCB woods

Transformer manufacturers turn to silicones, poly-alpha-olefins and modified hydrocarbons to replace PCB-based askarels

Hearings on the Environmental Protection Agency's proposed ban on polychlorinated biphenyls (*see also p. 19*) continued last week with discussions on decreasing allowable PCB contamination in transformer dielectric fluid to 50 parts per million, from 500 ppm., and on requiring incineration of contaminated oil. But for transformer manufacturers and suppliers of dielectric fluids, the big question is what to use as a replacement.

Three different classes of compounds are scrambling for the new transformer market, pegged at roughly 13-15 million lbs./year.

Silicone fluids lead in number of suppliers and, most likely, in consumption. General Electric's Silicone Products Dept., Dow Corning and Union Carbide's Chemicals and Plastics Division are actively competing in the market. SWS Silicones also has a fluid, although transformers are not envisioned as a major market for the company, says Stauffer, 51%-joint owner of SWS with Wacker Chemical, U.S. arm of West Germany's Wacker Chemie.

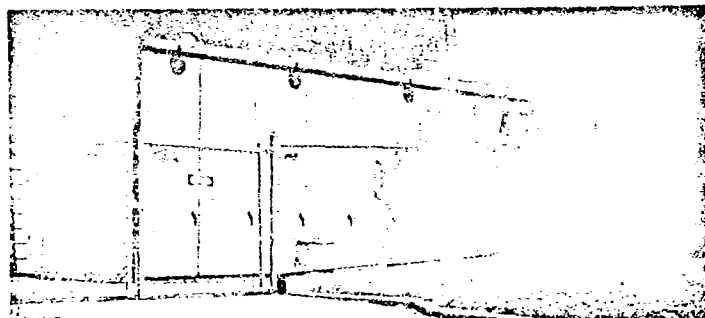
Poly-alpha-olefins, marketed by Uniroyal Chemical and Gulf Chemical, are more recent entries in the field.

And the Fluids Division of R T E Corp. (Waukesha, Wis.) is marketing a hydrocarbon-based product, dubbed RTEmp fluid, for transformer applications.

In addition to these three classes, a chlorinated aromatic, dubbed Iralec and imported from France, is being tested by some transformer manufacturers.

Waiting Game: But the dielectric fluid suppliers' scramble for a share of the market is complicated by the problem that ratings of the fluids for flammability are

CLOSED systems in transformers can still use existing askarel stocks, but pressure is on to switch.



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specialties

basing their optimism on what they see as outstanding field-experience for the fluids (technically polydimethylsiloxanes). A GE official notes: "Silicones are environmentally safe—they've been proven over a period of 25-30 years in electrical applications."

And fluids of the same chemical structure have been used for over 30 years, he says, in a variety of critical applications, including direct contact with food under Food and Drug Administration food-additive regulations.

They are also inert, points out Robert W. Lindberg, marketing manager for silicones at Union Carbide. "They don't react with anything. When you have a coolant in a transformer, you expect it to be there for 20 years or more," he says.

"The industry is designing units to last 20 or 30 years," adds William H. Bishop, product market manager at Dow Corning. "You just don't do that overnight, with something that has no data." Bishop reports that there are at least 2,500 transformers filled with silicone fluid in commercial use around the world. His company is tracking purchasers of the first units, filled some four or five years ago, to monitor the fluid.

"They are all performing very well," he says.

And silicone fluids are the least flammable of the three types of competing materials. Dow-Corning's Bishop figures it this way: on a rough flammability scale of water, 0, to ethyl ether, 100, askarels (PCBs) are 2 to 5, silicone fluids 4-5 and standard hydrocarbon oils 10-20.

However, in most of their applications, silicones tend to be premium-priced materials, and transformer dielectric fluids are no exception, silicone marketers concede. Still, GE points out that although "silicone fluids will likely be 20-25% more expensive" on a first-cost basis, "we believe they offer the best value when evaluated on a total systems basis." Reasons: durable without chemically breaking down, forming sludge deposits, few required for transformer.

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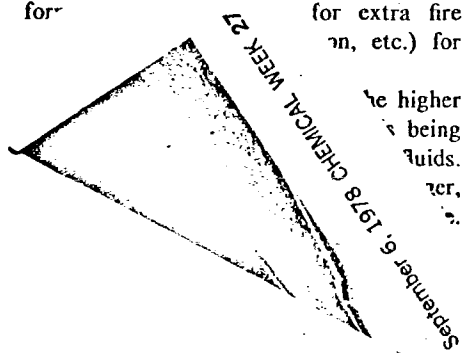
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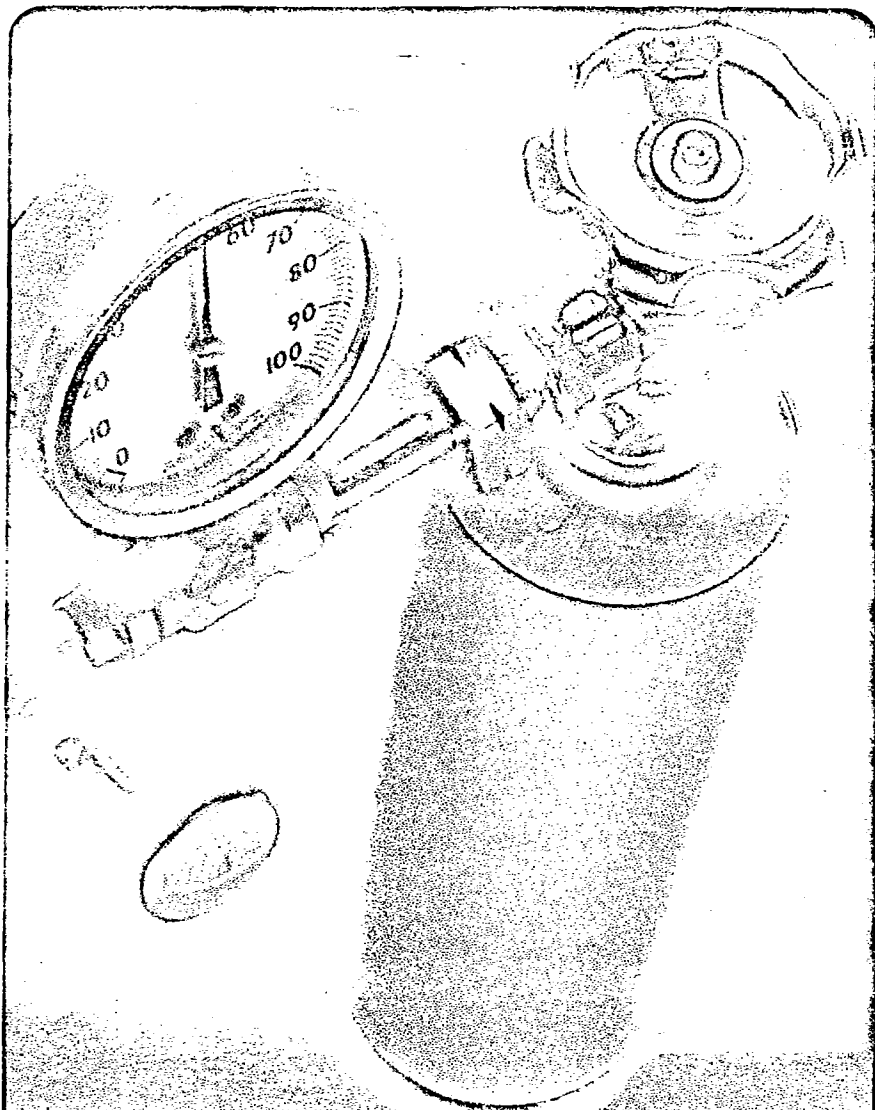
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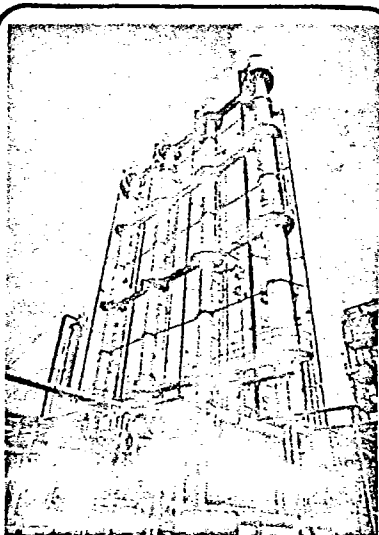
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2-Methylpentane		Hexene-1
3-Methylpentane		2,4,4-Trimethylpentene-1
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much heat of combustion during combustion, but if all you want is a measure of protection, how high is up? It's like buying a Le Mans instead of an Alfa Romeo."

Uniroyal marketers, too, note their "excellent pricing position." A potential user would have to evaluate the needs for a fluid; the Factory Mutual tests will help bring application points into proper perspective, the company predicts.

RTE marketers contend that one advantage for their RTEmp fluid is its base-stock—paraffin-based crude, which it says is readily available in abundant supply. The company, which makes transformers, established a fluids division last year, when full-scale marketing of the replacement for askarels (both for its own transformers and those of competitors) began, says James W. Baudhuin, director of investor relations.

Retrofilling? RTE also touts its material as being both a makeup fluid for PCB-filled transformers (at up to 40% by volume) and for retrofilling of either conventional-oil-filled or PCB-filled transformers.

Retrofilling, however, "is another can of worms entirely," says one marketer.

It is potentially a huge market: EPA estimates that there are presently some 140,000 transformers in service containing about 25 million gal. of PCBs. (There are about 900 million capacitors, including small appliances and fluorescent light ballasts, containing about 50 million gal. of PCBs. But capacitors have different requirements and can't use the same replacements as transformers. Manufacturers are changing to products such as nonchlorinated biphenyls, e.g., isopropylbiphenyl.)

But few marketers expect this market to come through. One immediate problem: "There is no reliable method for cleaning out all PCBs from transformers," says Bipen Doshi, Uniroyal's market development manager for new products. "If a transformer were filled 20 years ago, its insides are saturated. So if you don't clean it thoroughly, the PCBs could leach out into the fluid, give a concentration higher than whatever level EPA finally sets."

(Arguing against decreasing the allowable amount of PCBs in transformer fluid from 500 ppm to 50 ppm, NEMA estimated disposal costs of contaminated fluid at \$2.47-3.06 billion—considerably higher than the EPA estimate of \$612-769 million. Still-earlier EPA estimates placed the cost to all industry at \$46 million for compliance, plus \$100 million from prohibiting application of PCB-contaminated oil as a dust-control agent on roads.)

"Draining old fluid and putting in new is still very controversial," says Union Carbide's Lindberg. "First, you'd be handling a material that is very hazardous. Maybe the safest thing is to leave it until you're forced to do something with it—if a leak develops, for example," he says.

Another case for retrofilling: where transformers are near schools, ponds and streams, food-processing plants—"anywhere a leak could cause a catastrophe," adds Dow-Corning's Bishop.

All told, most customers probably agree that no one fluid will do it all. For a transformer costing \$13,000-14,000 and holding 220-230 gal. of fluid on the average, manufacturers will consider carefully between silicone fluids, at about \$14/gal., and the hydrocarbon fluids, at perhaps \$5-7/gal. And straight mineral oil, at 70¢/gal., will still be the material of choice for transformers needing no flame resistance.

Why PCBs lost out

PCB fluids (askarels) came into use in the electrical industry in 1929, as dielectric insulating fluids with fire-resistant properties. On certain installations, they replaced hydrocarbon mineral oil, which is flammable. Mineral oil is still used in many applications. It is well-suited for filling transformers in rural areas, for example, but might prove hazardous if the installation is near schools, hospitals, subway systems and other populated areas.

The askarels are nonflammable, long-lasting and inert—ironically, the properties that caused their downfall. Records of Monsanto, the only U.S. producer, show that before 1971, production was 85 million lbs./year, which went to thousands of customers (e.g., for lubricants, carbonless carbon paper, adhesives, surface coatings).

By 1971, however, research had indicated the persistence of PCBs and the company began phasing out sales for open applications. Sales were cut to 45 million lbs./year.

From 1971 to 1976, Monsanto reports, average production was 27 million lbs./year, with sales to fewer than 40 customers, all manufacturers of sealed electrical equipment. Even those uses seemed to offer potential hazards, however, and indications of adverse health effects—possibly causing cancer, birth defects, and liver, nerve and skin damage in humans—sealed PCBs' fate. Monsanto halted production in July 1977.