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CABLING: What You Don't Know Can Kill You.

Halogen cabling can emit toxic fumes in a fire. Many international governments have moved to less lethal alternatives. Why hasn't the U.S. done the same?

By Stephen Saunders - News Editor for Data Communications Magazine.

There's something corporate networkers should know. Most of the cable they're now pulling at central sites and branch offices across the U.S. contains halogens – chemical that give off toxic fumes when they burn. In a fire, halogen cable can release acid gases that sear the eyes, nose, mouth, and throat. The fumes can disorient victims, preventing them from escaping the blaze. They can cause severe respiratory damage. And they can kill. Recognizing this potentially deadly problem, a number of international governments have already standardized on zero-halogen cabling. But the U.S. National Electric Code, which serves as the basis for local standards in 45 sates, effectively forces net managers to use halogen-sheathed Category 5 UTP in the plenum spaces above ceilings and below floors in office buildings. And while some organization that are exempt from local building code – like the military and mass transit authorities – have banned halogen from their networks, most net managers have little choice but to obey the law.

And that, argue halogen-free advocates, could be fatal. Building plenums are typically used to circulate air throughout the workplace. If there's a fire, they warn, heating and air conditioning ducts could become conduits for hydrogen chloride, hydrogen fluoride, and the other gasses that cause far more fatalities than flames or visible smoke.

LIFE AND BREATH

For some critics, the difference between international and U.S. standards reveals start contrasts. "U.S. cabling codes are designed to save property. In Europe, we are more interested in saving lives, " says Dario Erba, Manager for structured cabling at IBM Europe (Vimercate, Italy), which installs only acid-free cables.

Erba's assessment my strike many as unduly harsh, but it raises an important concern: Given halogens' lethal potential, why are they used in cabling at all?

There's actually a method to this apparent madness. Halogens are an extremely effective fire retardant. Adding them to cable insulation increase its kindling point. "If the cable doesn't catch fire, it won't give off toxic fumes, says Lauren Caudill, senior development specialist for codes and standards at DuPont (Wilmington, DE). The chemical company is the leading manufacturer of FEP (fluorinated ethylene propylene), the most toxic halogen and the one used in the majority of cabling.

NO EASY ANSWERS

It's a deadly double blind: Halogen insulation helps prevent cables from catching fire, but if the cable jackets do ignite the resultant fumes can drive up the death toll. And this dilemma has been at the heart of a decade-long debate about the continued use of halogen. "Fluorinated polymers are hundreds of times more toxic than zero-halogen cabling." Comments Marcelo Hirschler, a consultant with BGH International Inc (Mill Valley, CA)< a firm that specializes in fire-safety issues. "They're also far less flammable."

To date, halogen's defenders, which include DuPont and B.F. Goodrich CO (Akron, OH), have carried the day. But the opposition, whose ranks include manufacturers of zero-halogen cable, is running up the heat in hopes of convincing the National Fire Protection Association (NFPA, Quincy, MA) to change the current code. The amended standards will go into effect in 1999, but the deadline for filing proposed changes is late this year.

This isn't the first time that halogen-free advocates have tried to alter the law, looking to ban halogen outright or allow zero-halogen cable to be used in building plenum. Thus far they've failed, partly because the onus is on the opposition to demonstrate that halogen-free cable will save lives. That's been particularly difficult to do given that both types of cable – halogen and halogen-free produce carbon monoxide when they burn. And carbon monoxide is the leading cause of death in fires.

"There was a lot of argument about this six years ago, but the people in favor of zero-halogen couldn't prove their case," says Dave McCormack, assistant to the president of the International Association of Firefighters (St. Louis). McCormick believes the code should be changed to restrict the use of halogen cabling, which some tests show to be more than five times as toxic as its acid-free equivalent.

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CATASTROPHIC CORROSION

This time around, however, the anti-halogen forces are taking a different track. They now argue that these chemicals should be outlawed because of the catastrophic effect acid fumes have on computer circuitry - causing millions of dollars worth of damage even in small fires. "Corrosivity is the Achilles' heel of halogen cables," comments Michael Keogh, corporate fellow at Union Carbide Corp. (Danbury, CT). "It's a matter of machine toxicity, now human toxicity," Union Carbide makes the raw materials used in both halogen and halogen free cable.

And where does all this leave net managers interested in eliminated halogen from their networks? Unfortunately, they don't have many options. The law is clear: Meet the code or risk the consequences, which range from being fines by building inspectors or fire marshals to insurance companies that refuse to pay up in the event of disaster (se "The Insurance Angle"). Switching to fiber makes no difference, because its insulation is subject to the same code as copper. About the only way to legally install halogen-free cable is to run it in metal conduits. Trouble is, these conduits typically double the price of a cabling system.

STANDARDS SCHISM

International cabling standards were developed in response to events in the Falklands War. Research showed that most shipboard fatalities during the conflict were the results of the smoke from fires started by missiles and bombs rather than by the weapons themselves. "Acid gasses also prevented personnel from fighting the fires," says Karen Long, a physicist at the Naval Sea Systems Command (Washington, DC). Long is responsible for developing fiber cabling standards for the U.S. Navy, which has decided to go halogen-free.

Many countries - including Australia, France, Italy, Japan, Korea, New Zealand, and the U.K. – have also moved to halogen-free cabling. And even in countries where the choice of cable is still left to the installer, zero-halogen is becoming the technology of choice, according to IBM's Erba. "Halogen-free cables account for 40 percent of the total communications cable in Europe, " he says. He believes that the remaining 60 percent is halogen sheathed PVC (polyvinyl chloride).

The easiest way to see the difference between international and U.S. cabling codes is to compare what they cover. International standards address three issues:
* fire resistance (how fast cable burns
* smoke density (how much visible smoke is produced)
* toxicity (how harmful the smoke is to human beings)

U.S. codes, in contrast, only address two of those criteria: fire resistance and smoke density. The National Electric Code is silent when is comes to toxicity. This is by design, not omission. "We try to stay out of health-related subjects. We're electricians. We're not in the health business," says Joseph Sheehan, senior electrical specialist with the NFPA.

It should be noted, however, that the U.S. standards for fire resistance are more comprehensive and more stringent than their international counterparts. Three levels are defined. The first and least demanding applies to general-purpose cabling (such as that used to connect a phone to a wall jack). The second applies to cables installed in building risers. The third and toughest code is reserved for cabling installed in plenum spaces.

CHEMICAL CONDITIONING

The only way to meet the more demanding U.S. standards is to add one of several halogens to the polymer plastic used in cable insulation. PVC cable contains chlorine; FEP (also known as Teflon ® FEP) is made with fluorine.

FEP is highly fire resistant. It can withstand temperatures to 800 degrees F before it begins to break down. It's also an extremely efficient electrical insulation which suite it to cable that carries high-speed data. Those two characteristics have made FEP the key component in plenum-rated Category 5 UTP (unshielded twisted pair) in the U.S. What's more, FEP cabling has largely replaced PVC cable in building risers and elsewhere, despite the fact that it's only legally required in plenums.

It's a different story overseas. In order to meet rigorous international toxicity specs cable manufacturers avoid halogens altogether, instead adding metal hydrates to their polyethylene and polypropylene cable insulations. When heated, these chemicals release steam.

But halogen-free cables made with metal hydrates are not a fire-resistant as their U.S. counterparts. And once the metal hydrate is exhausted, the insulation burns freely.

Zero-halogen cable meets the two less stringent U.S. fire-resistance standards. It's acceptable for general purpose use and for building risers. But in order to obtain a plenum rating manufacturers would have to add so much metal hydrate to their insulation that the cable would no longer meet Category 5 UTP electrical requirements. "The flame retardant additives, " explains Keogh, "do not have good electrical properties."

CHEMICAL CONDITIONING (continued)
Trying to sell lower performance CAT 3 or 4 cable into U.S. markets would be an exercise in futility. Corporations are now moving to higher speed LAN's and need the superior electrical properties of CAT 5 cable to cope with bigger bandwidths.

BURNING ISSUES
When the PVC cables used in building risers burn they emit both hydrogen chloride (an acid gas) and dioxin, which Greenpeace, the environmental advocacy group, calls "the most toxic synthetic chemical known to science" (see table I). Long-term exposure to dioxin has been linked to a number of health problems, including cancer, reproductive disorders, birth defects, impaired neurological development, diabetes, and immune system suppression.

When FEP cable burns it releases hydrogen fluoride, an odorless invisible gas that is considerably more toxic than hydrogen chloride. Tests conducted at University of Pittsburgh in the 1980's also indicate the presence of another, far more deadly gas, in FEP fumes – known in the cabling industry as "the supertoxin." Some scientist theorize the gas is a fluoro-phosgene- the fluorine equivalent to phosgene gas used in World War I. The supertoxin was never properly identified, and research into it has now ceased. "We know there's hydrogen fluoride, but that's not the real problem," says BGH's Hirschler. "There's something else in the gases, and nobody knows what it really is except that it's highly, highly toxic."

Not all researchers agree with Hirschler's assessment. "Most people have largely put the supertoxin down as a laboratory phenomenon, not a real-world phenomenon," says Edward Weil, professor at Polytechnic University (Brooklyn, N.Y.), which conducts research into halogen and halogen-free cabling.

FEP's poisonous potential has prompted some grisly jokes at cabling companies. "The advantage of fluorine cable is that the fireman can see your body and step over it when they arrive to put out the fire," says Paul Chalifour, senior manager of market development at Nordx/CDT, a subsidiary of Cable Design Technologies Corp. (Pittsburgh). Like almost all cable companies, Nordx sells halogen and halogen-free cabling.

LEARN NOT TO BURN
Champions of halogen-free cable are quick to point out that in a fire what can't be seen is far more lethal than what can. Invisible gasses given off by burning material are the cause of more than 80 percent of fire deaths, according to research published in the British Medical Journal. In the U.S. that translates into as many as 6,000 deaths a year. And halogen's opponents are sure that the chemicals are killers.

Most of the available data on cable toxicity was gathered after the State of New York changed its building code in 1988, requiring that all cabling products be tested for toxicity – the only state ever to do so. The tests were conducted by Anderson Laboratories (West Hartford, VT) on behalf of the National Electrical Manufacturers Associations (NEMA, Rosslyn, VA).

Anderson Labs measured cable toxicity on mice in a laboratory using the so-called Pittsburgh Test (named for the university where it was developed). In the test, a specific amount of insulation is burned, with the fumes shunted through a tube to four mice. This procedure is repeated with more insulation until two of the mice are dead. The insulation is then assigned an LC%) (life count 50) toxicity rating that indicated the number of grams of insulation that had to be burned to kill half of the test animals. The higher the LC50 rating, the less toxic the cable. Over 1,000 tests were conducted.

DATA COMMUNICATIONS obtained the LC50 ratings from the State of New York's Hazardous Materials Bureau (see figure 1). They show that halogen free FEP cable is more than 5 times as toxic as halogen-free and 1.5 times as toxic as halogen PVC.

FEP FIGHTBACK
The NFPA, the nonprofit association that oversees the national code, doesn't dispute FEP's lethal nature. "If the plenum tests were based only on toxicity, Teflon® FEP is probably the only material that would not pass," says Arthur Cote, vice president and chief engineer. "It's an order of magnitude higher in terms of toxic potency than almost any other material in use today."

But Cote, who also is secretary of the NFPA's toxicity advisory committee, doesn't think the code should be changed, citing doubts about the Pittsburgh Test methodology.

Other halogen advocates also challenge the test results. Some argue that the findings are academic because the tests don't mirror real-world conditions. "By the time the levels of heat in a building were high enough to release those gasses, everyone would be dead anyway," says Al Scolnik, vice president of power distribution products at NEMA's wire and cable division.

FEP FIGHTBACK (continued)
Halogen defenders also argue that autopsies of fire victims usually show carbon monoxide poisoning as the cause of death, not hydrogen chloride or hydrogen fluoride. And they all that cables only contribute a small amount of smoke to a fire. Computer simulations by the National Research Council of Canada suggest that less than 12 percent of the smoke comes from cable.

The anti-halogen forces have answers ready on all counts. For one thing, they argue that while carbon monoxide poisoning may be the direct cause of death in a fire, acid gasses can disorient victims and prevent them from escaping a burning building. What's more, they assert that where cable is located is just as important as the smoke it gives off. Since building plenum is typically used by the air-conditioning system, wiring ducts can distribute toxic fumes throughout the work-place – even if a fire hot enough to release the fumes is restricted to a small area. "If there's smoke in the plenum return it can be sucked back and redistributed," explains Mike Kerwin, principal at Cablenet Systems Inc. (Woburn, MA), which installs cabling systems for corporations and educational organizations.

THE DUSSELDORF DISASTER
That appears to be what happened during a fire at Dusseldorf Airport in Germany last April in which 16 people where killed and more than 60 hospitalized for smoke inhalation.

The fire appears to have been sparked off by welders working in a combined ventilation and cable shaft in the main arrival hall. According to the British newspaper The Independent, "PVC-covered cables began to smolder, emitting cyanide, chloride, carbon monoxide, and possibly dioxin fumes that spread through the building's ventilation shafts." The International Herald Tribune reported that the "fire carried a flood of lethal fumes into elevators, ventilation ducts, and passenger lounges."

That sort of disaster makes halogen opponents understandably nervous – especially since there's far more cable in building plenums than ever before. "There wasn't much wire above ceilings 10 years ago. Since then, the amount of cabling has gone up by several orders of magnitude." Says Richard Bukowski, senior research engineer at the building and fire research laboratory of the National Institute of Standards and Technology (NIST, Gaithersburg, MD) "The bigger the fuel load, the bigger the concern over fumes," he adds.

"There should be controls on where you can use halogen cable. The last place you want it is in a plenum. If you must run in there it's essential that it's contained in a rigid conduit or pipe," says McCormack of the International Association of Firefighters. He notes that conduit is compulsory in only two U.S. cities: Chicago and New York.

PLAYING POLITICS
Critics of halogen cable also argue that cable manufacturers and chemical companies have a vested interest in maintaining the status quo. FEP cabling is about 40 percent more expensive than halogen-free. DuPont has even more to lose; it has an almost total lock on the FEP markets, accounting for over 90 percent of production.

Some observers claim that the big cable and chemical manufacturers have used undue influence to prevent code changes. "The only reason we can't spec halogen-free is because of political maneuvering by the cabling companies," says Allen Kasiewicz, president of Trellis Communications Corp. (Manchester, HE), a cabling installer and consultancy.

But evidence backing up those charges is virtually nonexistent. And it's worth noting that the NFPA limits the number of panelists from any one organization to prevent packing the committees that discuss code changes. Of course, there are loopholes. As well as its official delegates, DuPont staffers attend NFPA meetings under the guise of the Chemical Manufacturers Association. Still, its representatives only make up a fraction of the 400 people that are involved in the review process.

THE ACID TEST
As indicated, zero-halogen advocates are gearing up for a new campaign aimed at amending the next edition of the national code. But rather than once again taking the toxic tack, the latest push focuses on the catastrophic damage that smoke can cause to computer and networking equipment. "It's the next big battle," says Tom Ebert, engineering group leader at Underwriter's Labs Inc. (Elkhart, IN), which is developing a new Corrosivity test.

Both sides agree that there's a problem. "There are numerous examples of multimillion dollar damages after even a very small PVC fire," says Paul Villien, coordinating manager at 3P Third Party Testing (Hoersholm, Denmark), an independent test facility.

"Even a smoldering fire can wreak havoc on a modern office. IT doesn't have to be big enough to set off the sprinklers," agrees Tom Chapin, member of the technical staff at Lucent Technologies (The recent AT&T consolidation, Murray Hill, NJ), which sells both halogen and halogen-free cabling.

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THE BURDEN OF PROOF

Despite the apparent agreement, it's by no means certain that the latest bid to permit the use of halogen-free cable in plenum airspace will be any more successful than earlier efforts. Once again, it's up to the advocates of change to prove that halogen-free cables are safer - although this time the debate centers on hardware rather than human beings. And the pro-halogen group is already preparing its counteroffensive.

What may make the anti-halogen push even harder is that there's less consensus on gauging Corrosivity than there is on measuring toxicity. Currently, there are about 20 different tests used worldwide.

In Europe, cable Corrosivity is generally matched to the PH value of the gas that's emitted when the insulation burns. (Levels of 1 to 4 are deemed corrosive; levels of 5 and above are not.) When PVC burns it produces hydrogen chloride, which has a PH level of 1. When FEP insulation burns it releases hydrogen fluoride, which has a PH level of 3 to 4. When halogen-free cables burns it gives off steam, which has a PH level or 6.5 to 8.5.

But some observers believe PH values are only part of ht story. "Smoke particles can have a traumatic effect on closely spaces electronic components on a circuit board. And the PH test doesn't measure the highly conductive ionic contaminants that can be produced when cable burns," says Chapin.

Lucent has come up with a new test - called an interdigitated comb pattern - that it claims more accurately emulates the effects of fire on a PC board. The test bed comprises two interleaved copper combs. Smoke is passed across the combs, and the amount of electrical leakage is then measured.

Chapin says test results show that going with zero-halogen cable doesn't guarantee fewer problems. "Some of the halogen-free cables are great. Bust some of them approach the Corrosivity of halogen cabling." Given that finding, Chapin recommends that net mangers wait for cross-comparison testing of cables to be performed and the finding published before opting for any particular brand. But with so many different tests in use, net managers still have the problem of whose results to trust.

In the end, it may take more than testing, lobbying, or even common sense to force a change in the U.S. codes. "There's an on-off attitude about fire safety," says Rosalind Anderson, president of Anderson Laboratories. "If you haven't killed anyone important recently, then it's not an issue."

Table 1: INSULATION ISSUES

Cable Insulation	Performance Ratings top data rate	Plenum Approved	Cost per 1,000 feet	Characteristics	By-products when burned	Toxicity Rating (LC50)*
Halogen FEP (fluorinated ethylene propylene)	Category 5 / 100 Mbit/s	Yes	$275	Low smoke, high toxicity, highly fire resistant	Hydrogen fluoride, carbon monoxide	LC50 range = 16.1 to 77.1
Halogen PVC	Category 3 / 10/ Mbit/s	No	$100	High smoke, high toxicity; low fire resistance	Hydrogen chloride, dioxin, carbon monoxide	LC50 range = 10 - 20.6
Halogen-Free	Category 5 / 100 Mbit/s	No	$160	Low smoke, low toxicity; fire resistant until metal hydrate exhausted	Steam, carbon monoxide	LC50 range = 4.4 - 15.

* Toxicity is measured using the LC50 rating, which indicates the number of grams of insulation that must be burned to kill half the mice in a lab experiment. LC50 ratings supplied by the State of New York Hazardous Materials Bureau.

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UP IN SMOKE?
BUILDING CODES ARE CLEAR about what types of cabling can – and cant – be pulled through the plenum spaces below floors and above ceilings. Still corporate networkers worried about toxic fumes and office fires have a few options open.

Wrap it up Installing steel or fiberglass conduits or tubing inside building plenum gives net managers the option to run any kind of cable they want – including halogen-free UTP. The downside? Conduits can increase the cost of a cabling system by anywhere for 40 percent to 300 percent.

Mix it up Halogen-free cable cant meet U.S. fire-resistance standards for plenum spaces, but zero-halogen is OK for building risers. More and more cable installers are adding halogen-free to their catalogs, and they say that mixing cable won't adversely affect performance.

Build a safe house One of the newest concepts in commercial architecture calls for the so-called areas of refuge that allow building occupants to sit out a fire in a sealed environment rather than attempting to feel the fumes and the flames.

Play politics State legislatures usually adopt the National Electric Code as a matter of course – but there's no law that says they have to. Net managers who don't like the code should say so. The Department of Public Safety is generally a good place to start.

Make some notice Net managers unhappy with the National Electric Code should know that anyone can propose changes to the spec. send suggestions to the Secretary of the Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, Mass 02169. The deadline for submitting proposals for the 1999 code is November 8, 1996.

The Insurance Angle
Corporate Networkers Considering new cable need to pay equally careful attention to performance specs and the law. "If a company knowing has a code violation – and most do – then its liable in the event of a disaster," says John Powers, principal consultant at Powers & Co. (Tewksbury, Mass), a consultancy that performs cabling infrastructure audits. According to Powers, 85 percent of the buildings his firm inspects are in violation of local codes. What's the most common crime? According to Powers, its pulling new plenum-approved cable without first removing the old wiring. "We've all been guilty of it over the years," he says. What makes the situation more complicated it that there are some instances when companies are permitted leave the older cable in place. "As a rule of thumb, if you're working in the ceiling but there's no major reconstruction, you can leave in old stuff in place," says Michael S. Chambers, president of Comlink Inc. (Falls Church, VA), a cable installer. What constitutes "major reconstruction"? if permanent walls are being moved or ceilings pull down, then companies or their contractors my apply for a building permit. That automatically means a visit from a building inspector who will "make you take out the old cable," says Chambers.

Hiring a contractor to perform a cabling audit is one way to ensure that a building meets code, but it can be expensive. "It's a scam. Some companies will charge you a quarter of a million dollars to audit your entire building," says Powers. He recommends that corporations hire a firm to spend two days auditing four or five major quadrants in the building, rather than the entire site. "It's a waste of money to audit cable if you're just going to pull it out anyway."
Given what's at stake, some companies may choose to bite the financial bullet rather than risk fines – or worse. "Its not the $1,000 spot fines that companies should be worried about, its litigation that can follow a fire," says Chambers.