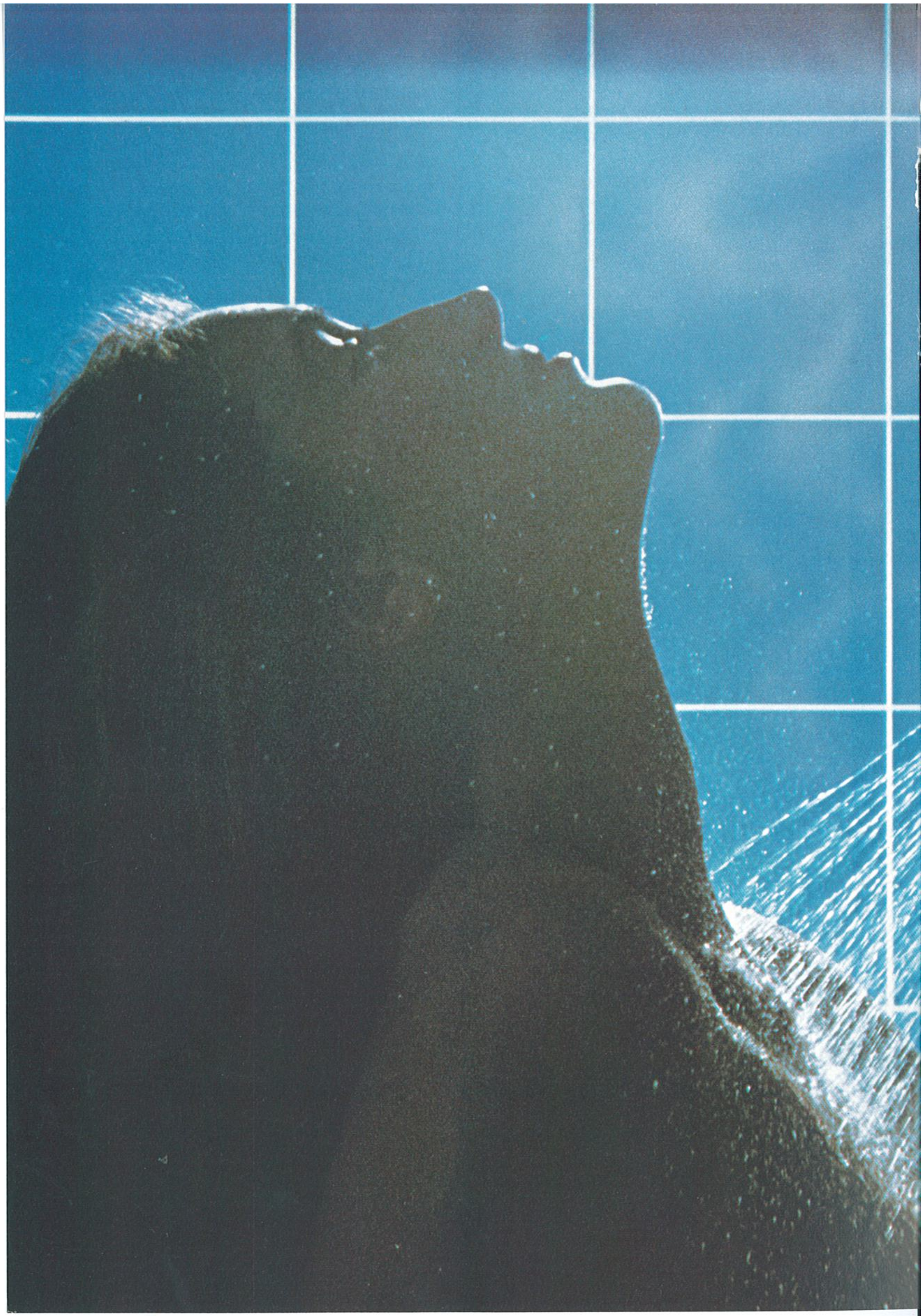
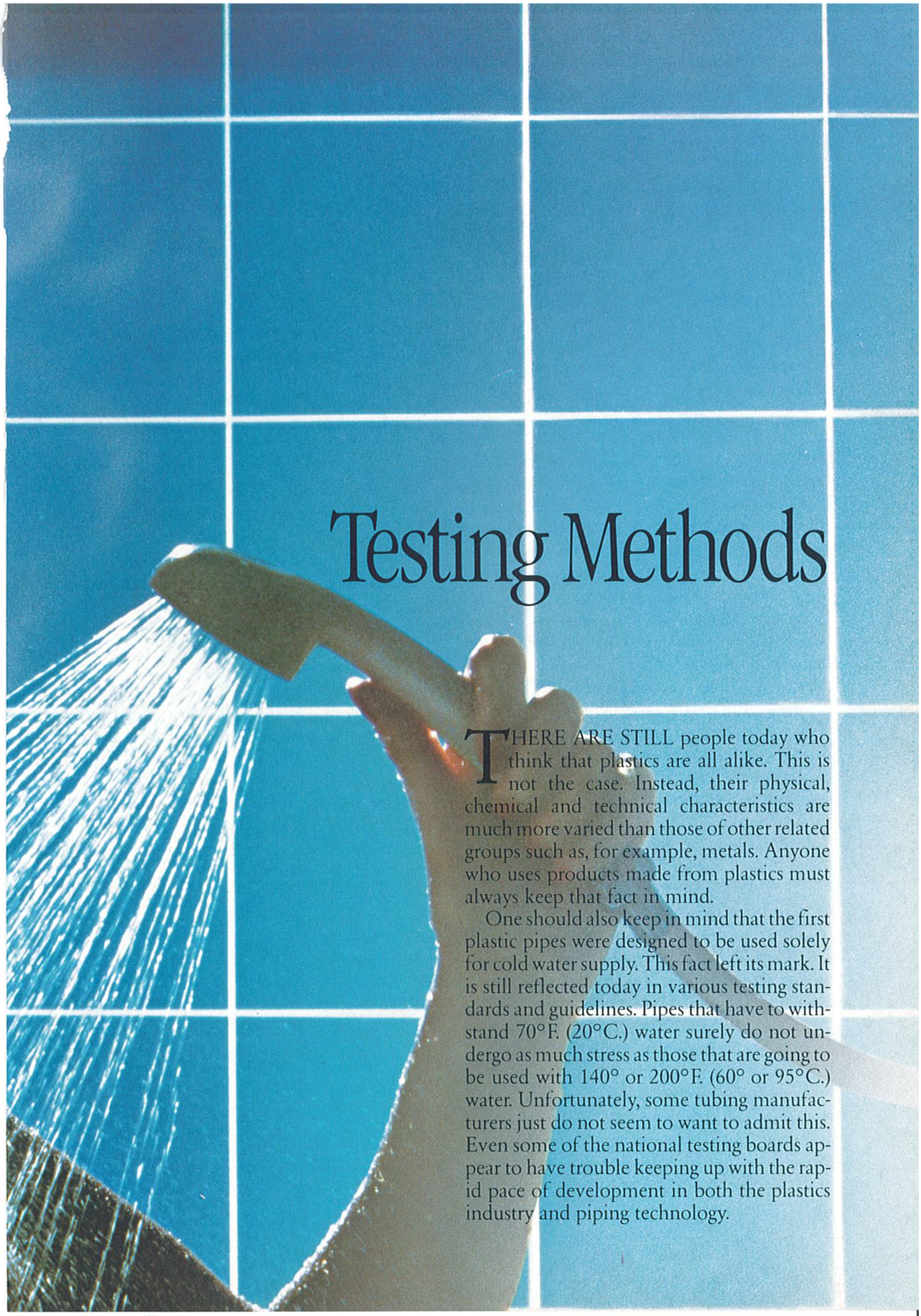




Testing Methods

THERE ARE STILL people today who think that plastics are all alike. This is not the case. Instead, their physical, chemical and technical characteristics are much more varied than those of other related groups such as, for example, metals. Anyone who uses products made from plastics must always keep that fact in mind.

One should also keep in mind that the first plastic pipes were designed to be used solely for cold water supply. This fact left its mark. It is still reflected today in various testing standards and guidelines. Pipes that have to withstand 70° F. (20° C.) water surely do not undergo as much stress as those that are going to be used with 140° or 200° F. (60° or 95° C.) water. Unfortunately, some tubing manufacturers just do not seem to want to admit this. Even some of the national testing boards appear to have trouble keeping up with the rapid pace of development in both the plastics industry and piping technology.

Questionable Methods

The use of plastic tubing for cold water pipes is covered almost everywhere today by standards and regulations. This is true in the area of design and manufacture as well as in the area of testing and actual usage in the field. At the present time, all manufacturers and testing laboratories recognize the method of long-term testing at low water temperatures (68° to 140° F. or 20° to 60° C.) and the determination of specific safety factors for each of the various piping materials.

Here are a few examples of some safety factors: polyethylene (PE), a rather rugged and well-tested material: 1.3; polypropylene (PP): 2.0; polyvinyl chloride (PVC): 2.0 to 2.5; polybutylene (PB): 1.8 to 2.0.

Attempts are sometimes made to apply conditions that are present when testing at low temperatures to the situation that is found at 200° F. (95° C.). This is done under the assumption that it is somehow supposed to provide a basis for reliable conclusions. Such attempts are not only a matter of questionable methods. They are also technically indefensible. When put under the stress caused by hot water, there are a multitude of new factors that can have a negative impact upon the durability of plastic pipes. That is why it is necessary to plan long-term tests not only with each of the parameters in mind that can affect the life of a product but also with various combinations of these same parameters.

It would also be technically indefensible to generalize the results of tests done on one kind of tubing and to apply them to all tubing of a similar type. Just in the case of PEX tubing alone, it is possible to distinguish five different manufacturing methods. This fact makes it somewhat less than honest for a manufacturer to put his tubing on the market accompanied by the technical data compiled from tests conducted on another manufacturer's product.

Among the worst examples of this sort of thing are references to test results that are achieved by subjecting samples to temperatures in the range of 275° to 340° F. (135° to 160° C.). The time it takes for the samples to melt or to begin to discolor is then presented as an indication of how long the tubing would last in actual field use at temperatures from 180° to 200° F. (80° to 95° C.). Using this same line of reasoning, steel pipes could be considered better suited for hot water than copper pipes because steel pipes can withstand higher temperatures without melting.

DEMANDS PLACED UPON THE MANUFACTURER. All these facts make it quite clear that the customer has to rely heavily upon the manufacturer and dealer for any guarantee or proof of a product's quality. This is especially true when the product we are dealing with is tubing that is to be used for hot water supply. A break in a cold water pipe that has been laid in the ground is not a huge catastrophe. But the consequences of a leak in a hot water pipe on the upper floors of an apartment building can be quite drastic.

Every manufacturing company that is concerned about its reputation should document the results of tests on its own products in each of the following five areas.

1.DIMENSIONS AND LABELS

Tubing should maintain the specified measurements. The labels serve the purpose of easy identification. They should contain the name of the manufacturer, the size of the tubing, the manufacturing date, the machine number and the machine operator. With this information on the tubing, it will be easier to investigate the causes of any possible trouble that might occur later.

2. LONG-TERM STRENGTH

Long-term tests should, by all means, be conducted by a qualified, independent testing laboratory. If in addition to such testing, the manufacturer also wishes to conduct tests of his own, all the more power to him.

3. HEALTH CLEARANCE

Plastic tubing for use in drinking-water supply lines must provide special official verification of its suitability for that purpose.

4. QUALITY CONTROL

By guaranteeing and monitoring the quality of its own production, a manufacturing company ensures the customer that the quality documented by the various tests is actually maintained in the product. This quality control is especially trustworthy when the manufacturer actually employs an independent testing laboratory to conduct the tests.

5. FIELD TESTING

Manufacturers should also be obligated to prove that the tubing they produce will perform as expected in actual use by conducting tests under field conditions.

In the following discussion we will go into more detail concerning some of the various specifications.

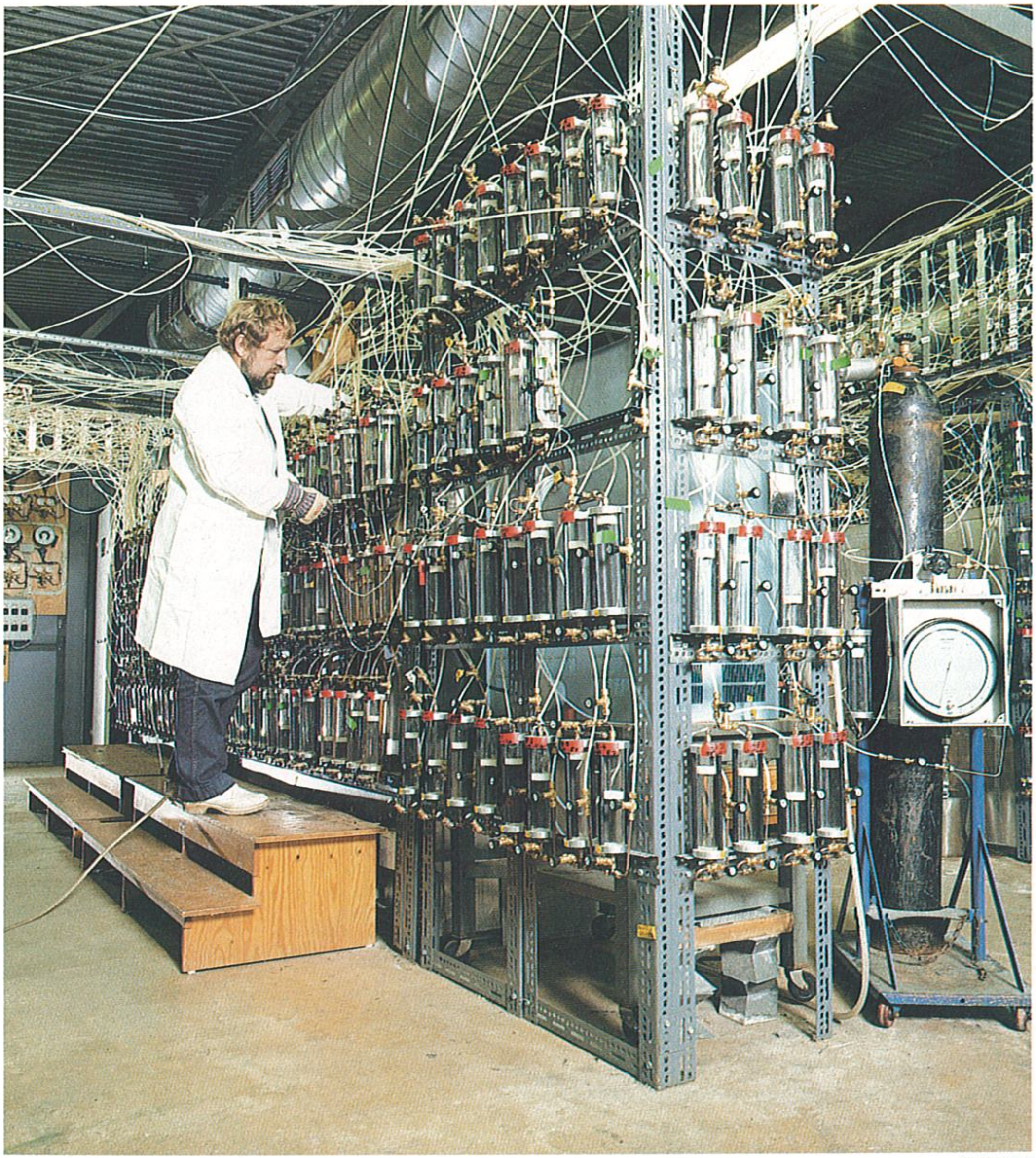


Plate 7:1

***Testing equipment** used for internal-pressure, time-to-failure testing of plastic pipes. This is the installation operated by the company, Studsvik Energieteknik AB, an internationally recognized testing facility. During the tests, stress and pressure are applied continuously until the sample breaks.*

LONG-TERM TESTING

"There is still hope." These words are often used to conceal uncertainty concerning the outcome of an event. But when laying plastic pipes, you should not have to settle for anything less than certainty. To put it bluntly, you have every right to ask how long they will last.

For the most part, the answer to this question can be gained from time-to-failure tests. This brings us to the next question. That is, just how are such tests conducted and what kind of data do they produce?

Heat and Pressure

First, the tubing that is to be tested is measured accurately. Then the piece of tubing is sealed at one end, filled with water and attached to a pressure source at the other end. After being prepared in this way, the sample is placed into a warm water bath or into a warm oven.

The Swedish testing laboratory, Studsvik Energiteknik AB, an internationally recognized institute for testing plastic pipes, provides a facility with the testing capacity shown in Table 7:1.

Testing stations: 650
Pipe Sizes: up to 4 inches (118 mm in diameter)
Temperatures: from 75° to 250°F., +/– 1°F.
Pressure: 0 to 450 psi (+/– .2 psi)
(0 to 3 MPa, +/– 10 MPa)
50 pressure levels
Testing medium: water, air, agents that induce stress cracks

Table 7:1

During the test, *stress and pressure are applied continuously until the sample breaks.*

Relationship Between Time and Stress

In order to create a time-to-failure graph that is highly reliable, it is necessary to log a large number of ruptures over a long period of time. To be specific, at least 15 ruptures have to be logged at every testing temperature within a standard interval.

Every rupture point represents a specific relationship between the load time or the length of time the stress is applied and the amount of stress applied. The stress on the tubing wall can be calculated from the simplified formula shown below:

$$\sigma_v = \frac{p \cdot (d_o - s)}{2\,s}$$

Where:
p = internal testing pressure
d_o = outside diameter
s = wall thickness

(See page 106, Formula 10.2)

Table 7:2

From the calculated stress values, we arrive at the so-called time-to-failure graph. In general, it looks like the diagrams below (see Figures 7:1 through 7:2:3).

Position of Curve Is Not Certain

When investigating the long-term strength of tubing, the ruptures are spread quite irregularly throughout the coordinate system. This presents a problem. What kind of curve can be used to connect these points? The answer to that question is almost a matter of conscience.

This problem can be solved by using the rules of mathematics or graphs. In principle, these rules are indisputable. Still, we have to pay special attention to how these rules are applied. In this case, that involves making a decision as to where the curve is to be positioned in the coordinate system.

It is not obvious at first where to place the curve. Just how is it to be interpreted as evi-

Figure 7:2:1

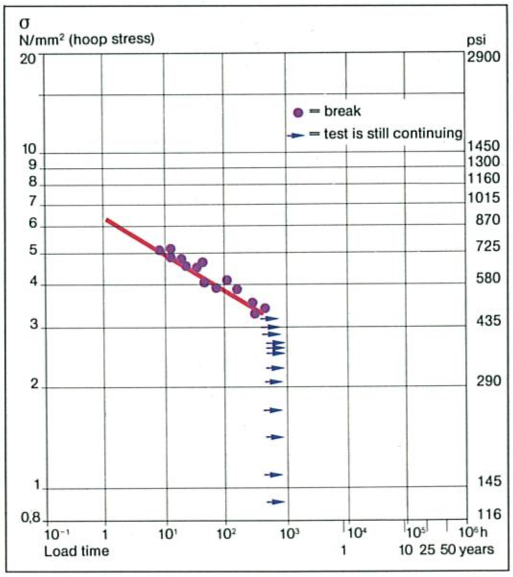
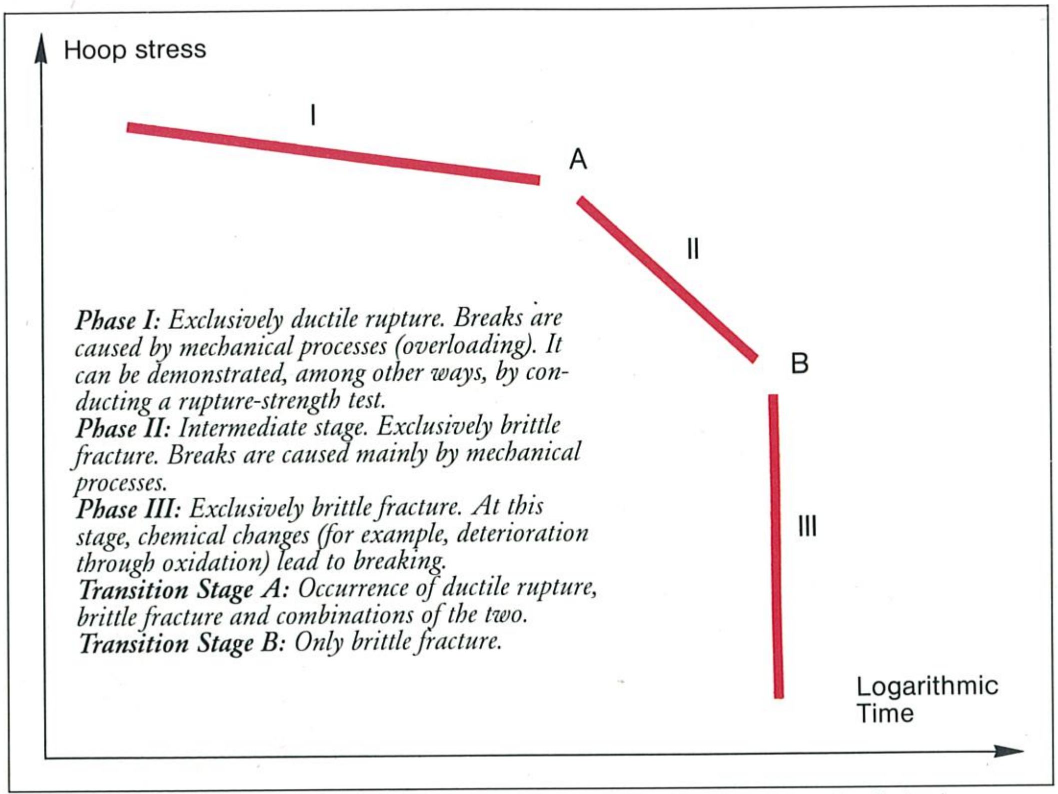


Figure 7:1



Phase I: *Exclusively ductile rupture. Breaks are caused by mechanical processes (overloading). It can be demonstrated, among other ways, by conducting a rupture-strength test.*
Phase II: *Intermediate stage. Exclusively brittle fracture. Breaks are caused mainly by mechanical processes.*
Phase III: *Exclusively brittle fracture. At this stage, chemical changes (for example, deterioration through oxidation) lead to breaking.*
Transition Stage A: *Occurrence of ductile rupture, brittle fracture and combinations of the two.*
Transition Stage B: *Only brittle fracture.*

Time-to-failure graphs based on internal-pressure tests on plastic tubing (generalized view).

Figure 7:2:1. *Test results after about 500 hours. In many cases, the samples have already ruptured (dots). In other cases, the test is still continuing (arrows).*

Figure 7:2:2. *Test results after 8,700 hours (approx. 1 year). The line that had been straight up to now begins to slope downwards.*

Figure 7:2:3. *Test results after 5 years. All the samples have now failed. The curve drops off quite quickly towards the end.*

Figure 7:2:2

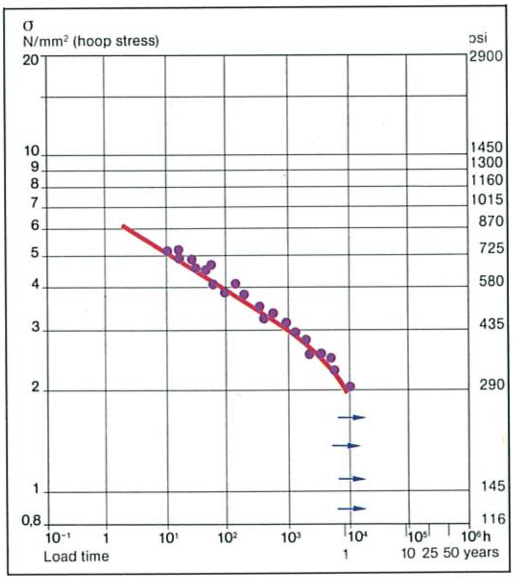
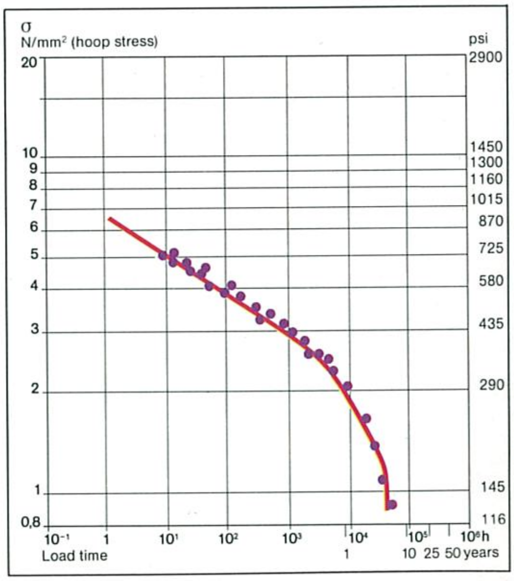


Figure 7:2:3



dence? Are we dealing with average values or does the curve represent minimum values? The probability that the actual tubing will perform up to, if not better than, the standards indicated by the test results is greater when the manufacturer provides a graph showing the minimum values.

Wirsbo always bases its time-to-failure graphs on minimum values. As a result, the statistical reliability lies at about 99 percent.

Even more important than all this are the questions as to whether the manufacturer monitors the performance of the pipes after the testing period is over and how this continued monitoring is done.

How Long Is "Long-term"?

Practically all pipe manufacturers can come up with a time-to-failure graph for their plastic tubing. That is the least that should be demanded of them. On the other hand, it is not a good idea to let oneself be influenced by such graphs until they have been checked out.

Unfortunately, the fact is that some manufacturers are more interested in making a quick profit than in spending money for serious and time-consuming tests.

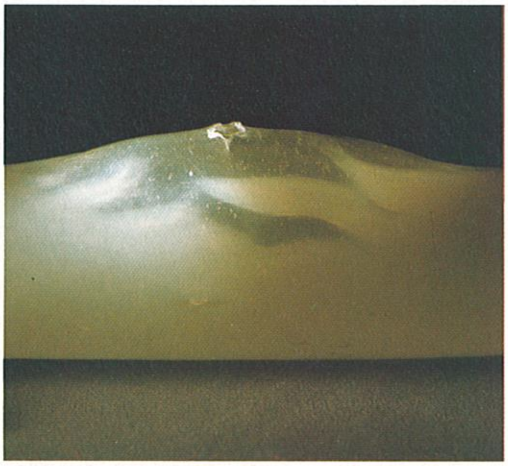
A question that should be asked is to what degree the curve on the graph was built from actual testing and to what degree it was formed by extrapolation (theoretical projection). In the case of some important plastic materials, long-term-strength tests have lasted up to 100,000 hours (longer than ten years). In the USA, tests usually run for 10,000 (10^4) hours at a specific testing temperature. On the basis of that length of time, extrapolation to 10 years is allowed.

For a long period of time, 10,000 hours was considered the minimum testing time. In the meantime, there have been more and more experts who are of the opinion that at least 30,000 hours (about 3.5 years) should be set aside for such testing. The ISO (International Standards Organization) is even talking about 40,000 hours.

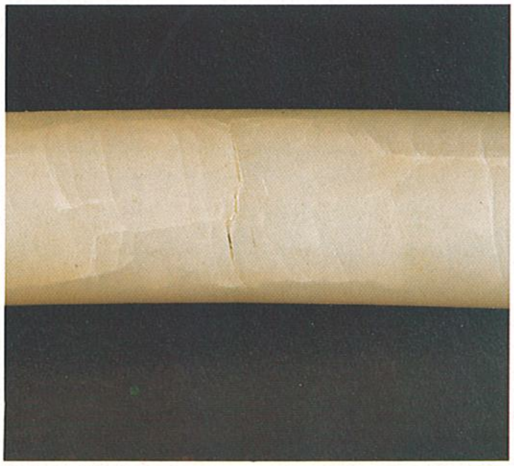
The Determining Factor: Time

All time-to-failure graphs attempt to prove that the tubing being tested will have a useful life of at least 50 years. This is a piece of wishful thinking that is based upon some very pragmatic considerations. The houses that we build are supposed to last 80, 90 or perhaps 100 years. For this reason, it makes sense that we would also want the piping systems that complement our houses to last just as long.

We still have not arrived at an adequate explanation of cracking caused by brittleness. Some investigations have traced its causes back to oxidation from the oxygen normally present in the atmosphere. We at Wirsbo do not share this viewpoint. Time-to-failure tests conducted at 180°F. (80°C.) on normal (non-cross-linked) polyethylene produced enough tubing failures already after 100 hours to cause a downward slope (a so-called knee) in the strength curve. That is too short a time for a chemical breakdown to have taken place. In our opinion (as stated in Figure 7:1), the brittle



Ductile rupture Plate 7:2



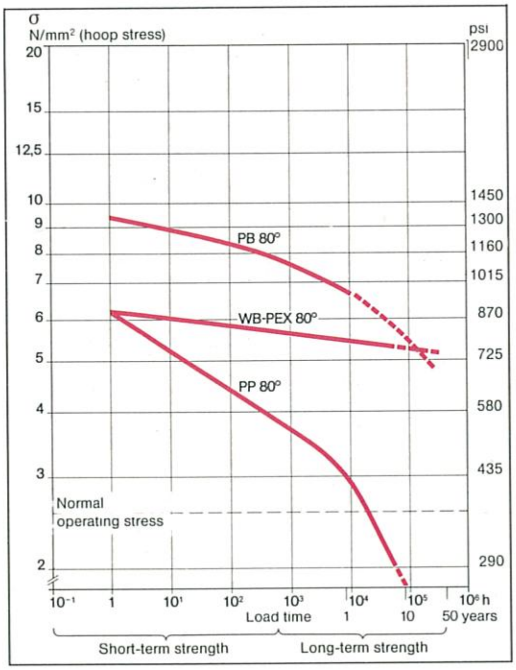
Brittle fracture Plate 7:3

fracture observed in Phase II is caused mainly by mechanical processes. Brittle fracture of the tubing in Phase III, on the other hand, is caused exclusively by oxidation at high temperatures (thermal breakdown).

When the normal operating temperature is expected to be over 100°F. (40°C.), it is absolutely essential that the time-to-failure graphs of the all the types of tubing that are available for use at those temperatures be checked. To what degree does the graph correspond to actual fact? Is the far end of the curve based upon an extrapolation? And if it is, does the curve take into account the downward slope that is normally there when the rupture points are plotted using actual test data? The observation made earlier bears repeating, "The longer the testing time, the more accurate the evidence given by the graph."

It is also very enlightening to compare the downward slope of the time-to-failure curve for the various types of plastic tubing materials. The slope is quite different for each different type. In the case of PVC and PP, the curve shows a sharp downward trend. PEX (Wirsbo-PEX) by contrast, displays a much more gradual downward slope. This means that its strength is affected less by the passage of time. One consequence of this fact is that although the strength exhibited by PP tubing during short-term testing is significantly higher, the opposite is true in the case of long-term testing. It is also true that while there is a wide gap between the strength of PP tubing at low and high temperatures, the difference for Wirsbo-PEX tubing is comparatively small.

Figure 7:3



Time-to-failure graph for straight, scratch-free tubing tested with water.

Look at the long-term strength comparison in Figure 7:3. The dotted lines in the illustration represent extrapolated data. Note that the first downward sloping trend that normally makes up Phase II is missing from the characteristic curve for PEX (Wirsbo-PEX) tubing. After a nine-year testing period at 203°F. (95°C.), we have reached the conclusion that there is no difference between Phase I and II for Wirsbo-PEX tubing. Only when the temperature is raised to very high levels does thermal deterioration begin (Phase III).

Accelerated Testing

One method of producing similar results faster than through long-term testing is by conducting tests at high temperatures. The interpretation of these results should be undertaken with a maximum of care.

Even a temperature that is only 15° to 20°F. (8° to 10°C.) above normal can cause some basic molecular changes to take place. The result is that we have an almost completely different material to test. Even the performance of the stabilizers that prevent deterioration can change radically at higher temperatures.

If accelerated testing is to lead to reliable conclusions, a long list of factors must be taken into account. These factors must be considered both in the context of normal and above- normal temperatures. Wirsbo has conducted exhaustive tests to arrive at just these relationships and comparisions.

Straight Tubing Does Not Provide All the Answers

What we have heard up to now concerning long-term testing is valid for straight tubing only. While the results of such tests are quite valuable, they do not provide us with everything we have to know to draw conclusions concerning how long the tubing might last in the field. Installation and use put a great amount of stress upon it. It is bent. It gets scratched. Agents that cause stress cracks and other chemicals that may be present in water affect the tubing. These are only a few of the many examples we could mention.

Bent Pipes

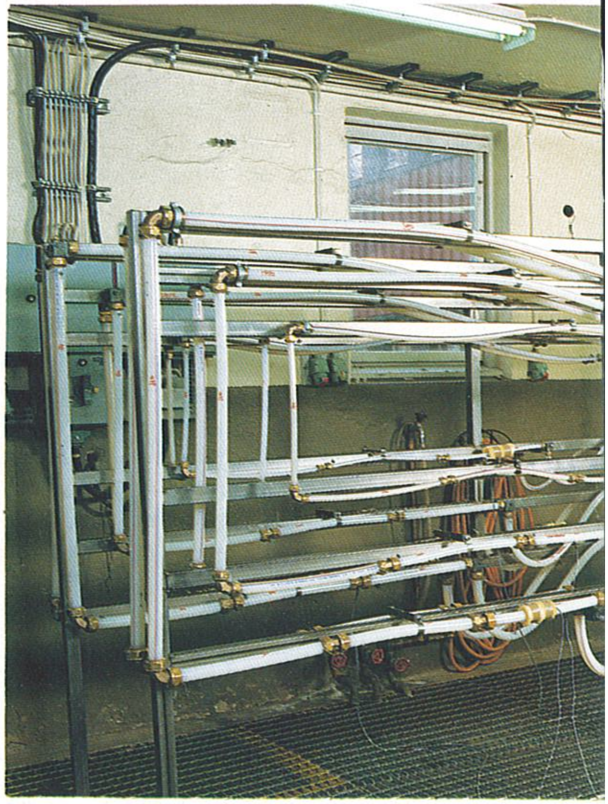
The elasticity coefficient (E-modulus) of plastic tubing is, among other things, a measurement of its flexibility. It is generally known that, on the one hand, plastic tubing is more or less easy to bend but that, on the other, it is quite sensitive to the internal stress that is created by being bent. The stiffer the material that is used in the tubing, the less suitable the tubing is for bending.

For this reason, it is appropriate to request the manufacturer to provide the results of long-term (at least 3000 hours), internal-pressure, time-to-failure tests. These tests should be performed at the highest operating temperature on tubing with bends that are equivalent to the smallest bends allowed for the tubing being tested.

FORMATION OF STRESS CRACKS. We use the term "stress cracking" to refer to the brittle fracture of materials that normally tend toward creep rupture. Stress cracks can be caused by mechanical forces (either outside or inherent) when there is some sort of other agressive influence present even though the stress might be below that which would normally cause cracking.

A classical example of stress-crack behavior is a polycarbon rod that remains normal while it is being stretched until it comes into contact with a drop of methyl chloride. At the exact moment of contact, it suddenly disintegrates into bits.

Similarly, stress-crack formation in tubing is often the result of a combination of internal stress and the presence of impurities in the water. The presence of internal stress can be detected by immersing a piece of tubing into a methyl chloride bath. Another method is to cut up a piece of tubing and heat it up. Any change of shape that then takes place is an indication of the presence of internal stress.



Is the knowledge of a tubing's stress-cracking behavior important? It could be a matter of life and death! A pipe that is under internal stress is a sensitive pipe. This situation is then made worse by the stress that it has to undergo when it is being installed, such as being bent. The test results that are obtained during time-to-failure testing of straight tubing is no longer valid under these circumstances.

It is just not acceptable to depend on guesses when dealing with properties that are decisive for a pipe's longevity, such as its stress-crack behavior. That is why it is necessary to require two different types of information from the manufacturer when tubing is going to be bent. The first type is data on time-to-failure tests at the maximum operating temperatures. The second is data from testing conducted with agents that tend to form stress cracks (detergents).

Wirsbo has had both of these types of tests done for them on their PEX type tubing by an official testing institute. The testing conditions included a temperature of 203°F. (95°C.), and were conducted in pure water

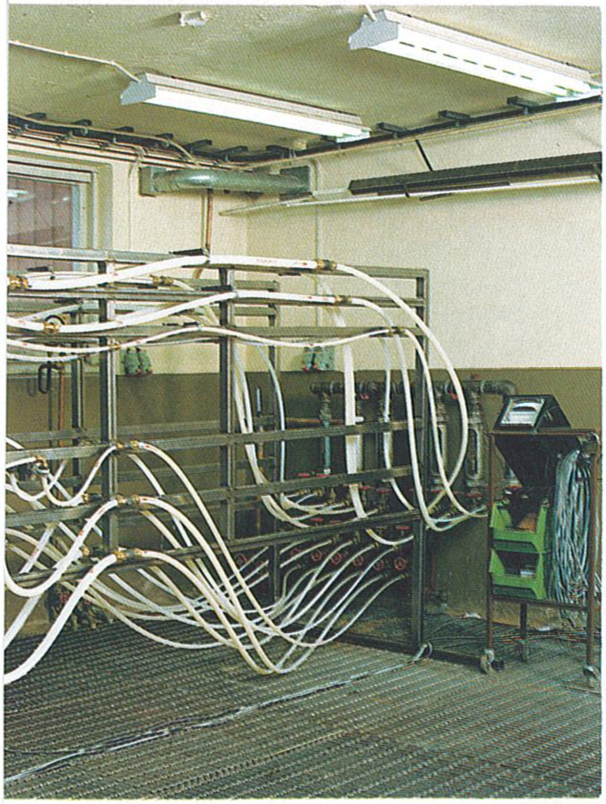
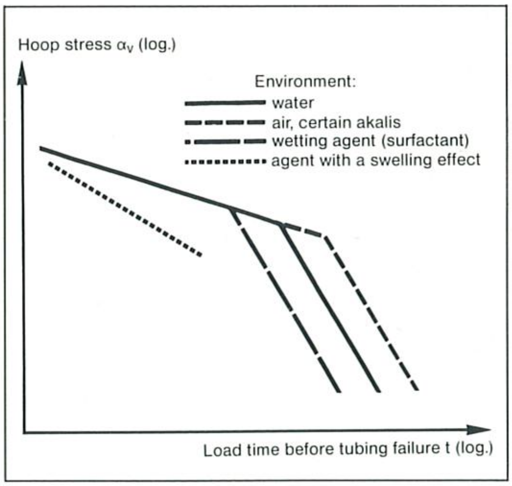


Plate 7:4

Figure 7:4



Influence of certain environments *on the time-to-failure behavior of polyolefins at normal temperatures.*

Plate 7:5

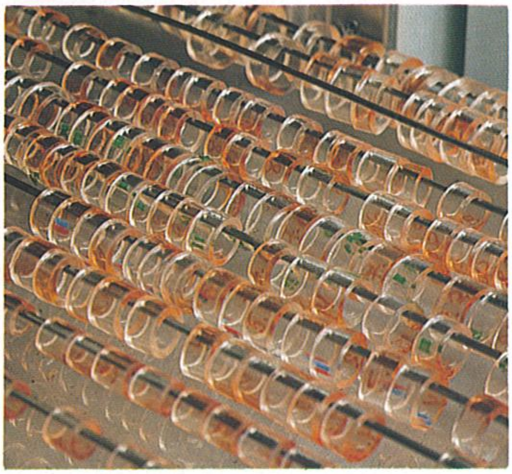


Plate 7:6

Plate 7:4. *Pipes and pipe connectors during the temperature-cycle test using the specifications of the DVGW (The German Gas and Water Specialists Association)*

Plate 7:5. *Dr. P. Stagge of the MPA Darmstadt seals a joint for the official pipe connector test.*

Plate 7:6. *Checking for thermostability (resistance to aging) during production.*

and in a 2 percent solution of a stress-crack inducing agent. After a two and one-half year study, they were not able to observe any stress-crack formation nor notice any sharp downward slope in the time-to-failure curve.

As a rule, the liquids carried by pipes have a different effect on the long-term strength of the tubing material. For a generalized illustration of this, see the diagram in Figure 7:4.

Scratches Are Unavoidable

It is just not possible to avoid scratches when installing pipes. This fact should not be ignored. Instead, it should be taken into account when tests are conducted and data should be gathered concerning how scratches affect the life span of the tubing being tested.

At the present time, there are no international standards for testing the strength of scratched tubing. That is unfortunate. That is why Wirsbo is temporarily using the pressure test that is officially employed during production monitoring. The testing is done at a temperature of 202°F. (95°C.) at a hoop stress of 667 psi (4.6 N/mm^2) which corresponds to an internal pressure of about 160 psi (11 bar/mm^2) in a typical tubing used for intermediate pressures. The duration of the test is at least 170 hours.

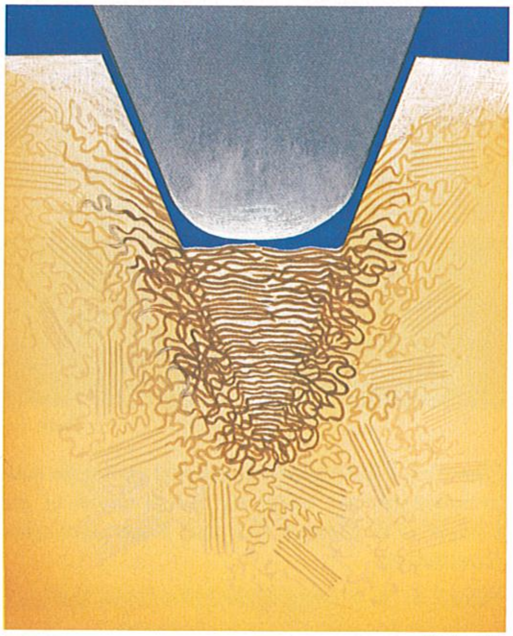


Plate 7:7

A scratch in tubing made of polyolefin reduces its durability.

Wirsbo creates the scratches on the PEX tubing used in the tests with a blade that produces a cut 1 µm (.00004 in.) in edge diameter. The depths of the cuts that are made both on the inside and the outside of the tubing are between 1 and 30 percent of the thickness of the tubing walls.

The results show that the tubing from Wirsbo that is manufactured according to the Engel process came through the 170-hour test without damage after being subjected to scratches as deep as 20% of the tubing wall. Even when Wirsbo continued the tests for up to 20,000 hours, no breaks occurred.

By comparison, it should be noted that there is tubing whose durability is already impaired by scratches that are only one percent deep.

The reason for the insensitivity of Wirsbo-PEX tubing to scratches and for its favorable stress-crack behavior is to be found in, among other things, its cross-linked molecular structure. The forces that are released by the tearing of the molecule chains, no matter how the tearing takes place, are held in by the surrounding molecules in the overall network. In this way, all concentrations even themselves out. For more information concerning cross-linking, see page 75ff.

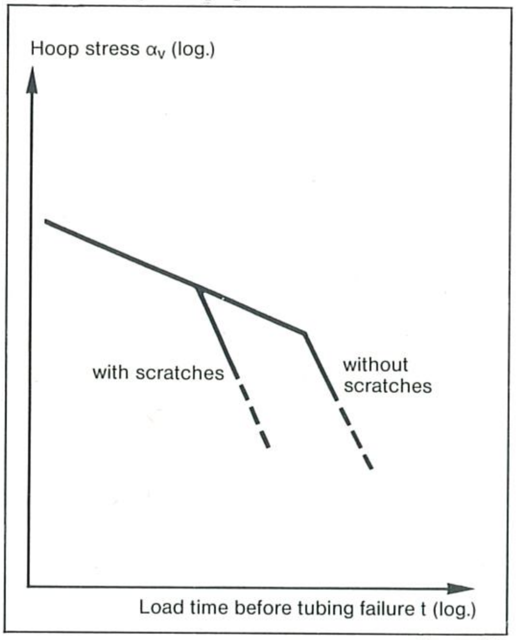


Figure 7:5

Influence of scratches on the long-term strength of plastic tubing.

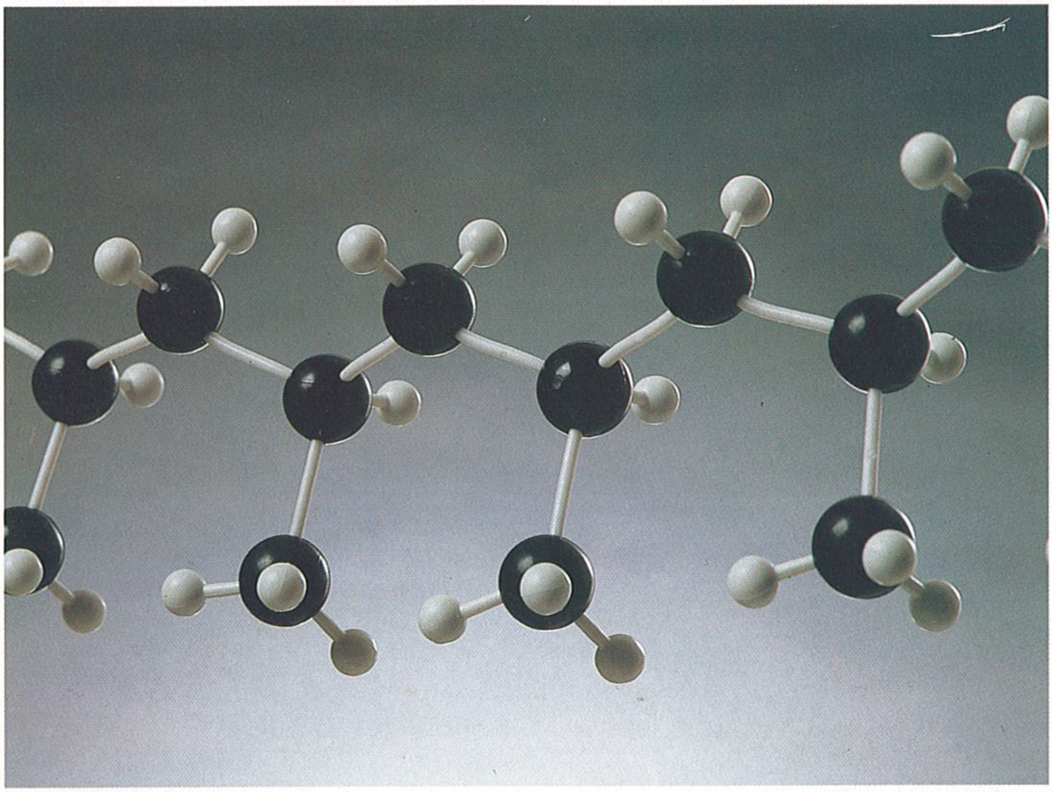


Plate 7:8

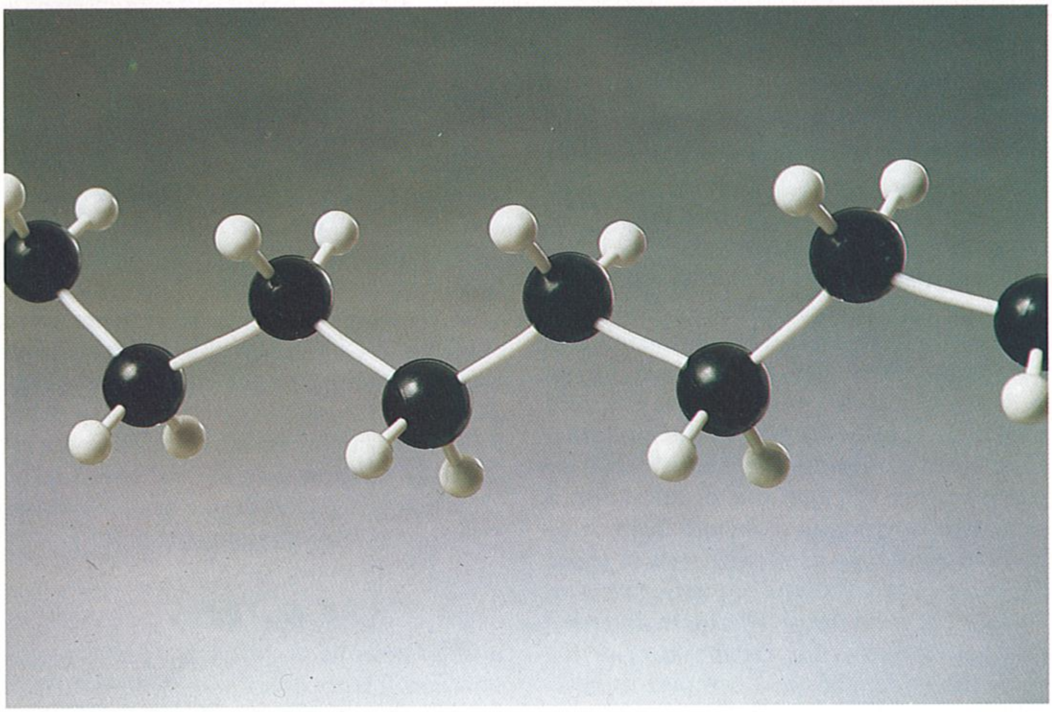
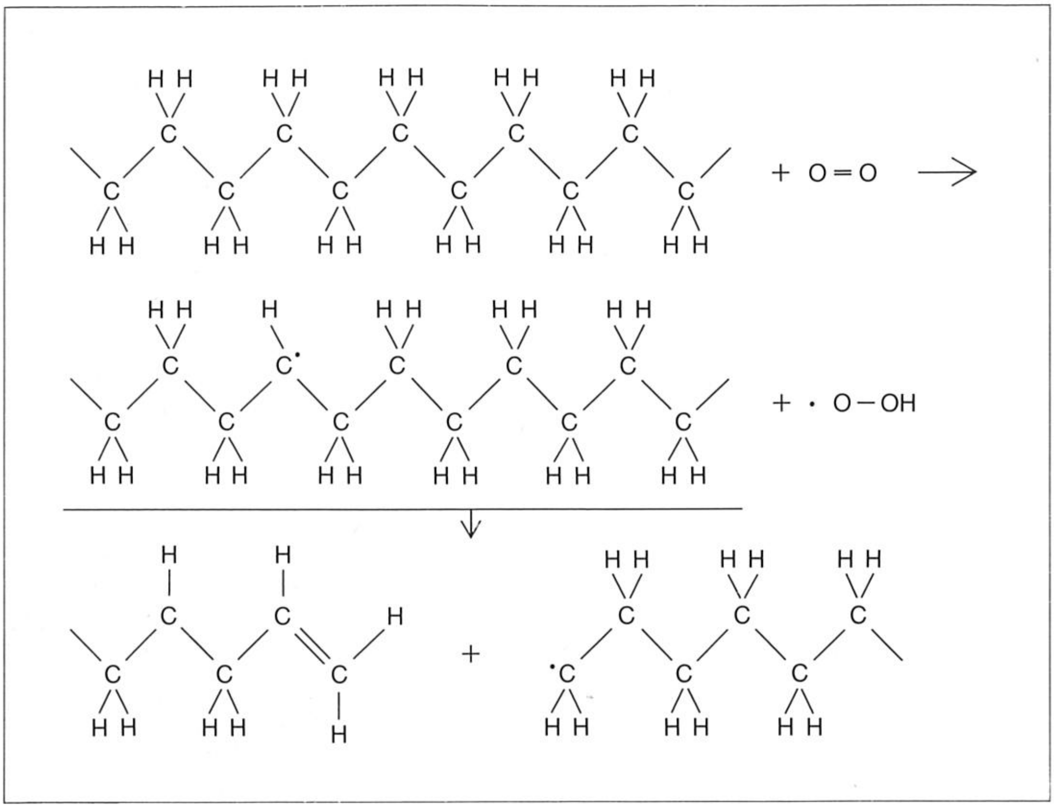


Plate 7:9

Molecular structure *of polypropylene (above) and polyethylene (below). The black spheres represent carbon (C) and the white, hydrogen (H).*



***Thermal oxidation** of polyethylene (a simplified presentation of the chemical reaction).* Figure 7:6

The Worst Enemy of Plastics

Without oxygen there would be no life. That is for sure! But something that is at the very foundation of life can, in some cases, be quite detrimental. Because of its oxidizing effect, oxygen is also a great destroyer.

It is also a destroyer of plastics. Especially under the influence of heat, oxygen works itself into the material and breaks the molecular chains down into ever smaller pieces. When this happens, we can see the effects of oxidation. It causes breaks in the molecular structure of plastics. Sunlight has a similar effect on them. Whether this deterioration is caused by oxygen, by ultraviolet light or by both, it takes place at varying rates of speed depending upon the type of plastic that is involved. The most decisive factor in the speed of deterioration is the composition of the chain molecule. The more complex its structure, that is, the more secondary groupings it has, the more likely it is to show a tendency toward deterioration.

Branches are the weak points of molecular chains. That is where deterioration starts and where the breakup begins. The molecular structures of polyethylene and polypropylene illustrate the difference between simple and complex molecules.

The type of polyethylene raw material used by Wirsbo for their process, shows an average of about 10,000 carbon atoms between every branch in the molecular chain. The situation is quite different in the case of polypropylene. In it, there is a branch for every second atom. As a result, PP is more endangered by the effects of oxidation than PE and so has to be subjected to a greater degree of stabilization. The same is true of polybutylene (PB).

"Radical Eaters"

It is not possible to completely prevent deterioration. It is possible to slow it down to such a degree that the plastic tubing achieves an acceptably long life span. In order to do this, it is necessary to institute the controlled use of a stabilizer.

For polymerized piping materials, phenol compounds (cyclic or annular compounds) are often used as stabilizers (antioxidants). One of their characteristics is that they react more quickly to the destructive effects of oxygen than the polymers, that is, they oxidize more quickly.

The pieces of molecules that break off as a result of a polymer's reaction to oxygen are called "radicals". The main accomplishment of a stabilizer consists in the way it attaches itself to radicals. When polymers are unprotected, the radicals that are freed take part in splitting the molecular chains. It is just this chain reaction that is eliminated by an antioxidant.

Searching and Researching

Anyone who manufactures plastic products has to demand a lot from an ideal stabilizer. For example, it may not be poisonous. In order for it to work correctly, it must be spread finely throughout the material. It must display a certain degree of mobility but still be immobile enough so it does not wash out or escape through the walls of the tubing. These items are only mentioned to give you an idea of the many factors that have to be taken into account when trying to protect plastic tubing from the effects of oxidation and aging.

Wirsbo has been dealing with these problems for more than ten years now. The tests that are currently being conducted for them at BASF are just part of a search for the optimum stabilizer. The long-term strength tests are still continuing there after a period of ten and one-half years (as of early 1984) at a temperature of 203°F. (95°C.). This is a world record time for testing at such a high temperature. It has already been shown that the stabilizer that was chosen is doing the job it was intended to do.

There Are No Pat Answers

It is really tempting to suppose that one could conduct quick tests at high temperatures on stabilized plastics and then simply apply the conclusions reached in these tests to the behavior of these same plastics at lower temperatures. It is tempting but is really just a little too easy. It is a pipe dream that only exists in the minds of some technicians. But the polymers themselves cannot be fooled as easily. They cannot be fooled quite simply because the structure and behavior of their molecules at 300°F. (150°C.) is completely different from their structure and behavior at 140°F. (60°C.).

This difference is reflected in different rates of deterioration at different temperatures. As a result, the ability of the stabilizing agent to work in the way that was planned is adversely affected.

So we are left with long-term testing at different temperatures if we want to gather reliable data concerning the thermal stability of a product. It would be advisable for the customer to ask the manufacturer for that type of data.

Here are two examples of the careless use of test results. In one case, a manufacturer had arrived at a life expectancy rating of 204 years for a particular type of tubing by conducting short-term tests at high temperatures and then using theoretical extrapolation to arrive at a long-term conclusion. In actual usage in the field, the tubing began to "deteriorate" after only 90 days. In response to such methods, we would just like to repeat the observation that impressive facts and graphs should only be given credence after one knows how and by whom they were gathered and created.

The other example deals with the sensitivity of certain polymer materials to metal ions (for example, brittleness caused by copper). The tendency toward this type of deterioration is greater depending upon how complicated the molecular chains are. The polypropylenes and polybutylenes are especially prone to this so-called "catalytic deterioration". To combat this reaction we have to resort to the use of special stabilizers called "metal deactivators". Still, all of them have a decided disadvantage. They are poisonous and so cannot be used in drinking-water supply lines. Some manufacturers avoid this problem by using pipe fittings made of stainless steel instead of copper when conducting long-term tests. In this way, they are able to achieve results that are quite a bit rosier than they would otherwise be.

Discharging the Stabilizing Agent

During the usual long-term, internal-pressure tests, the water is kept in the test sample during the whole testing process. That leads to the liquid's being quickly saturated with the antioxidants that, under normal circumstances, are quite difficult to dissolve in water. Any further elimination of these materials comes to a halt. The situation is completely different when the tubing is actually being used under normal conditions. Water is constantly streaming through the tubing. When it does, it causes a continuous discharge of the antioxidizing agent, especially when the agent has not adhered sufficiently to the tubing material.

Wirsbo is investigating this behavior by boiling the samples repeatedly in distilled water. Then the material's resistance to oxidation is tested both before and after being boiled. Keep in mind that Wirsbo expects its tubing to last for 50 years. If this is the case, then the bulk if the antioxidants must still be present after being boiled for months.

HEALTH CONCERNS

The effect of metal water-supply pipes on human health has never been the subject of much debate. That might just be the case because they have been in use for such a long time. An exception to this has been restrictions on the use of copper pipes in certain countries in order to preserve water quality.

In the case of plastic pipes, the situation has been quite different. Right from the start, people have been skeptical concerning whether humans could tolerate them. They should be. For example, there have to be limits to the amount of lead that a PVC pipe may give off. The stabilization system of Wirsbo-PEX tubing has been proven not to be toxic. That is, the test results have shown that it is no more toxic than, for example, sugar.

Discharge of Harmful Materials

Plastic tubing is investigated for purposes other than toxic material content. It is also tested to discover the extent to which it af-

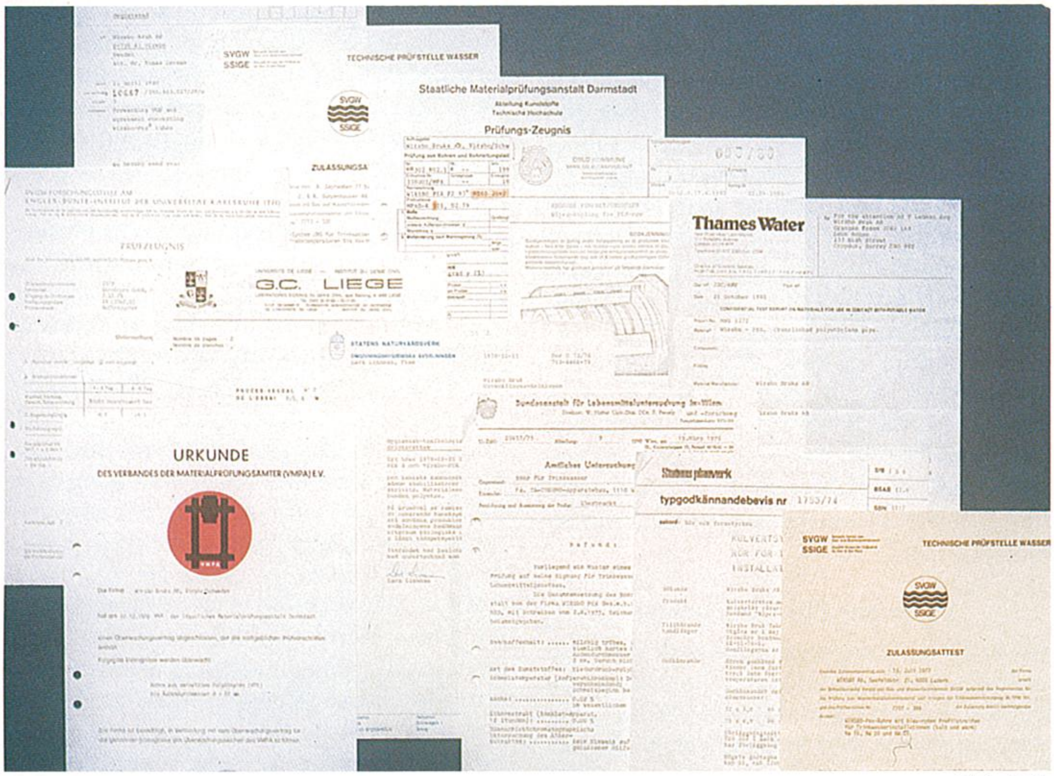


Plate 7:10

***Documents,** certificates and testing contracts – all evidence for the quality of Wirsbo-PEX tubing (representative sampling).*

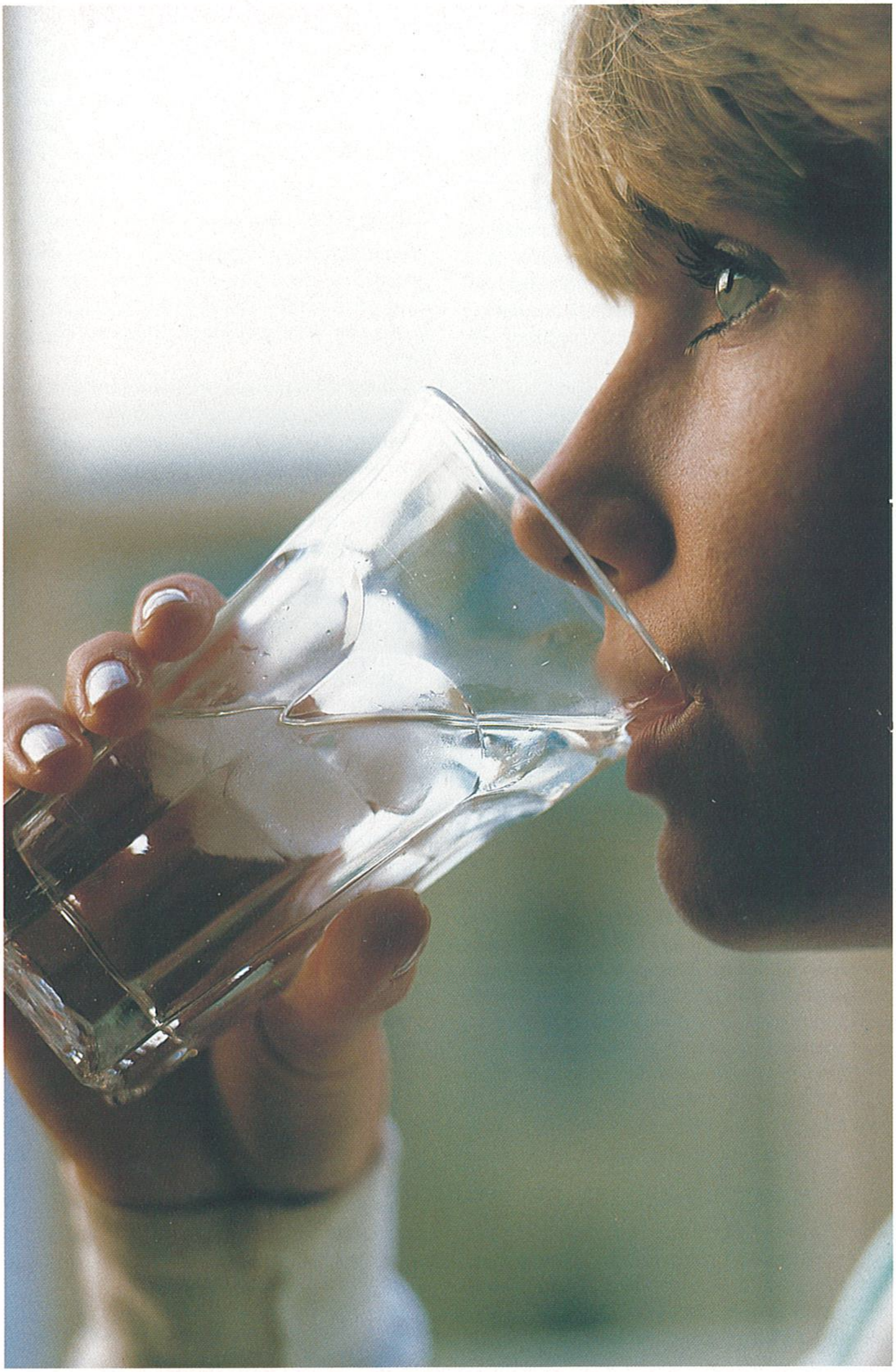


Plate 7:11

fects the taste, odor, color or clarity of the water that passes through it. One of the testing and resarch institutes that conducts just that kind of test for manufacturers around the world is KIWA in Holland. Among the various tests that this institute conducts on plastics is one that entails leaching them in distilled water. After a period of 72 hours the water is chemically analyzed to determine values for taste, odor, discoloration and clouding. Other European institutes also conduct similar tests. The National Sanitation Foundation (NSF), Standard Number 14, covers the U.S.A.

Ask For Documentation

Health standards (food and drug laws and so on) can vary significantly from country to country. Because they can, there is some importance advice that the customer would do well to follow. Always ask the manufacturer or dealer for an official certificate that is valid in the country where the tubing is to be installed attesting to the safety of the material. Documented data is much less likely to be questionable.

REALISTIC TESTING

No test gives as much insight into the actual behavior of plastic tubing as one conducted under conditions similar to those actually found in the field. Such tests just do not permit any compromises.

Wirsbo began its first broad-based testing program back in the years 1972 and 1973. The Swedish Building Research Institute (SIB) and all of the official testing boards in Scandinavia took part in it. It was during those tests that the certification of the various types of Wirsbo-PEX tubing for drinking water, hot water and heating systems was granted. By the year 1982, we were able to get similar certification in ten different countries.

75,000 Temperature Cycles

The following items were of special importance during the extensive testing program:
Different installation conditions: tight, loose, in conduit and in cement.
Rough handling: scratches, kinks and bends.
Pipe connectors: various brands and types of fittings.
Temperature cycles: admission of cold (50° F., 10° C.) and hot (203° F., 95° C.) water (at about 145 psi or 10 bar/cm^2) in three-minute cycles. The pipes underwent a total of 75,000 temperature cycles during the 15-month period.

Four Pipe Connectors Out of Twenty

"The joints are the weakest links in the whole system," is what one often hears. Just what kind of evidence did the practical tests performed by Wirsbo bring in support of this belief?

- Of the 20 types of connectors tried out on the tubing, only four of them could measure up to the demands placed upon them. In later tests, a few other pipe connectors proved to be usable. When installed properly, there were no problems presented by any of them.
- There have been close to six million pipe connectors installed on Wirsbo-PEX tubing in past years. There have been few if any complaints throughout this whole period. Those few cases all involved faulty installation (nuts not tightened enough, parts left out and so on).

Experience tells us that some people in the industry tend to doubt the truth of these statements. Our response to this takes the form of a question. Where can you find a testing program that is as encompassing as that of Wirsbo?

Speed of Water Flow Not a Factor

Copper tubing is normally permitted for hot water supply when the water flow is ten feet per second or less. When the water flows faster than that, there is danger of pitting caused by corrosive erosion.

The Swedish Building Research Institute tested Wirsbo-PEX tubing (with and without bends) over a one-year period with water running at a speeed of 92 feet (28 m) per second at a temperature of more than 195° F. (90° C.). These tests showed that the tubing developed no problems whatsoever from such treatment.

No Noise From Water Hammering

Closing a valve very rapidly causes a pressure

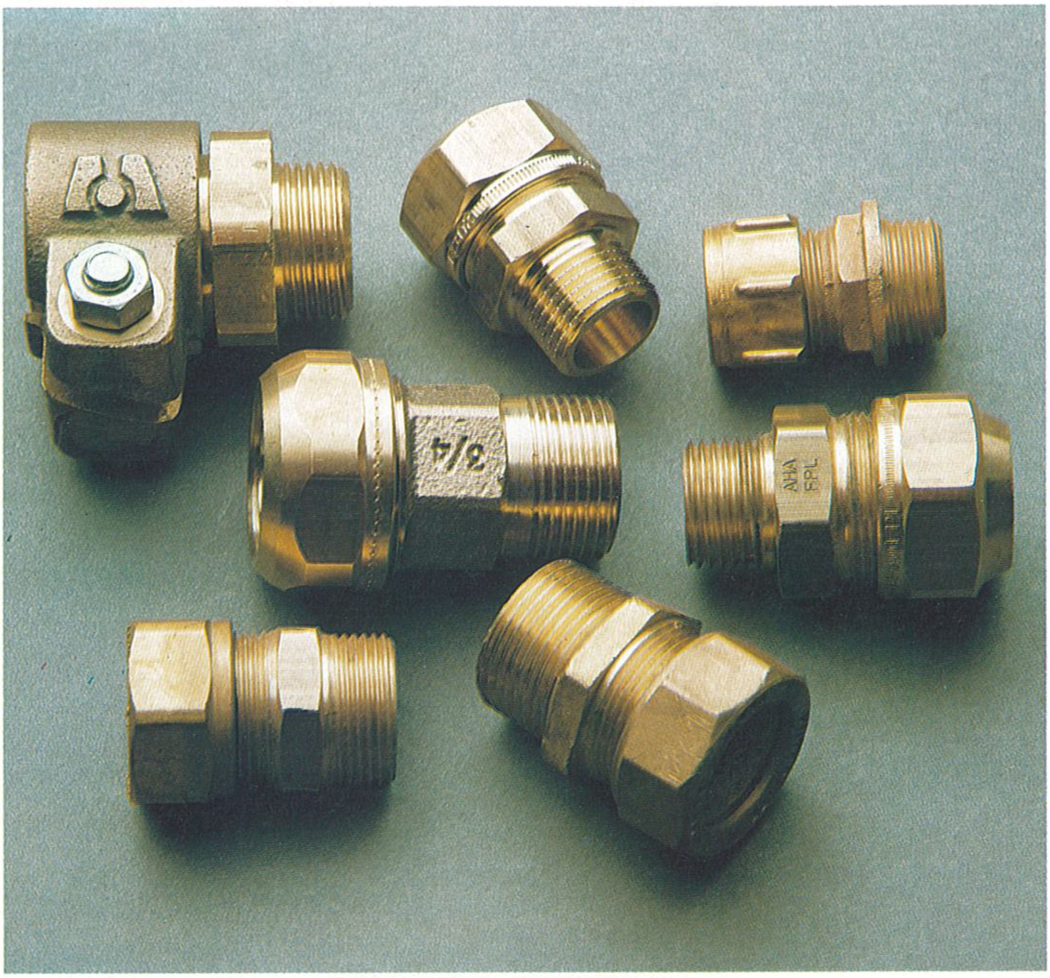


Plate 7:12

Connectors approved *for use with Wirsbo-PEX tubing (a selection).*

surge in a water supply system. Pipelines and other equipment have to take this problem into account. The city waterworks of Adelaide, Australia has investigated the behavior of Wirsbo-PEX tubing in that regard. Tubing that was intended for use at up to 145 psi (10 bars) of pressure was submitted to 833,000 surges at 220 psi (15 bars). The tubing withstood even this test without any problems. The current and projected standards specify 10,000 to 40,000 surges as an adequate test.

Pressure surges do not only put extra stress upon pipes. Their presence can also be noticed through the annoying noise that they cause – when the pipes are made of metal, that is. Plastic pipes do not have that problem because the tubing material itself dampens the sound.

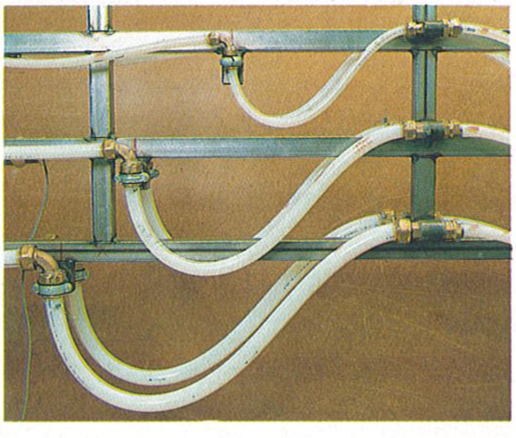


Plate 7:13

Fatigue testing *of pipe connectors through 75,000 temperature cycles. This test shows which connectors can withstand such treatment.*