Corrosion of Lead Sheathed Cables in Plastics Multiway Ducts (End)[1]

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4 Results of investigation of water and sediment samples

In all cases investigated, the bare lead sheaths of the cables pulled into the plastics multiway ducts had come into contact with water. Water contact had occurred not only at duct inlets in the jointing chambers but also within long duct sections. It is therefore surprising that the lead sheaths were not more extensively attacked and that deeply penetrating corrosion was confined to narrowly limited resting surfaces. It must therefore be assumed that water of varying aggressiveness was effective. We therefore tried whenever possible to collect and analyse water samples from different sites in the same chamber. In total, more than 30 water samples were investigated from the various plastics multiway ducts checked. On the basis of the results of analysis all the samples can be allocated to three different water qualities:

– *Strongly basic water with pH values from 11...12.6*
All samples which could be taken from water emerging directly from penetrated concrete layers belong to this category. They contain dissolved calcium hydroxide at saturation level and are unstable, precipitating lime sediment immediately on contact with air. The proportion of sodium ions is also abnormally high (up to 100 mg Nà/l), and in individual installations these water samples also showed high chloride content (up to 200 mg Cl'/l). The quantity of dissolved material amounted to 1...2 g/l (determined as dry residue). The specific electric resistances (185...250 Ω cm at 18 °C) are correspondingly low.
– *Weakly basic water with pH values from 8.5...10.5*
This water quality, with analysis values scattering more widely, embraced all the samples originating from chambers and ducts with large quantities of deposited lime sediment. The water involved had seeped through concrete and the originally dissolved calcium hydroxide had been precipitated as lime as a result of the effect of atmospheric carbonic acid. The individual analysis values differ greatly according to the degree of carbonization and mixing ratio with ground water, surface water or condensation water. However, the content of dissolved calcium ions is generally relatively low (20...40 mg¨/l) and the total of dissolved material amounted to 80...360 mg/l; in individual cases the content of chloride and sodium ions

exceeded very substantially the calcium content because these highly soluble alkali salts (sodium chloride) are not precipitated out.
– *Neutral water with pH values from 7...8*
This water quality was found in the samples taken in manholes with no white lime sediment but where a dark soil sediment had sometimes been found, i. e. it originated from sites where the water had not penetrated through concrete layers but had flowed in in some other way e. g. via cable protection channels of the local network connected to the chamber or by backflow from badly functioning drainage pipes. The analysis data of these samples show average values such as are normally found in ground water (specific electrical resistance 2000...3000 Ωcm, dry residue 250...350 mg/l, total hardness 15...30° French hardness, chloride content 1...10 mg Cl'/l).
– *Sediment samples*
The results of analysis of some of the samples taken from the chambers inspected confirm that the sediment deposits mentioned several times are indeed lime precipitated from the water. Thus we have found lime proportions ($CaCO_3$) of 95...97 % in the dried sediment samples. The highest lime proportion was found in a sample of pure white sediment taken from an empty plastics duct. In contrast a sediment sample of dirty yellow colour from the chamber floor with 95 % lime content had the highest content of subsidiary components, such as rust and sand (1 % Fe_2O_3 and 2 % SiO_2). We also found about 1 % lead as an impurity in a lime deposit on the concrete inlet funnel in the vicinity of a deeply penetrating lead sheath corrosion.

It is clear that only the highly basic water quality attacks the lead sheaths of the cables in a markedly aggressive manner because lead is relatively easily soluble in strong bases. In fact, deeply penetrating corrosion was observed only at the direct contact sites with these strongly basic streamlets. The aggressiveness reduces rapidly with decreasing pH value. In any case, only superficial yellow and red lead oxide layers of varying thickness appeared on those lead sheaths which were in contact with weakly basic water even for a long time. Neutral water is harmless although even this can lead to lead sheath corrosion after many years. Certainly one can assume that neutral ground water is less to be feared in plastics duct installations than in cable protection channels made of steel (Zorès iron) since the progress of corrosion in water of this type is extensively determined by the potential differences present, local element formation, external currents or differential aeration. These are all factors which are generally absent in

plastics ducts so long as the ducts are occupied by a single cable.

Since the ingress of strongly basic water is primarily responsible for the locally limited lead sheath perforations occurring in plastics duct installations in the first few years of operation, the following two questions must be elucidated:
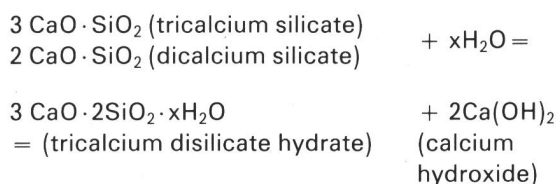
– To what is the presence of unusually strongly basic water attributable?
– Why has strongly basic water such an extraordinarily aggressive effect on lead?

We shall attempt to answer these questions in a generally intelligible way in the remaining part of this article.

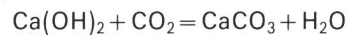## 5 To what is the presence of unusually strongly basic water attributable?

Concrete structures vary in their imperviousness to water in accordance with the mixture ratio cement/sand/ballast, but they are never completely watertight. Mixtures which are referred to as lean (low cement content), of the kind used for packing plastics ducts are relatively permeable. If the level of mountain pressure water or ground water is sufficiently high, the water penetrates concrete layers of this type. The water becomes saturated with the calcium hydroxide incorporated in the cement and finally arrives at the exit surface, depending on volume of flow and speed, as a lime efflorescence, as a stalactite or as a lime sediment-precipitating lye. In order to achieve better understanding we will look at the factors underlying the phenomenon and describe the process in greater detail.

Lime is extracted from the quarry in its natural form as limespar ($CaCO_3$) and used as a raw material in the manufacture of cement. It is mixed with clay minerals (marl, e.g. $Al_2O_3 \cdot SiO_2$) and is exposed to high temperatures in a rotary kiln. It is then encountered again in the cement as roasted lime (CaO) but mostly in mineral combination with the silicates. When water comes into contact with a cement mixture, the roasted lime present in the cement in a proportion of about 1 % is dissolved and then appears as calcium hydroxide ($CaO + H_2O = Ca(OH)_2$). Calcium hydroxide is produced however not only from the free CaO present but is formed mainly as a result of the process of hydration (setting reactions) from the various calcium silicates. This is represented in the following part reaction:

$3\,CaO \cdot SiO_2$ (tricalcium silicate)
$2\,CaO \cdot SiO_2$ (dicalcium silicate) $\quad + xH_2O =$

$3\,CaO \cdot 2SiO_2 \cdot xH_2O \qquad\qquad + 2Ca(OH)_2$
$= $ (tricalcium disilicate hydrate) (calcium hydroxide)

The $Ca(OH)_2$ which is included in the set cement is relatively easily soluble in water and is therefore leached out by penetrating water. At 16 °C, 2.1 g of $Ca(OH)_2$, dissolve in 1 l of water so that one can speak of a saturated lime lye. Under normal conditions the calcium hydroxide is converted into lime by the atmospheric carbonic acid

in the outer concrete layers in accordance with the formula

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

Calcium carbonate is about 100 times less soluble in water than calcium hydroxide and therefore precipitates out in solid form so that the concrete is sealed from the outside in. The well known carbonate zone is formed which with increasing thickness restricts the ingress of CO_2. The carbonatisation of freshly set concrete consequently proceeds extremely slowly and achieves only a modest depth of penetration even after decades. We have been told by cement experts that after two years the carbonate zone has reached a depth of about 5 mm in a P 350 concrete mixture and has not reached a depth of 10 mm after 30 years. In addition, the carbonatisation process is greatly delayed in a damp atmosphere. The effect of the superficial carbonatisation layer is such that for exemple water stored in an old concrete container becomes only weakly basic with pH values of 8 to 10 at the most. In contrast, water which has penetrated through a concrete layer emerges as a lime lye with pH values over 12.

In experiments in which water was forced through freshly set concrete, pH values of 13.3 were measured in the first portions of water having penetrated, i. e. the easily soluble alkali oxides Na_2O and K_2O which are present in the cement in proportions up to about 1 % were washed out first. After some time the pH falls to a value of 12.6 which then remains constant. This corresponds to the pH value of a saturated calcium hydroxide solution.

If concrete is penetrated by water for a number of years, this not only causes the naturally occurring calcium hydroxide to be washed out but it also produces a breakdown of the mineral calcium silicate hydrates with the formation of silicon dioxide (SiO_2) and calcium hydroxide ($Ca(OH)_2$) until the concrete finally moulders. A case is known in which the penetrating water was still emerging as a saturated lime lye (pH 12.6) after 40 years, the concrete being totally broken down at the affected site.
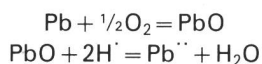
The consequences of the water action are strongly dependent on the volume and the speed of the water seeping through. If the water penetrates very slowly and in very small quantities, the well known lime efflorescence appears directly at the point of emergence because the lime lye forced out is continually neutralized by the atmospheric carbonic acid at the ventilated surface and is thus converted there and then into white lime.

As the volume and speed of the water increase, the carbonatisation effect is delayed so that the lime lye can first flow over the surface to a certain extent before the lime is fully precipitated out. This causes white drainage traces to appear as can be seen for example in Figure 4. In cases where the calcium hydroxide-saturated water emerges from a concrete layer in a rapid sequence of drops in free fall, stalactites are formed as can be seen in an impressive manner in Figure 5. The amount of water is then so great that the drops become encrusted only at the surface, thus forming lime tubules in which
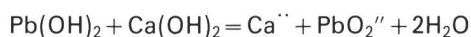
the water is then protected from further ingress of CO_2 and can flow on as a saturated lime lye. Finally, if the water penetrates the concrete as an unbroken streamlet running through fissures or joints, rather as shown at the site indicated in Figure 6, it takes much longer for the atmospheric carbonic acid to produce complete neutralization. However, even in this case the increase in surface area which occurs when the inflowing water spreads out over the whole floor area of the chamber causes complete carbonatisation in a few hours, the lime being deposited on the floor as a sediment. How much lime remains in solution in the supernatant water and what pH value the solution takes on is dependent on the air/water carbonic acid balance. Whereas in the complete absence of carbonic acid 2.1 g of calcium hydroxide dissolve in 1 l of water, this solution having a pH of 12.6, the lime solubility decreases with increasing partial pressure of CO_2 and consequently decreasing pH value to a minimum of 15.9 mg $CaCO_3$ per litre, to increase again with increasing carbonic acid enrichment in the water. The lime then dissolves as calcium bicarbonate in accordance with the equation: $CaCO_3 + CO_2 + H_2O = Ca^{..} + (HCO_3)'_2$. Thus a calcium content from 100 to 400 mg/l at a pH value of 7 to 8 is commonly found in natural water, corresponding to 10 to 40 French degrees of hardness.

6   Why does strongly basic water have such an extraordinarily aggressive effect on lead?

Lead is indeed resistant to strong acids such as sulphuric acid or hydrochloric acid since it is located immediately in front of hydrogen in the electrochemical potential series. In addition, most inorganic lead compounds are almost insoluble in water. If oxygen is present, however, the resistance to chemicals is altered very considerably and lead is attacked even by dilute acids, indeed even by distilled water, in accordance with the following reaction:

$$Pb + \tfrac{1}{2}O_2 = PbO$$
$$PbO + 2H^. = Pb^{..} + H_2O$$

Under favourable conditions (appropriate humidity, ventilation and carbonic acid content) covering layers are formed which protect the lead against further attack. These layers consist of basic lead carbonates $(2PbCO_3 \cdot Pb(OH)_2)$ and the lead is hardly attacked further by natural water in the pH range from 7...9. The protective effect of the covering layer can be affected by the most diverse influences and correspondingly varied types of corrosion appear, for example in lead sheathed cables installed underground. Basically, the reaction formulated above occurs, i. e. metallic lead goes into solution as a cation. Because of its amphoteric property, however, lead can also be brought into solution as an anion. Since the non-metallic character appears only very waekly in lead, this occurs only in a very strongly basic environment. During this process, the lead hydroxide primarily formed goes into solution as plumbite, i. e. as an anion:

$$Pb(OH)_2 + Ca(OH)_2 = Ca^{..} + PbO_2'' + 2H_2O$$

However, this reaction is possible only in solution of very high OH ion concentration. According to our observations of lead sheath corrosion occurring in multiway ducts, deeply penetrating attacks can be expected only at pH values higher than 11. Model experiments in which we subjected lead samples to the effect of alkaline earth solutions of varying OH ion concentration confirm our practical experience. Visibly deep damage similar to the type occurring in the cases mentioned was observed in the lead samples after four months of treatment with the corrosive solutions only after the pH had been set at a value of 12.6, as is shown in the description of the experiments set out below.

61   Effect of alkaline earth solutions on lead samples (model experiment)

For the purposes of the experiment lead strips of 100×30 mm and 2 mm thickness of the cable lead qualities pure lead, tellurium lead (0.04 % Te + 0.04 % Cu) and antimony lead (0.7 % Sb) were formed into small tubes of about 15 mm diameter and inserted into gently sloped glass tubes through which the corrosive solutions were fed in the form of streamlets. The experimental arrangement is sketched in *Figure 11*. Four calcium solutions were used with pH values of 10.5, 11.4, 12.6 and 13.1. For the two lower values, 1 n calcium acetate solution was titrated to the desired pH with 1/10 n caustic soda solution. For pH 12.6, saturated calcium hydroxide solution (slaked lime) was used and for the value 13.1 roasted lime (CaO) was slaked with 1/10 n caustic soda solution. All the solutions were produced with low

Fig. 11
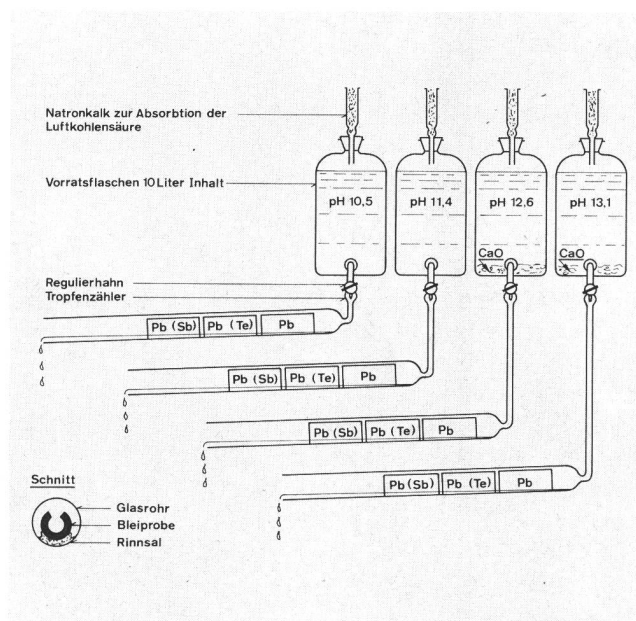**Corrosion experiment with calcium solutions of different pH values**
Skizze der Versuchsanordnung — Sketch of the experimental arrangement
Natronkalk zur Absorption der Luftkohlensäure — Soda lime to absorb atmospheric carbonic acid
Vorratsflaschen 10 l Inhalt — 10 l stock bottles
Regulierhahn — Stop cock
Tropfenzähler — Drop counter
Schnitt — Cross-section
Glasrohr — Glass tube
Bleiprobe — Lead sample
Rinnsal — Streamlet

carbonic acid, desalted water and were fed in drops (10...20 drops per minute) from 10 l stock bottles into glass tubes which contained the lead samples. During the 120 day period of the experiment, 100 l of solution flowed over each of the lead samples. The surface of the lead tubes was not wetted uniformly but only in the regions of the resting surfaces just as in the case of cables lying in the plastics ducts. The corrosion pattern found after termination of the experiment was correspondingly inhomogeneous.

After removal of adhering corrosion products we determined the weight loss of the lead samples and calculated from that the corrosion rate expressed as usual in grams per square metre and day. Because the corrosion is in part non-uniform, the individual figures should not be taken as values which apply generally but merely as comparative figures. Thus, in the experimental solutions adjusted to pH values of 10.5 and 11.4, we obtained removal rates of 2.2...4.8 g/m^2. day, pure lead providing the lowest values, antimony lead the highest, while tellurium lead is ranked between those and has the greatest scatter. However, all values lie in the region of the figures given by *F. Ritter* [14] in his corrosion tables for distilled water: 1...5 g/m^2.day. In contrast, corrosion rates 4...5 times greater resulted in the two more strongly basic solutions (pH 12.6 and 13.1), for pure lead 11.6...12.9, for antimony lead 16.9...17.1 and for tellurium lead 10.1...16.3 g/m^2.day.

X-ray analysis of the corrosion products appearing also yielded interesting results. One could detect differences with the eye to the extent that predominantly white to yellowish covering layers appeared on the samples laid in weakly basic solutions while the lead surfaces exposed to strongly basic solutions had predominantly yellow and red lead oxide crusts. Evaluation of the X-ray photographs led to the following result:

- predominantly white corrosion product, *appeared at pH 10.5:* consists of a large amount of 2/5 basic lead carbonate [$3PbCO_3 \cdot 2Pb(OH)_2$] and about the same amount of lead oxide hydrate [$2PbO \cdot H_2O$]
- mixture of white and yellow corrosion product, *appeard at pH 11.4:* consists of a large amount of yellow lead oxide [PbO_{yellow}] and a large amount of lead oxide hydrate [$2PbO \cdot H_2O$] together with a small amount of 2/5 basic lead carbonate [$3PbCO_3 \cdot 2Pb(OH)_2$]
- mixture of red and yellow corrosion product, *appeared at pH 12.6:* consists of a large amount of red lead oxide [PbO_{red}] and a somewhat smaller amount of yellow lead oxide [PbO_{yellow}]
- mixture of red and yellow corrosion product, *appeared at pH 13.1:* consists of a large amount of red lead oxide [PbO_{red}] and a small amount of yellow lead oxide [PbO_{yellow}] together with slightly more lead oxide hydrate [$2PbO \cdot H_2O$]

A notable feature is that basic lead carbonate was formed in the more weakly basic solutions in addition to lead oxide hydrate and yellow lead oxide (only to a small extent at pH 11.4) while carbonate is completely absent in the more strongly basic solutions. This agrees with a phenomenon described by *W. Katz* [15] according to which dilute alkaline earth solutions attack lead in a manner which progresses linearly with reaction time

Fig. 12
Condition of the pure lead samples after termination of the experiment
The samples lay for 120 days in streamlets of calcium solutions of pH values 10.5, 11.4, 12.6 and 13.1. The two strongly basic solutions have eaten deep trenches into the lead surface while the two samples in the weakly basic solutions are only superficially corroded (half natural size)

while dilute alkali solutions are less dangerous because protective covering layers of basic lead carbonate can form in an alkaline environment subject to the action of carbonic acid. In calcium hydroxide on the other hand the carbonic acid is kept away from the lead surface as a result of the carbon dioxide being fixed as virtually insoluble calcium carbonate and being precipitated out.

The fact that solutions with pH values of 12.6 and 13.1 are many times more aggressive than solutions having pH values of 11.4 and 10.5 is clearly expressed in the removal rate determined as weight losses and related to the total surface. The difference in corrosivity between the strongly and weakly basic calcium solutions is seen even more impressively in the appearance of the lead samples at the end of the experiment. *Figure 12* shows the tubes of pure lead which have been slit longitudinally and then flattened into lead strips. Whereas the first two lead strips, over which the weakly basic solutions have flowed, are merely superficially discoloured
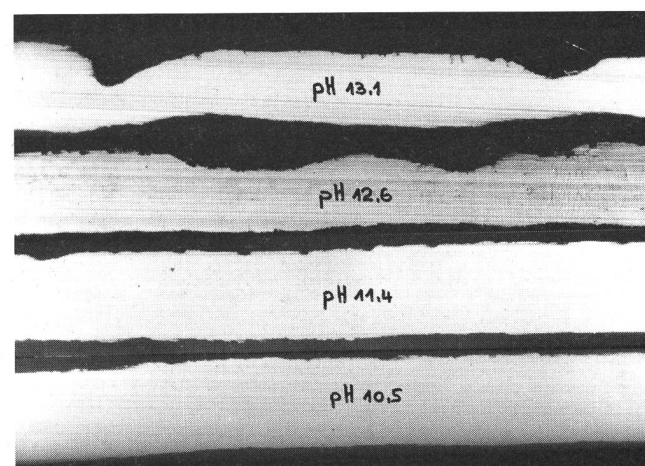

Fig. 13
Cross-sections through the lead samples illustrated in Figure 12
At pH 10.5 and 11.4 hardly any lead removal can be detected whereas at pH 12.6 and 13.1 substantial quantities of lead have been dissolved and corrosion trenches of varying depth have appeared (magnification 5.6-fold)

Fig. 14
There are no corrosion products on the surfaces rinsed with strongly basic solutions, indeed they have been strongly etched
As a result the grain boundaries are clearly visible in this enlarged section of the sample treated at pH 13.1 (magnification 5.1-fold)

Fig. 15
Fault in the lead sheath of JC Colombier—Auvernier
Outside the corroded strip, which approximately corresponds to the contact surface with the concrete support rinsed with water, the lead sheath is completely intact, bare and free of corrosion products. Even in the attacked area, which consists of a number of sinuous longitudinal grooves of varying width and depth, some corrosion product is present only in the trench located in the centre (half natural size)

and covered with thin layers of white and yellow corrosion products, the other two samples, which have been rinsed by the strongly basic solutions, show deep corrosion trenches along the liquid/air boundary line. The depth of the corrosion trenches and the trough-shaped to planar lead removal zones of the lead samples exposed to the strongly basic solutions can be discerned particularly clearly in a comparison with the cross-sections depicted in *Figure 13* of the pure lead samples. There are no covering layers or deposited corrosion products present at those sites where lead has visibly been removed (in planar or trench formation). As can be seen in *Figure 14*, these sites are indeed quite bare and even appear clearly etched so that grain boundaries can be recognized. Adhering yellow and read lead oxide has been formed mainly on lead surfaces located above the flowing solution but moistened by vapour and by capillary action. In contrast, in the case of lead samples exposed to the weakly basic solutions, deposits of corrosion products appeared predominantly in the surface region rinsed in the liquid. The samples of tellurium
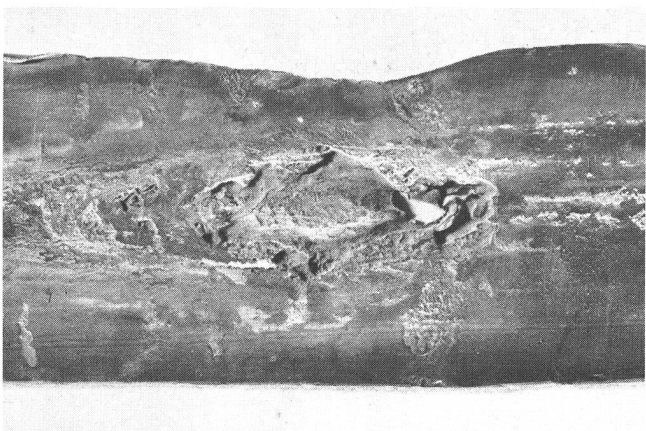
alloyed lead treated in the same solutions showed practically the same corrosion pattern at the end of the experiment. In contrast, the antimony alloyed lead samples deviated somewhat in their behaviour, forming less deep corrosion trenches but having correspondingly more planar lead removal.

7 Appearance of lead sheath damage caused by strongly basic water

Basically the same corrosion pattern appeared in lead sheath ruptures occurring in plastics multiway ducts as we observed in the experiments described above with strongly basic calcium hydroxide solutions. However the practical instances sometimes show corrosion patterns which deviate substantially from those mentioned above, as will be clear from the examples mentioned below:

– The lead sheath damage produced in the region of the duct inlets in the plastics multiway ducts at Auvernier

Fig. 16
Fault site in the lead sheath of a subscriber cable in the multiway duct at Arbon
The cable was in contact with the wet concrete support only over a short stretch (a few cm) so that this oval corrosion surface formed where the lead has been removed by the lime lye in trough-like and trench formations until rupture occurred (half natural size)
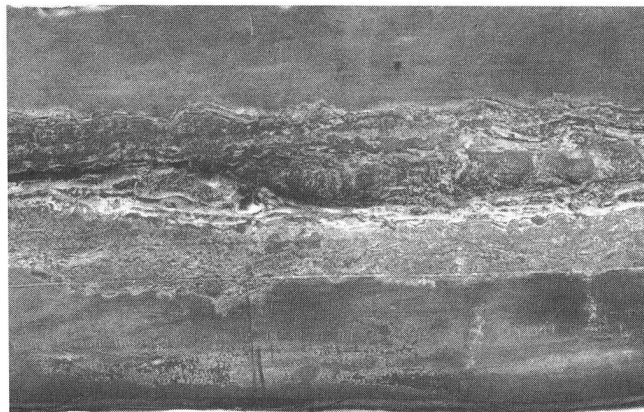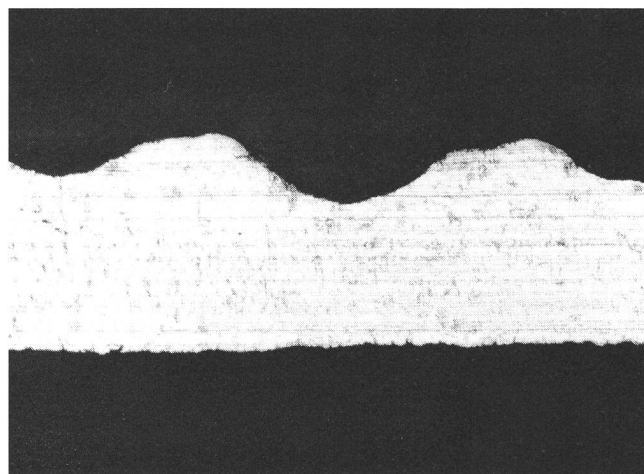

Fig. 17
Cross-section through a corrosion of the lead sheath sample illustrated in Figure 15
The corrosion grooves and trenches have erosion-type rounded edges and smooth walls (magnification 15-fold)
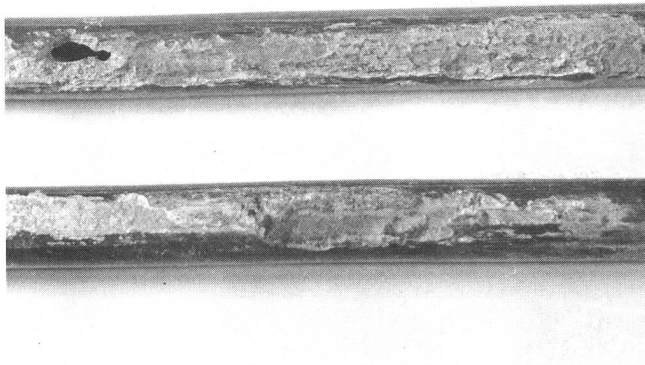
Fig. 18
Fault in a subscriber cable within a plastics duct in Eschen
The small cable (diameter 10 mm) has been corroded along the resting surface in the form of flat, elongate troughs with rounded boundaries. The intact lead surface outside the zone of attack is covered with a thin compact layer of red lead oxide (natural size)
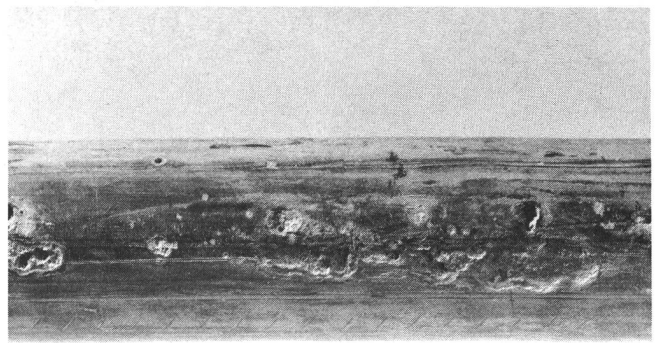

Fig. 19
Fault site in JC 20006 in a duct between Vesenaz and La Capite
In the region of the resting surface, in addition to flat, round troughs, some small areas of corrosion are present which are similar to electrolysis craters, and annular traces of white deposits can be discerned around some holes (three quarters natural size)

and Arbon in a short time (1...2 years) is especially typical of the type of corrosion caused by streamlets of strongly basic water containing calcium hydroxide. Thus, *Figure 15* shows the fault site on JC 20084 Colombier—Auvernier and *Figure 16* shows the fault site in a subscriber cable from the Arbon installation. In both cases, deep corrosion grooves have been eaten into the lead sheath so that a rupture has finally occurred at one point. There are practically no corrosion products present and the lead sheath is completely intact, bare and free of deposits outside the corroded resting surface. The areas eaten away — deep, narrow trenches and flat troughs — have erosion type rounded edges and smooth walls as can be seen from the example in *Figure 17* of a cross-section through two adjacent corrosion grooves.

- A small subscriber cable within a duct in Eschen was corroded through in a similar manner after one year of operation. As can be seen in *Figure 18,* the lead sheath was again eaten away solely along the resting surface in flat, elongate trough formations with rounded boundaries. In this case, however, the intact

lead surface is covered with a thin compact red lead oxide layer (which appears dark in the picture). The resting surface being attacked over a length of about 2 m is bare and contains no deposited corrosion products.

- Occasionally however corrosion patterns appear which at first glance are comparable to patterns arising from external current electrolysis. For example, JC 80056 in the plastics multiway duct at Altdorf and JC 20006 in a multiway duct between Vésenaz and La Capite, illustrated in *Figures 19...21,* were corroded in this fashion. The corrosion rupture occurred in 1976 after six years of operation within the duct section. The cable sheath has been eaten away in round patches at several points in the region of the resting surface along a length of about 1 m. As is shown in Figure 19, in addition to flat, round troughs there are some small perforations present which are like electrolysis craters and still contain some corrosion products. However, electrolysis processes caused by external currents are scarcely imaginable in plastics ducts so that we assume that the electrolytic corro-
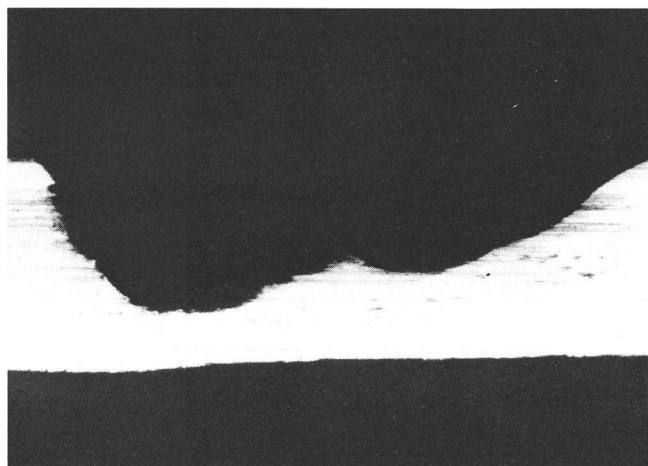

Fig. 20
Cross-section through a trough-shaped corrosion site in the lead sheath sample illustrated in Figure 19 (magnification 12-fold)
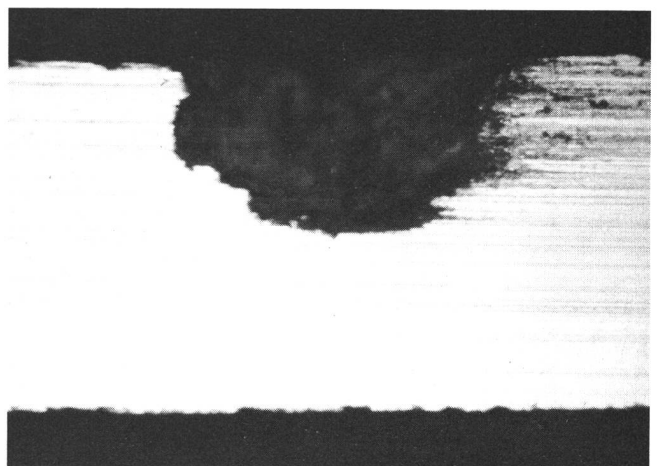

Fig. 21
Cross-section through a crater-shaped corrosion in the lead sample illustrated in Figure 19 (magnification 20-fold)

Fig. 22
Lead sheath sample from JC Wollerau—Freienbach
The whole surface is covered with a thick porous layer of lead oxide. The wall thickness of the lead sheath has been reduced throughout and large areas are present where the remaining lead sheath is only a few tenths of a millimetre thick (one third natural size)
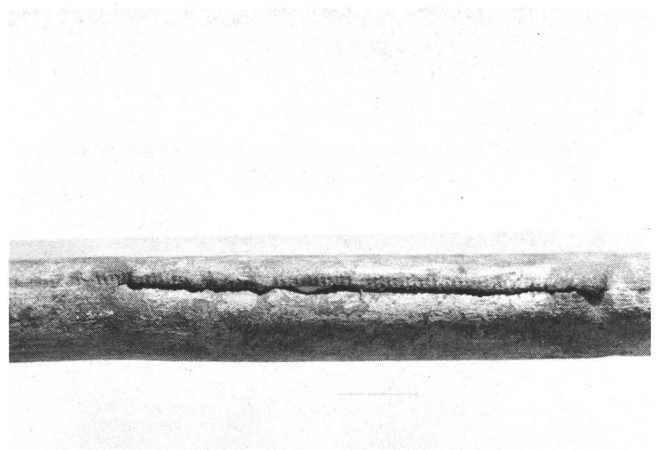

Fig. 23
Fault site of JC Wollerau—Freienbach
After the lead sheath had been removed in planar fashion to varying depths over its whole circumference, a crack finally formed in the region of the lead seam which forms a structure imhomogeneity (half natural size)

sion components are attributable to the formation of aeration elements or concentration chains. Cross-sections through the lead sheath also show electrolysis type craters with undercut edges (Fig. 21) in addition to the trough formations (Fig. 20) typical of cement water corrosion. Annular traces of white deposits around individual corrosion sites (barely discernible in Fig. 19) lead to the presumption that corrosion formations of this type arise if cement water reaches the interior of the plastics duct only in very small quantities and evaporates again in time.

– A completely different corrosion pattern appeared in the lead sample shown in *Figure 22*. This cable sheath section of antimony alloyed lead (0,7 % Sb) comes from the plastics multiway duct at Wollerau. The lead sheath is covered over its whole surface with a thick, porous crust of red and yellow lead oxide so that the lead wall thickness is more or less reduced over the whole cable cross-section. As can be seen in *Figure 23*, the lead seam eventually tore since it was preferentially removed as a structural inhomogeneity by the attacking solution. The formation of this type of corrosion is attributable on the one hand to the fact that the cable length affected was completely flooded with basic water having a pH value of only 10.3 at the time of investigation but which must have reacted much more strongly basically from time to time as can be concluded from the lime deposits found (Fig. 10). On the other hand, antimony alloyed lead is obviously removed more homogeneously and over a wider surface area by basic water than is the case for pure lead or low alloy tellurium lead. We were able to observe this in the experiment described in Section 61.

8   Protective measures

It will be clear from the instances of the occurrence of damage presented here that it would not be practicable to maintain complete plastics multiway ducts dry at all times and in all places. At least it appears a great deal easier to accept the local leaks and occurrences of wa-

ter ingress in individual installations and to provide the lead sheaths of all cables with corrosion protection. As a consequence of the corrosion damage in cables with bare lead sheaths (Type A) in the plastics multiway duct installations at Auvernier and Eschen in 1971, a working party had been fromed whose task it was to devise measures to prevent damage from cement water corrosion. In September 1972 this working party proposed the following measures:

– Only cables with a corrosion protection sheath should be pulled into plastics multiway ducts. Polyethylene coated lead sheath cable (Type AT) should be used instead of the cable with bare lead sheath (Type A).
– Cables with a diameter round the wire bunch of more than 43 mm should be provided with a lead sheath thickness reduced by 10 %, thus covering in part the extra cost of the required plastics sheath.

In this way, the danger of cement water corrosion has been eliminated for cables pulled into plastics multiway ducts since then. However, the bare lead cable sheaths introduced into these installations previously remain vulnerable to corrosion. In the meantime, further cases of damage have occurred so that we had to investigate a case even in 1977. However, because of the rapid progress of corrosion due to the effect of strongly basic water it may be assumed that cables with bare lead sheaths lying in plastics ducts at the moment will for the most part remain intact for years because they are presumably in dry situations or at least not in contact with aggressive cement water. It is our present opinion in any case that it would be exaggerated and uneconomic to replace all Type A cables lying in plastics duct sections by polyethylene sheathed cables. Instead, the action will be limited to treating corrosion damage on a case by case basis.

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