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Prepared for:

NEKAP s.r.o.
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Sulfate corrosion attack tests of concrete class C30/37

Prepared by:

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1. Introduction

As requested by NEKAP s.r.o., of Kosorska 5, 152 00 Prague 5 request no.43/Ko/2006dated November 14, 2006, corrosion testing of class C30/37 concrete samples with addition of XYPEX C-1000 and NF was completed. The C-1000 additive was used in amounts of 1%, and. 2%, and the NF additive was used in amounts 0.5%, and 1%.

At the same time control samples with no additives were tested.

The purpose of the testing was to examine the effectiveness of the XYPEX crystalline additives under sulfate exposure and their ability to block sulfate corrosion (attack).

2. Sulfate Corrosion (Attack)

Sulfate attack studied in this report is referred to as Type III corrosion. During the transportation of liquid media (usually underground water) that contain sulfate content through concrete, the sulfates react with tri-calcium aluminates in cement. The product of this reaction is so called ettringite, which has a volume that is significantly larger than volumes of initial phases. As a result of this process the pore system becomes filled with products of this sulfate reaction. Initially this leads to a minor increase in concrete strength. Once all the pores are filled with reaction products, internal pressure will become a destructive force damaging the concrete microstructure with dramatic effects on first the tensile strength and later the compressive strength of concrete. During typical and even elevated concentrations corresponding to characteristics of XA2 and XA3 environments, this reaction takes months or even years. Therefore, accelerated tests are used for testing different types of concrete for sulfate attack resistance - tests which due to increased concentration of corrosive media can identify surface damage in weeks or months.

The standard concentration, used in laboratory tests, is 36,000mg of SO_4/l. This concentration is six times the upper limit of the characteristic chemically aggressive environment XA3 (3,000 to 6,000 mg/l).

During sulfate attack/corrosion testing it is possible to evaluate changes in mechanical properties of concrete, i.e. changes in tensile or compressive strength. However, due to the fact that the damage caused by sulfate attack is always primarily surface damage, the sensitivity of these tests is relatively small and in order to objectively compare changes in mechanical properties it is necessary to complete testing on a large number of samples.

The second possibility is to use the CSN 73 1326 method, which evaluates the influence of the aggressive environment by “loss of surface”. By this method the loss of weight of the sample is measured as a result of the degradation reaction on the surface of the test samples. This loss is recalculated per cubic meter and is referenced as a basic quality parameter during evaluation of the freeze-thaw resistance of concrete exposed to combination of freezing and salt exposure. This method was used during this test program.

3. Completed Testing and Results

The tests were completed on cubes with 150 mm sides, which were cast in the laboratory of the Rohansky Island central concrete plant. Concrete of all cubes met the C30/37 classification. A total of 14 cubes were tested:

- additive C-1000 - 1% - 3 cubes
- additive C-1000 - 2% - 3 cubes
- additive NF - 0.5% - 3 cubes
- additive NF - 1% - 3 cubes
- concrete with no additive - 2 cubes

Samples were placed in plastic containers with constant concentration of sulfates at 36,000 mg/l for the entire duration of the experiment. The testing started on October 2006 and was completed in February 2007. The total exposure time of the samples was approximately 4 months.

After the samples were fully saturated their mass was recorded with 0.1g precision. After the test was completed the samples were rinsed with running water and again their mass recorded. The mass difference was considered the mass loss caused by sulfate attack/corrosion. At the same time photographic documentation of the samples was completed.

The results show that mass loss of samples made with the XYPEX Admix C additive in both concentrations as well as with the additive NF in both concentrations was between 5 and 50 g/m^2 and the samples were characterized by visual examination as showing no deterioration.

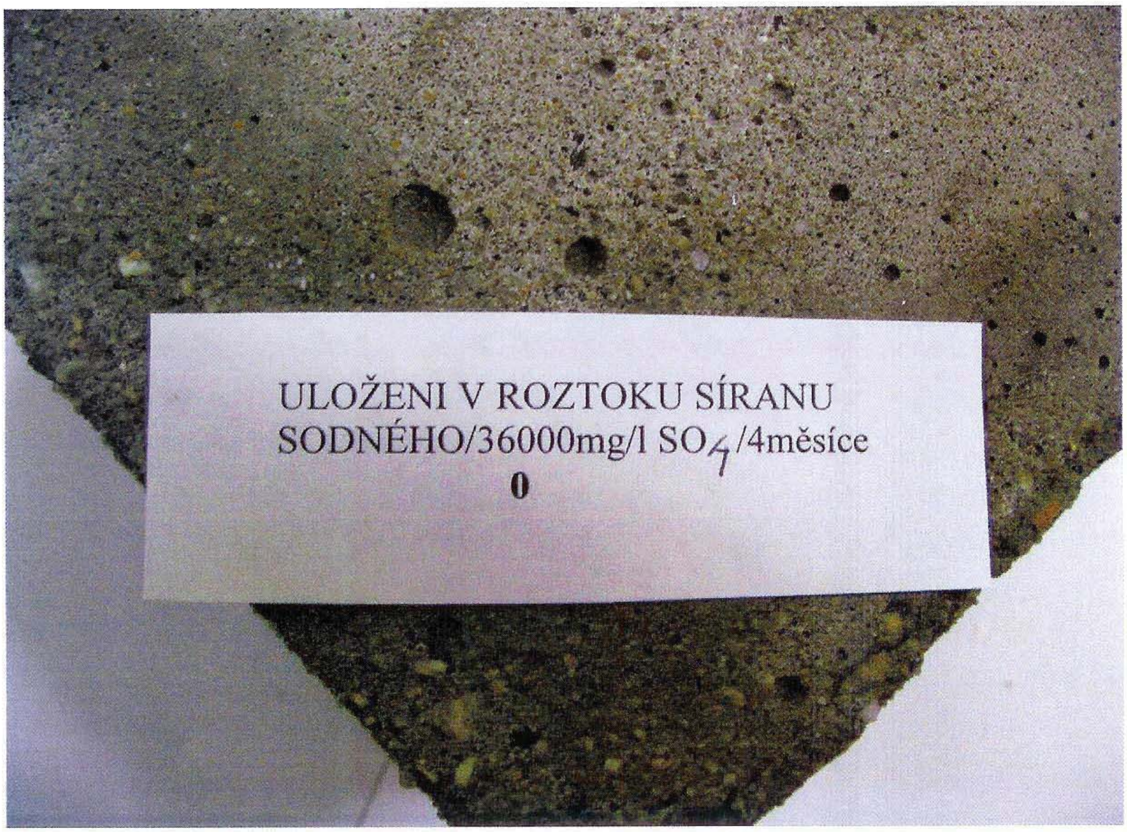
In the case of the control samples, the mass loss was 4,860.0 g/m^2 .

If we compare these results with a typical criteria according to CSN 73 1326 used for evaluation of concrete for freeze-thaw damage and salt exposure (upper accepted limit of 1,000 g/m²), it is evident that concrete with XYPEX is “resistant” even under the given sulfate exposure, while the control concrete without XYPEX deteriorates on the surface and would continue to deteriorate into the core.

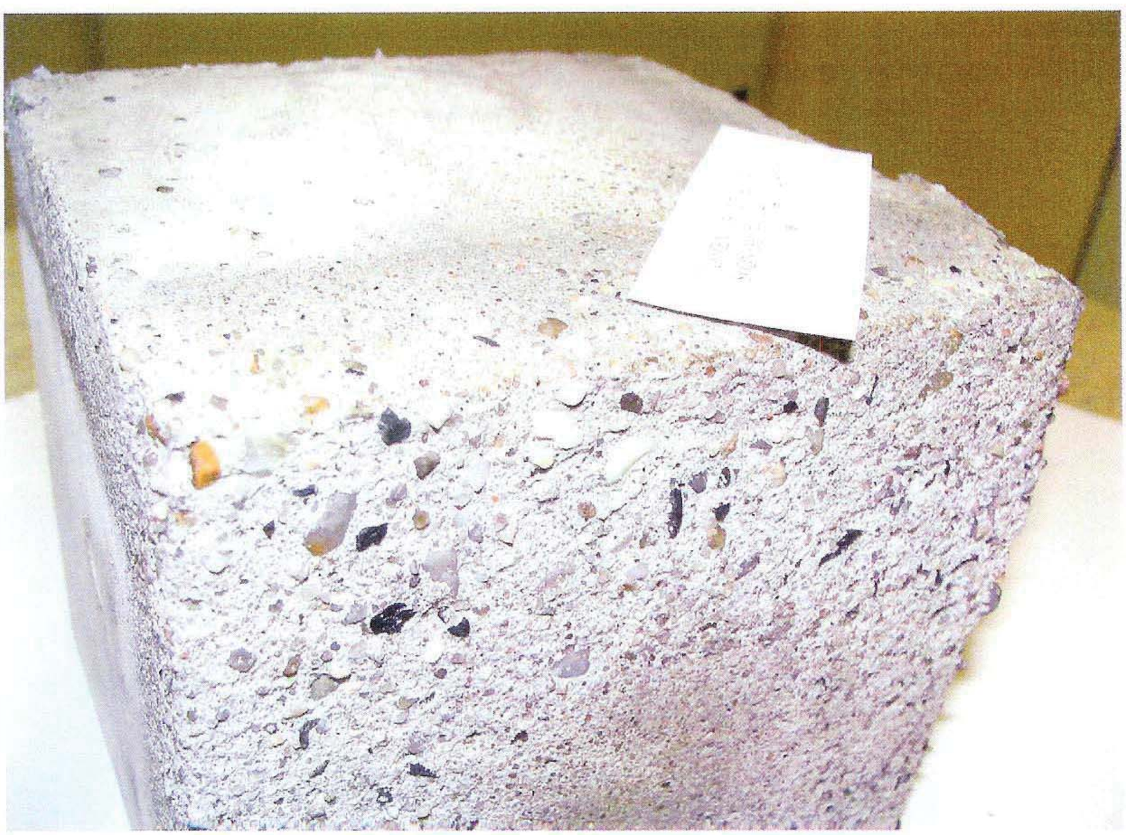
4. Conclusions

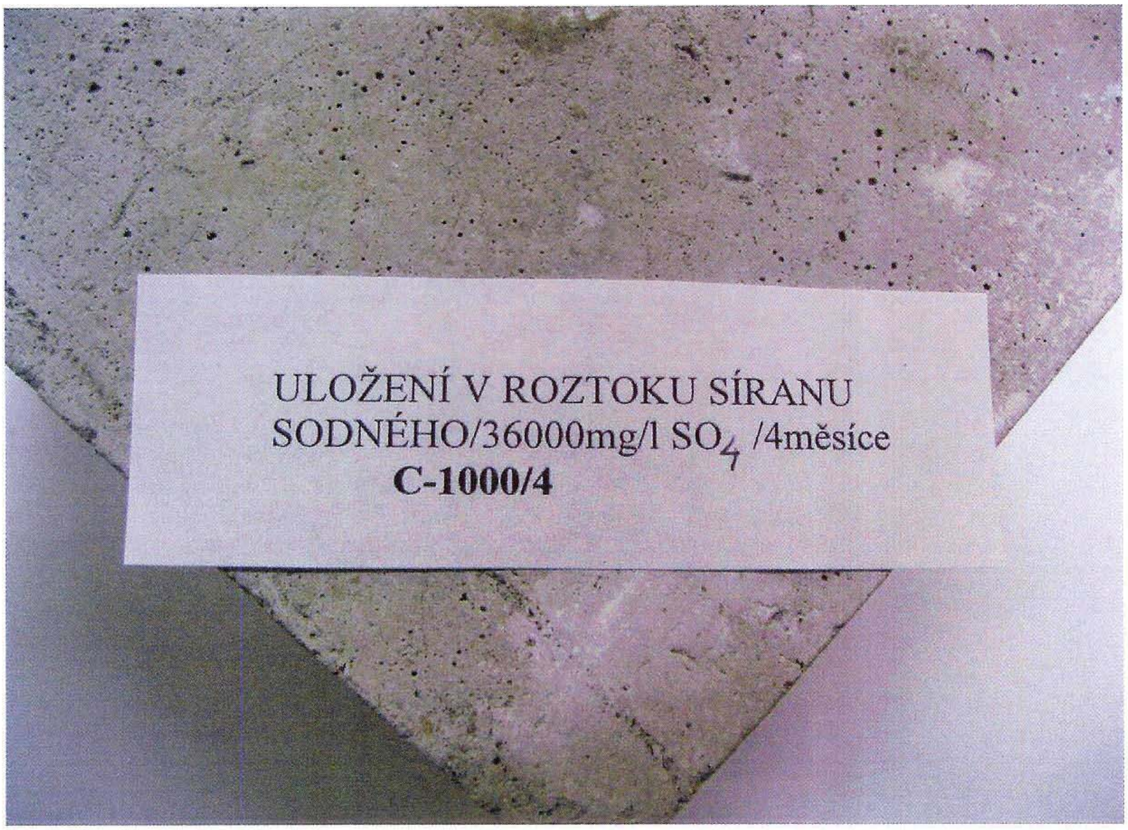
The completed evaluation of sulfate resistance of concrete made with additives XYPEX Admix C-1000 and NF concluded that these additives provide concrete with resistance against sulfate, including extremely high sulfate concentration of 36,000 mg/l. After four months of exposure to the sulfate solution the samples experienced practically no mass loss and were visually intact. On the other hand, the control samples made with he same concrete but without additives showed a major disintegration of the surface area and a mass loss per m² significantly greater than the upper limit of 1,000 g/ m² specified by CSN 73 1326. Based on these tests it can be concluded that the XYPEX additives provide concrete with exceptional resistance against sulfates, even in concentrations corresponding to chemical characteristics of specification XA3 according to CSN EN 206-1.


Datum

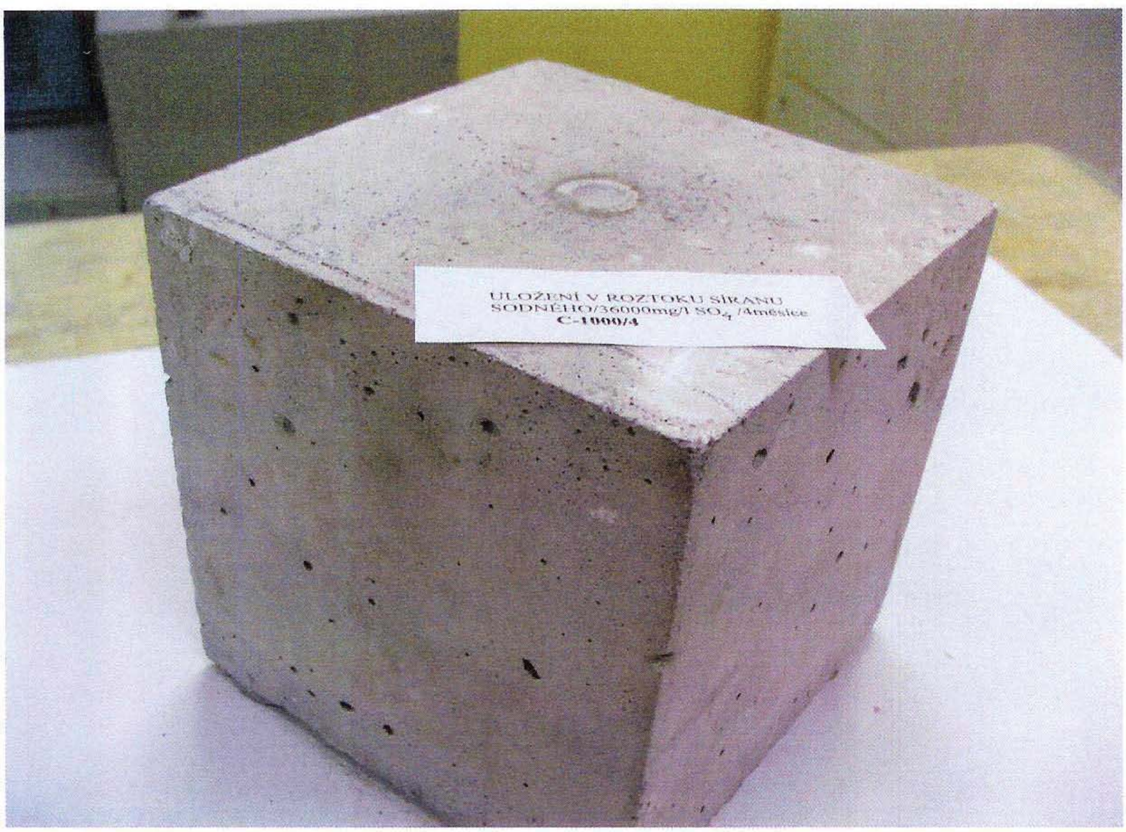


Stored in SO4 solution 36000mg/l 4 months 0=control sample (no additive)

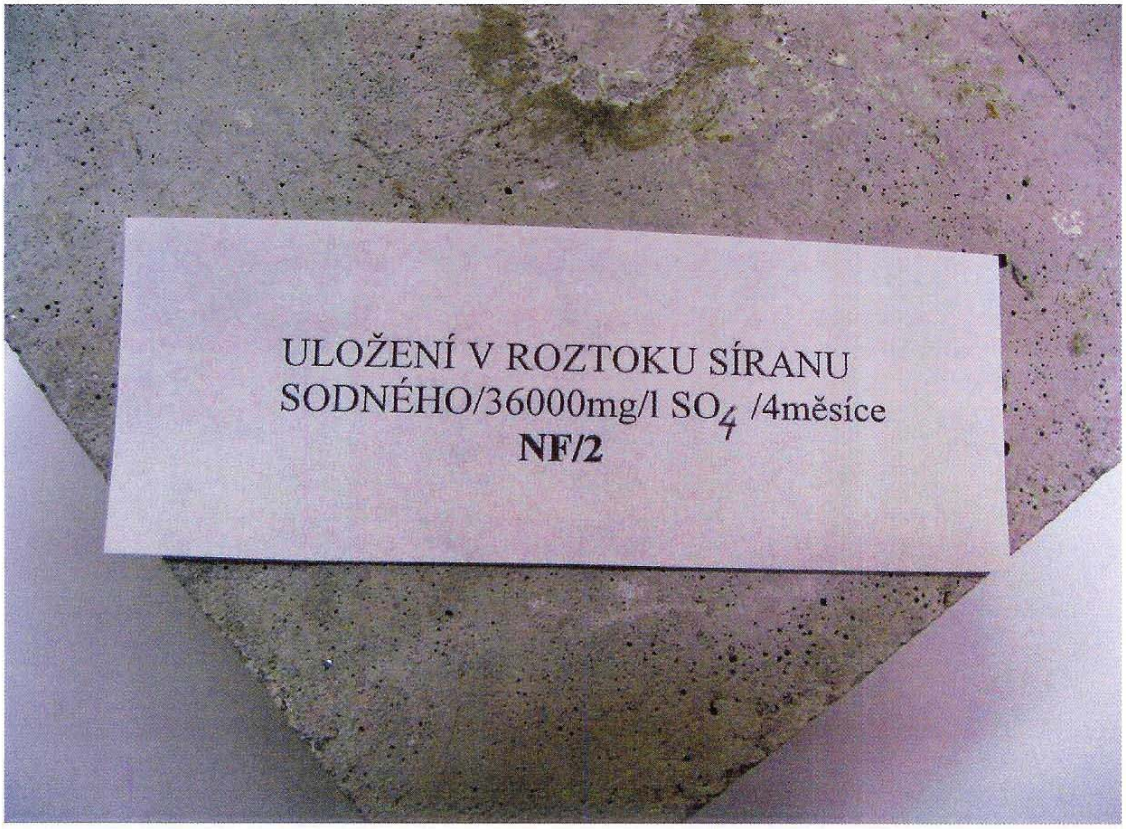




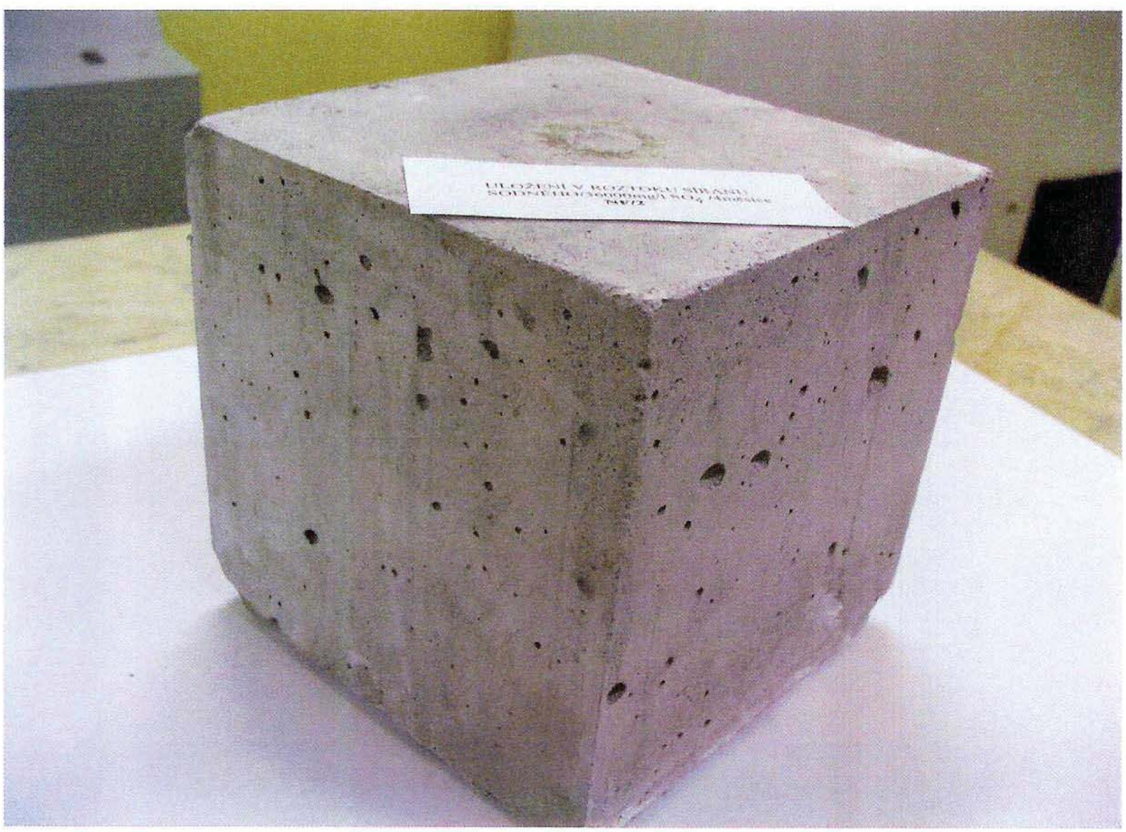
Stored in SO4 solution 36000mg/l 4 months Sample 4 with C-1000

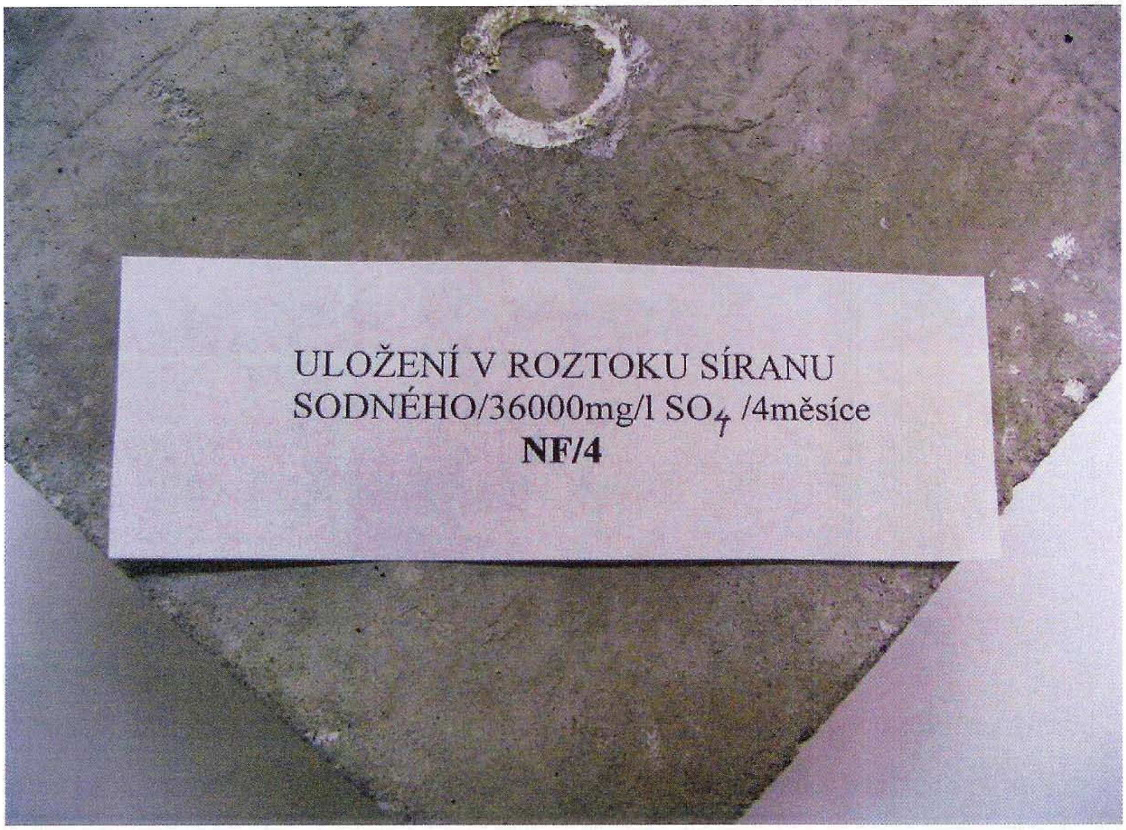


Stored in SO4 solution 36000mg/l 4 months Sample 8 with C-1000



Stored in SO4 solution 36000mg/l 4 months Sample 2 with NF





Stored in SO4 solution 36000mg/l 4 month Sample 4 with NF