

ODOR PROBLEM CAUSED BY OLEATE-BASED PIPE JOINT LUBRICANTS

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Pipe joint lubricants are used during the installation of plastic and ductile iron water mains. Lubricant is added to the gasket on the bell end and to the external surface of the spigot end. This allows the bell and spigot to be forcefully connected and rotated without disrupting the gasket's integrity. The pipe cannot be connected without a lubricant.

Lubricant is supplied with the pipe from the pipe manufacturer. The industry relies heavily on a very inexpensive compound that is labeled as a non-toxic vegetable soap. It is brown colored, soapy and thick and sticky. It has the NSF seal and is reported to have no adverse effects on drinking water, including odor, if used properly.

The Seacord Corporation, which produces most of the pipe-joint lubricant that is used in the United States, has provided the following information about the oleate-based lubricant (1). It has been in use since 1956. The lubricant is made from common soap compounds, is low in cost and does not support bacterial growth (does not require a biocide additive). It has been extensively tested and found to be safe for use in construction and to be non-toxic in water. It is compatible with pipe materials, causing very minimal swelling of rubber gaskets. Seacord has not been aware of any water quality problems during the lubricant's proper use and application. In fact, testing has suggested that flushed new mains should not experience residuals exceeding 1 mg of lubricant per liter and its expected odor threshold is about 10 mg of lubricant per liter. Thus, there has been no impetus to develop a more complex and costly lubricant. The odor problem caused by these lubricants has not been previously reported nor is it currently recognized. One reason is that responses to customer

complaints typically miss the problem. By the time the water is sampled the lubricant has been sufficiently diluted out or flushed away. Another reason is that very few water suppliers conduct odor analyses of the water in new mains before they are released for use. This is one of those cases where a problem has been occurring but no one has looked at it. Once we started looking we began to find it in many places. This paper reviews the problem, recommends that new mains be tested for odor before release, and calls on the industry to find an alternative lubricant.

PHILADELPHIA'S BACKGROUND

The Philadelphia Water Department first became aware of the odor problem in January, 1990 when customers complained for two weeks after the construction of a new main. Extensive odor testing and organics analyses were made. Several more cases appeared over the next two years with the same odor, and at new main sites. Because the lubricant, straight from the can, matched the problem by odor quality, attempts were made to confirm the lubricant as the cause of the problem.

Beginning in January, 1992 all new mains were subjected to odor testing using Flavor Profile Analysis (2). In addition, closed-loop stripping and gas chromatography (CLSA/GC) was used to correlate trace organic compounds to the odor (2).

In Philadelphia, all new mains require a sanitary release (3). The testing done during the sanitary release (i.e. total coliform, pH, chlorine residual, turbidity) determines whether the new main can be safely put into service. Samples are collected at about every 500 feet of new pipe from disinfected copper tubing connected to ferrules.

Philadelphia uses cement-lined ductile iron pipe. New mains are disinfected with free chlorine, flushed and held for at least 16 hours before testing. The water is approved if it meets the quality of the City's drinking water: chloramine residual over 1.0 mg/L; turbidity under 1.0 NTU; pH from 7-8.5 units and no coliforms. The City's water has slight chlorinous and musty taste and odor profile.

The proof that the odor problem in new mains was caused by the lubricant came by:

1. Direct comparison of the lubricant's odor to the odor in new main and customer complaints by a trained FPA panel.
2. CLSA/GC analysis of the lubricant, of water from new mains and of customer complaint samples.
3. Checking all other construction materials (cement lining, seal coats, gaskets) for absence of the odor.

Philadelphia FPA panel described the lubricant's odor (from water in new mains) as wet paper, chalky or wood putty in character. In just four months of odor testing of new mains 45.5 percent of 136 sanitary release samples had the off odor at the following FPA intensities (scale of 1 to 12):

<u>FPA Odor Intensity of New Main Water with Lubricant Odor</u>	<u>Frequency of Occurrence of Odor Intensity</u>
1.0	9.7 (% of samples)
1.5	21.1
(background intensity of tap water)	
2.0	14.5
2.5	11.3
3.0	4.8
(above background of tap water)	
3.5	9.7
4.0	16.1
4.5	6.4
5.0	3.2
5.5	3.2

Although in most cases, the new mains' water quality was otherwise acceptable, the odor problem caused many not to be approved for use without additional flushing. In 51 new mains, 30 had the lubricant odor. About 34 percent of the new mains had to be failed. This resulted in extensive flushings, sometimes for weeks, before the odor dissipated.

The lubricants are oleate-based. Oleates are derived from vegetable and animal fats. They may be low in odor until they are oxidized (upon exposure to air, upon disinfection by chlorine). Table 1 summarizes the results of CLSA/GC on water from customer complaints that had the odor problem. The aldehydes, hexanal, heptanal, octanal and nonanal were from the lubricant. Hexanal occurs in Philadelphia's drinking water at about 300 ng/L whereas in odor complaint samples the level was up to ten times the background.

FPA work in Philadelphia has found that when aldehydes like hexanal exceed 1000 ng/L they have a noticeable effect on taste and odor. The lubricant introduces a mixture of aldehydes. Aldehydes such as heptanal have a rancid oily odor (see below). Although the aldehydes are not the sole cause of the odor that lubricants contribute to the water, there is no doubt that they play a role.

Odor Characteristics of Aldehydes Found in the Pipe-Joint Lubricant

Flavor Profile Analysis

<u>Near Threshold Odor at 45C (ng/L)</u>	<u>Odor Quality</u>	<u>Literature Report of Odor Quality (4)</u>
Hexanal 700	lettuce heart, pumpkin	green, woody, fatty
Heptanal 700	rancid walnut oil	fatty, sickening, rancid woody

Since Philadelphia has added odor testing into the sanitary release requirements for new mains the complaints have been greatly reduced.

EDMONTON'S BACKGROUND

The City of Edmonton, during 1990, found that taste and odor complaints were occurring in new construction areas of their distribution system (5). Edmonton started using FPA in 1989, and found it useful for identifying this distribution problem. Approximately 20 percent of the total complaints received during 1991 were traced to the lubricants used in construction and repairs. It was particularly evident in new subdivisions with few homes and where flushing had been limited. Customers complained of turbid water, a difficult to describe sickening odor, a "sticky" feel to the water and in a few instances, of feeling ill ("greasy stomach").

Edmonton's went further to confirm the effects of the lubricant (Table 2). The lubricant was found to dissolve slowly over four hours, increase the turbidity of water, to form a surface scum and an insoluble precipitate in tap water. At a concentration of 0.2 mg of lubricant per liter it had a just detectable odor. At a concentration of 1 mg of lubricant per liter its odor was clearly noticeable. Philadelphia found that 2-5 mg of lubricant per liter of water gave a noticeable odor (note that variability between lubricants from different manufacturers has not been evaluated). Super chlorination as used to disinfect water mains (100 mg free chlorine per liter) did not reduce its potential to produce an odor. In fact, chlorination produces aldehydes. The lubricant's odor was detected before a noticeable increase in turbidity appeared.

Edmonton took action to alleviate the customer complaints. Construction and inspection staffs were trained on proper use of the lubricant and to recognize its odor. Staff involved with flushing of new mains or complaint areas had to rely on odor to determine the extent of flushing. Staff involved with design of new mains had to be made aware of the need to provide good flushing points.

Edmonton developed a SOP: Sampling for Taste and Odor in New Construction Areas. It requires odor and taste testing at new subdivisions in order to approve the work. An initial sample is collected after disinfection and another sample is collected seven days later. Failure to meet water quality standards, including

odor, requires action and more testing. Complaints still continued, attributed to a lack of care in the lubricant's application.

ADDITIONAL TESTING IN PHILADELPHIA

The oleate-based lubricant was tested to better understand its impact on the drinking water in a new main. Three tests were made: 1) contact with non-chlorinated water for 2 hours; 2) contact with non-chlorinated water for 24 hours; 3) contact with 200 ml of a 5% sodium hypochlorite solution in 1600 ml of non-chlorinated water for 24 hours. The lubricant was applied, as in the field, to a one-inch section of rubber gasket. Since the lubricant contacts free chlorine during the disinfection of new mains, it was important to include a test with chlorine. Oxidation can change the lubricant's impact on water quality.

Table 3 summarizes the results. The thick and sticky lubricant increased the water's pH (partly due to the use of hypochlorite) and greatly added to the turbidity. It foamed like soap when stirred into solution. When exposed to free chlorine (as during new main disinfection) it produced a very cloudy suspension consisting of a white precipitate that settled out in 24 hours and dried onto the gasket. Chlorine did not oxidize out its odor but increased the concentration of certain odorants. The aldehydes, hexanal, heptanal, octanal, nonanal and decanal were the major contaminants identified. A variety of unidentified, higher molecular weight compounds also appeared.

ALTERNATIVE LUBRICANTS

The market for pipe-joint lubricants is almost totally composed of oleate-based products however, alternatives can be found. But care must be taken in switching to an alternative lubricant.

An alternative must be non-toxic, water soluble, an excellent lubricant, useable under all weather conditions, not readily dried out and have no effects on water quality such as odor. Jameel Rahman (Philadelphia Water Department) has proposed a lubricant that consists of:

FORMULA SIMILAR TO:
BLUE LUBE

In comparison to the oleate-based lubricant, this potential alternative does not increase the pH, does not cause turbidity problems and does not contribute odor problems. It is clear and readily soluble. It does not foam and does not contribute organic contaminants as measured by CLSA/GC. It is not intended for sealing the gasket connection but provides the necessary lubrication to join two pipes together.

CONCLUSIONS

Oleate-based lubricants are causing customer complaints. They have been causing a problem in the distribution system that has not been identified until Philadelphia and Edmonton used Flavor Profile Analysis for new main testing.

The lubricant is not readily flushed out of new mains. This is compounded by the difficulty at many construction sites in getting an effective flush through a new main. Problems caused by the lubricant through a new main. Problems caused by the lubricant can be reduced if construction practices are improved. But although lubricant manufacturers find that careful application can be enhanced and construction contractors have been repeatedly warned of delays, the nature of construction does not provide for such control as to avoid any odor problems.

Although the lubricant increases pH and turbidity, its rancid-wet paper type odor is the common problem that is experienced. If customers cannot accept the water's taste and odor then the problem must be resolved.

Philadelphia carries a chloramine residual in its distribution system. Philadelphia's FPA panel has found that a free chlorine residual of 1.0 mg/L would give water a bleachy, chlorinous odor at an intensity of 6 (at 45°C). Since the background odors in Philadelphia's chloraminated water have an odor intensity around 2-3, then 69 percent of new mains with detectable lubricant odors exceeded the background odors. If Philadelphia used a free chlorine residual of at least 1 mg/L then no new mains would have exceeded the background odors. The Disinfection-Disinfection By-Product Rule being proposed by the US EPA may eventually force utilities to switch to chloramines. When this happens we will see other utilities complaining about the odor from oleate-based lubricants.

All new construction should be tested by odor analysis before the water is released for public use. Organics testing by CLSA/GC is too expensive and time consuming to be incorporated into every sanitary release. Opportunity must be provided for new mains to be well flushed – i.e. putting a hydrant in a cul-de-sac. **The long-term solution, however, is to develop an acceptable alternative pipe-joint lubricant for those utilities experiencing odor problems.**

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