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FATS, OILS AND GREASES (FOG) - WHERE WE ARE AND WHERE WE COULD BE

PROTOCOL FOR BIOLOGICAL DOSING INTO SEWER SYSTEMS

PART 2 - CATCHMENT, SITE AND DEPLOYMENT RELATED ASPECTS

SUMMARY REPORT

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FATS, OILS AND GREASES (FOG) - WHERE WE ARE AND WHERE WE COULD BE

PROTOCOL FOR BIOLOGICAL DOSING INTO SEWER SYSTEMS

1 Introduction

Sewer system operators estimate that FOG is a major factor in typically 30 to 50% of all sewer blockages. FOG is also a reason why pumping stations fail, in particular due to pump controls fouling and large blocks of FOG being ingested into pumps. All of these problems can lead to sewage flooding and environmental pollution incidents.

There are a number of ways that FOG deposition into sewer systems and pumping stations can be controlled, for example through better kitchen practice and the installation/ management of suitable grease interceptors at food service establishments. However, these measures are usually outside the direct control of Water and Sewerage Companies (WaSCs). For the foreseeable future it will be necessary for WaSC's to 'manage' FOG accumulations in the sewer network.

One approach to managing FOG accumulations is to dose the FOG deposits with microbial bio additives. These have been available for a number of years but, as of early 2015, had not been widely accepted as a viable approach by the majority of the UK Water Industry. One of the obstacles has been previous poor experiences with so-called FOG removal compounds. A decade ago a number of products of uncertain composition had been aggressively marketed as "biological treatment" and as a cure all for FOG problems in sewers. On many occasions these products were of little benefit or totally ineffective.

However, manufacturers and suppliers state that the products now on the market are a significant improvement over what was previously available. Most dosing compounds now digest FOG (total degradation to CO^2 and water) and don't simply break down the fatty acid bond. Experience gained with sewer system / pumping station dosing has provided practical experience and given a focus on the site related issues that need to be considered. Although, a small number of WaSCs are now routinely using dosing and finding that it is effective at the majority of locations, many sewer system operators are still reluctant to use biological dosing. There is, therefore, the potential for missed opportunities when, if applied correctly, bio additive dosing of the sewer system could be successful and help to reduce operational impacts and costs.

Another reason for WASC's being reluctant to use dosing has, until the publication of this Protocol in the summer of 2015, been a lack of recognised guidance. The reality has been that manufacturers often blame WaSC staff for a lack of awareness of how the products work and conversely WaSC staff in turn often suspect manufacturers are supplying ineffective products.

With the above in mind UKWIR funded a project to investigate the viability of FOG dosing into sewer systems. This project which was undertaken by WRc and Cranfield University commenced in April 2013 and was completed in April 2015. The objective was "*to produce*

standards that could be developed and applied to biological products, to give WaSCs confidence that they will be effective in the breakdown of FOG".

The research required the effectiveness of biological products used to treat / remove FOG from sewers / pumping stations to be investigated and to subsequently report on the issues that can impact on their effectiveness.

At the start of the UKWIR project, there was a general assumption that the success or otherwise of dosing lay primarily in the effectiveness of the dosing compound. However, after consulting with both those offering dosing services and WaSC staff that had significant experience of FOG related dosing in sewers/pumping stations, it soon became apparent that site related aspects were an equally / possibly more significant factor in the success of dosing programmes and these also needed to be considered.

This protocol therefore addresses both the compound effectiveness and site related aspects, as follows:

- Part 1 - A laboratory based testing procedure, to establish if a particular compound has the ability to degrade FOG, through the observation of lipolytic activity.

- Part 2 - Site procedures and practices for undertaking the various stages of dosing in a sewer systems/pumping stations, from initial planning to routine maintenance dosing.

Provided that these procedures are followed it should enable dosing to be applied in a manner that is most likely to result in the required level of FOG reduction.

This short report is a summary of Part 2 of the Protocol. It is intended for suppliers and contractors who undertake dosing, as well as WaSC operations staff who are considering dosing as an approach to manage FOG deposition in sewer systems and/or pumping stations.

2 Protocol Part 2 - Development of guidance for the planning, management and on site application of bio additive dosing

This part of the protocol gives guidance regarding the site issues that need to be taken into account.

The following site related aspects are considered:

a) The initial (pre-dosing) catchment survey and the planning of a dosing exercise.

b) Consideration of effluent parameters.

c) Planning a dosing regime. including:

   - Initial dosing.

   - Maintenance dosing.

d) Dosing application methods.

An important consideration is "*how is success measured?*" Dosing is unlikely to totally remove FOG deposits; however, it can reduce FOG deposition to levels that no longer cause serious operational problems.

Dosing at food service establishments (FSEs) and at wastewater treatment works is outside the scope of this protocol. Whilst the dosing products may appear to be similar, the site characteristics are very different and offer different challenges, requiring different considerations to be taken into account and, sometimes, different methods of dosing.

The WaSC preferred method of dealing with FOG discharges at FSEs is to use good kitchen practice and a suitable method of grease separation in order to prevent the majority of FOG being passed into the sewer system. Dosing at FSE premises may be required if the other methods cannot be made to be entirely successful.

Part 1 of the protocol, which specifies a methodology for laboratory based product testing, is detailed in a separate document. (This testing is to demonstrate the potential effectiveness of a dosing compound, through the observation of lipolytic activity in laboratory controlled conditions).

2.1 Initial (pre-dosing) catchment survey

It is essential that consideration is given to planning the dosing programme before dosing commences. There is a temptation to 'get on' with the dosing once the problem has been identified and a dosing compound sourced. However, experience suggests that this can all too often result in the dosing exercise failing or at best only being partially successful.

There is evidence that, when a dosing exercise is adequately planned, dosing will reduce FOG levels to where they no longer cause operational problems in typically 80% of catchments.

The issues that should be considered are:

a) Catchment details:

i) Sewer layout plans/records, including:

- Location of the FOG problems within the sewer (and pumping station) system.
- Potential source(s) of those FOG problems.

ii) Potential sources of concentrated and aggressive trade effluents /chemicals. These can be lethal to microorganisms contained in the dosing compound

and if present in sufficient concentrations and quantities may render dosing ineffective.

b) Effluent and hydraulic conditions.

It is essential that the bacteria released by the dosing have the opportunity to attach to the FOG to enable the digestion process to commence. As a general rule, if the hydraulic conditions are sufficiently tranquil for the separation of FOG from the sewage flows and deposition of FOG on the pipe walls, the same conditions will allow attachment of bacteria to the FOG.

Conversely, if the dosing bacteria are applied into a flow with normally high velocities, the bacteria is likely to be washed downstream before it is able to attach to the FOG deposits on the sewer wall. Alternatives in such locations may be to:

- Dose closer to the FOG source, so that the compound can attach to emulsified FOG irrespective of the velocity, because both are dispersed in the flow.

- Apply the dosing compound directly onto the FOG in the pipe/manholes/wet well walls.

c) Access issues.

Dosing will need to be repeated at intervals so it is important that sites that are accessible are chosen.

d) Dosing locations

In some catchments the FOG problem areas will be well-defined, for example significant FOG deposition in certain sewer lengths or in pumping station wet wells. In other catchments the problem may be more widespread, for example there may be reports of a significantly higher than average sewer blockage rate with FOG being a significant component of many of the blockages. In the latter case care should be taken to ensure that FOG is the primarily cause and, hence, dosing will help to reduce the problem.

Dosing directly onto the FOG accumulation is often the most effective way of dealing with an existing FOG deposition. Once this has been degraded it may be appropriate to relocate the dosing upstream. This has the advantage of enabling the bio additive to mix with the FOG laden discharges to enable the FOG digestion process to take effect before the effluent reaches the site where FOG deposits have previously gathered.

The number of dosing locations will depend on the distribution of the FOG deposits, flow conditions, system configuration and the method of application of the product.

e) The measure of success.

The extent of FOG removal required must be considered at the planning stage and should be measured throughout the dosing programme. This is to ensure that the anticipated benefits are achieved.

The removal of FOG to a level where it no longer causes operational problems is normally attainable. Total removal of FOG deposits is generally not necessary from an operational perspective and is rarely possible.

It is important that the pre-dosing starting point is benchmarked, both in terms of visual (photographic) evidence and operational data. (Also, see Section 3 of this summary report).

2.2 Effluent parameters

2.2.1 Introduction

Dosing compounds that are used to treat FOG are naturally occurring bacteria that have been identified as being particularly effective in the decomposition of FOG. However, the conditions in most sewer systems are not the preferred environment of the bacteria. It is therefore necessary to assess the effluent parameters to ensure that they are within the range which the bacteria can live and multiply. These key characteristics include:

i) Temperature.

ii) Dissolved Oxygen (DO) concentrations.

iii) pH.

iv) Moisture.

v) Nutrients.

2.2.2 Temperature

The optimum temperature for bio-additives to thrive and reproduce is generally between 25^{o} and 40^{o}C (depending on the specific strains of bacteria). However, the temperature of sewers is generally in the range 10^{o} to 20^{o}C (Thames Water 2012) and although this is below the 'optimum' temperature, the bacteria will remain active, although at a reduced rate, down to a temperature of approximately 5^{o}C.

2.2.3 DO level

Sewage effluent is generally aerobic (or at least anoxic) and provides, in most locations, a sufficient oxygen level to sustain the bacteria used in bio additive dosing.

If low DO is suspected, prospective treatment systems that incorporate oxygen generation or include bacteria strains that can survive in anaerobic conditions would need to be used. Such systems are commercially available and include those with an integral source of O_2

generation, or one where mechanical oxygenation of the system (such as bubbler systems), or products that contain bacteria that are low DO tolerant (facultative anaerobes).

2.2.4 pH

Bacteria which are commonly used in bio additive treatment products are tolerant to a pH range from c. 5 to c. 8. The pH of typical sewerage in an urban environment is in the range 5.9 to 7.8 (Thames Water 2012), so are generally appropriate for biological treatment programmes.

However, in anaerobic conditions and where the decomposition of FOG generates H_2S, the pH value will be less than 6 and this will impair the activity of the bacteria.

2.2.5 Moisture

Bacteria present in bio additive compounds require a moderate level of moisture for the dosing to be effective. Sufficient moisture is usually available in relatively fresh deposits of FOG and in deposits located at the air/water interface on pipe/wet well walls. However, older deposits of FOG located above the diurnal flow depth are often in a harder 'dewatered' condition.

It is the lack of moisture in the older deposits above the diurnal flow depth that are often the reason for the perceived 'failure' of the FOG treatment products. Where hard FOG is periodically submerged in the flow, sufficient moisture is available for some bacteria to colonise the surface layer of the FOG and digestion takes place. The increase in the frequency of submergence, the greater is the opportunity for the bacteria to be effective. As the conditions are not ideal, the surface of the FOG appears as a soft, partly digested layer.

2.2.6 Nutrients

Bacteria require nutrients in order to survive. Nutrients are normally available as carbon from organic sources and minerals like sulphur, phosphorus, potassium, magnesium, calcium, iron, and trace elements are also required. Carbon makes up 50% of nutritional requirements of bacteria and is in abundant supply in the FOG.

2.2.7 Concentration of FOG in the effluent

The concentration of FOG in the effluent must be assessed by the supplier/contractor prior to commencing dosing. This is in order to determine the correct amount of bacteria to be applied to ensure the FOG digestion exceeds deposition.

2.3 Dosing regimes

2.3.1 Introduction

Assessing the dosing requirements and developing a dosing regime is an important task. It should be undertaken either in parallel with or immediately following the pre dosing catchment assessment.

The factors that influence the effectiveness of biological dosing products are:

a) Hydraulic conditions.

b) Effluent parameters.

c) Dosing methodology, including:

   i) Dosing locations.

   ii) Dosing frequency.

   iii) Contact time.

   iv) Dosing method.

2.3.2 Dosing locations

There is no hard and fast rule regarding the number of dosing sites and the location of those sites. This will be site specific and will depend upon, *inter alia*, the sewer system layout, the number and extent of the FOG sources and the location and extent of the FOG deposition.

Dosing will be more effective if it is undertaken upstream of the locations where FOG deposition is most severe, thus giving time for the FOG reducing compound to mix with the effluent and attach to the deposited FOG. Whilst the dosing bacteria can migrate downstream with the flow, they cannot migrate upstream. Thus dosing will need to be at or upstream of the FOG depositions requiring treating.

At some locations applying the dosing compound directly onto the deposited FOG should be considered. This approach is particularly suitable where the predominant flow conditions are unsuitable for dosing directly into the flow (high velocities/high flow volumes). Once attached to the FOG, the bacteria are resistant to being washed from the FOG. The approach should also be considered where there are significant FOG accumulations on the crown of the pipe, out of the normal diurnal flow range.

The direct dosing onto FOG accumulations is also appropriate as an initial dosing approach, for example in pumping station wet wells.

Once the accumulated FOG has been reduced to a more manageable level it may then be appropriate to consider dosing upstream. This is to enable the FOG to be managed in the incoming flows.

2.3.3 Dosing regime

An important aspect that is sometimes overlooked by WaSC staff is the need for **regular dosing**. There is sometimes a misconception that dosing is a one-off exercise or, at best, needs to be carried out only until the problem has gone away.

FOG discharges and the consequent FOG deposition is a continuous process and dosing will need to be maintained in the long term to ensure that the problem does not return.

Some “topping up” of the bacteria will be required from time to time to maintain the population of active bacteria. This should be undertaken at regular intervals, the frequency of which will depend upon the extent/nature of the problem and method of dosing.

2.3.4 Dosing frequency

The frequency of dosing is determined by the need to maintain the population of microbes at a level that is adequate to effectively remove the FOG. This in turn is determined by the quantity of the FOG to be removed.

In most circumstances the dosing at the start of an exercise will need to be relatively frequent. This **initial dosing frequency** is to enable the population of microbes to be become established. It is also when the greatest depositions of FOG are present, so a greater microbe population will be required.

The time that it takes for the bacteria to degrade the FOG will depend upon the site, dosing compound and dosing methodology.

Once the microbial community has become established and the extent of FOG deposition reduced, the dosing can normally be reduced to a **maintenance dosing frequency**.

2.3.5 Contact Time

Contact time, i.e. the time during which the bacteria can attach to the FOG, is one of the primary considerations when selecting locations for dosing and an appropriate application method. This is particularly important where flow velocities are high.

The longer the contact time the greater the effectiveness of the bio additive. However, in reality there is little that can be done on site to extend the contact time, that is apart from:

i) Applying the bio additive solution direct onto the deposited FOG, for example by spraying.

ii) Applying the product as far upstream of the FOG accumulation as possible.

iii) In some circumstances it may be possible to temporarily modify the flow characteristics so that the contact time can be extended, for example by changing pumping station on/off levels or by throttling flows in trunk sewers.

2.4 Dosing methods

The four main methods of application are:

- Blocks, suspended in the flow/effluent;
- Powder, sachets or loose;
- Liquid injected in to chamber/wet well; and
- Liquid sprayed to pipe surface by jetting machine.

Some suppliers/contractors only supply their products in a form suitable for one dosing method. If this method is not appropriate to the site, alternative suppliers/contractors should be consulted.

Manufacturers/suppliers claim there is no need to pre-clean the system, but larger populations provided by higher frequency dosing are required to remove large volumes of FOG. In some circumstances, where the level of deposition is significant, it may be cost effective to pre-clean, at least to remove the bulk of the deposition This is especially so where much of the FOG is old and hard, making the treatment by dosing particularly challenging.

Blocks (tablets or cakes) are available in a variety of sizes from a few hundred grams to 25 kg. The main advantage of this system is that as the block dissolves, it provides a continuous supply of bacteria to the effluent.

Although a constant and fresh population of product is released, it is into the effluent and the bacteria are still required to attach to the FOG. Attachment will only occur at or below the water level and only if the velocity of the flow is low enough for attachment to take place.

Powder application methods are limited in their use in the sewer - the risk is that all the product could be washed away by a single high flow event. However, this approach may be appropriate where there is a thick and continuous layer of FOG on a wet well.

Injecting a microbial culture into a chamber or wet well is a commonly used method of application. The bacteria are mixed with the carrier liquid, and if this is in powder form, requires a period of incubation to generate an active population. This will require suitable conditions to be provided by the carrier liquid, temperature, pH, nutrients etc.

The method requires the mixing and timing procedures to be adhered to. Without adhering to the appropriate timings (re-dosing etc) the success of the treatment program will be compromised.

Liquid sprayed to pipe /manhole wall is used to target the removal of specific accumulations (hot spots) of FOG in a length of drain/sewer or pumping station wet well.

The product is sprayed via a jetting head directly onto the FOG accumulation. The major advantage of this method is that the product is applied direct to the FOG and in particularly those accumulations on the crown of the pipe that are untreated by products applied to the flow.

3 Measuring success

An important aspect that needs to be considered both when planning and whilst undertaking a dosing exercise is "*how is success measured?*"

A dosing exercise should normally be regarded as successful if the level of FOG deposition has been reduced to a level where it is no longer causing a serious operational issue. This may be when the number of blockages or pumping station failures caused by FOG has been

significantly reduced. In some circumstances success may be reducing FOG from a very hard difficult to move state to a softer compound that can be more easily removed from pipe or wet well walls.

It is therefore essential that the sewer system operator and the organisation who will be undertaking the dosing agree what success will look like and the method of measuring this before a dosing exercise commences. It is also important to benchmark the starting position, preferably both in terms of the level of operational failures and visual impact (i.e. a photograph(s) of the FOG accumulation).

Measuring success in terms of a reduction in operational problems alone will take time and in many circumstances will not be immediately apparent.

An initial indication of success can be gained, where access is possible, by taking photographs of the FOG deposition at the start of the dosing exercise and at regular intervals once the dosing is underway. The photograph should be taken from the same location and looking in the same direction each time.

Where photographic access is difficult, for example in pipes, an alternative could be fast pass CCTV and compare the footage recorded from previous surveys.

4 Discussion

There are many factors that can impact upon the effectiveness of bio additive FOG reduction. Many of these are inter-related.

The most important factors which should be taken into account when planning dosing are:

a) The bio additive compound, to ensure that it has lipolitic activity.

b) The catchment:

- Location of FOG problems;
- Potential sources of the FOG;
- Access; and
- Potential sources of trade effluents.

c) The Flow (hydraulic) conditions at the dosing site and in the sewer where the FOG requiring treatment has accumulated.

d) The FOG compound - The age of the FOG and, in particular, the level of moisture contained within it.

e) The effluent:

- Temperature; and

- pH.

(The concentration of DO and nutrients are normally present in sufficient quantities in the sewer environment to enable the microorganisms to thrive).

All of these factors will need to be taken into account when considering the most appropriate dosing application method. Blocks, powders, injected liquid into the flow and sprayed liquid onto the FOG all have their advantages and disadvantages and the relative merits of each of these needs to be considered at the dosing planning stage.

It will be necessary to ensure that the dosing technique enables sufficient contact time with the FOG and this will influence the choice of both the dosing location and dosing frequency.

5 Conclusion

The site specific factors that influence the effectiveness of bio additive FOG reduction compounds and systems have been identified and advice has been incorporated into the protocol.

Whilst the choice of dosing programmes, compounds and methods and the reasons for choosing them may initially sound complicated, by following this protocol, the user and potential supplier(s) will be guided to select an effective dosing method for any given site.

It is clear that where manufacturers/suppliers and WaSCs are working together and allocate a high priority to the maintenance of the treatment programme, dosing can be made to be effective. Experience has shown that, provided adequate pre dosing planning is carried out, dosing will be successful in significantly reducing FOG problems at the majority of sites.

Examples of successful dosing include cases where suppliers/contractors manage and operate the programme and in other cases where WaSC staff deploy the dosing compound.

6 Recommendations

It is recommended that the guidance given in this document is followed when planning and undertaking bio additive FOG reduction dosing schemes.

An understanding of these factors and an agreed method of assessing the success of the dosing, both by the sewer system operator and those carrying out the dosing, will significantly increase the effectiveness of dosing and reduce FOG accumulations to a manageable level.

Bio additive dosing should be considered as an alternative to sewer cleaning as a FOG management methodology. This can often be a cost effective way of reducing FOG deposition related problems in sewers / pumping stations to a manageable level, with secondary benefits to the downstream network.