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GRIT SAMPLING FOR EQUIPMENT EVALUATION

TECHNICAL NOTE REF	**:**	**TRPM – TN008**
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VERSION	**:**	**1.0**
DATE	**:**	**JANUARY 2016**

1.0 INTRODUCTION

Grit can be defined as inorganic mineral material such as silt, sand or fragments of metal and glass, typically ranging in size from 50 to 100 µm. It is important to remove this relatively heavy abrasive material from influent prior to primary processes as it deposits throughout a treatment works, gradually reducing operational capacity, blocking pipes, channels, sedimentation tanks and digesters. Grit will also cause significant damage to mechanical equipment such as pumps and sludge handling equipment

The density of grit is much greater than that of other organic solids within sewage, hence there is a tendency for it to settle when the flow rate is low, and this may occur in a sewer with inadequate gradient, or in a pumping station wet well. The latter can be minimised with careful design of the sump structure, pumping capacity, rates and frequency of pumping. Grit deposited / accumulated in the sewerage system during periods of low flow can often be flushed to the treatment works in large quantities when storms occur.

There is a wide variation in the quantities of grit received at different treatment works, dependent on catchment type, geographical topology, climatic conditions, etc. In a combined sewerage system, surface water entering the sewers from streets, drains and paved areas is likely to contain large amounts of grit, which may also arrive by infiltration via cracked or damaged pipes.

2.0 INDUSTRY GUIDANCE / CONTEMPORARY DESIGN

The Urban Waste Water Treatment Directive (91/271/EEC) was introduced by the European Union and adopted on 21 May 1991 with the objective of protecting the water environment. In England and Wales, the national legislation to implement this directive is the Urban Waste Water Treatment Regulations (1994), which is enforced in England by the EA. These regulations provide for varying degrees of sewage treatment over a timescale dependent on population size, but in general require that Sewage Treatment Works include a Preliminary Treatment Process Stage to remove grit and gravel by flow attenuation, and large solids by screening.

The magnitude of grit received at a treatment works can very considerably and typically ranges between 0.005 m^3 and 0.05 m^3 per 1000 m^3 of sewage. A higher range of 4 to 12 m^3 per 1000 persons was quoted by the Standing Technical Committee of the National Water Council (NWC).

Historical grit data, including for moisture and organics content, has often been found to have wide ranges of values and can be considered unreliable. The limited availability of grit data may be due to unrecorded deposits in channels, activated sludge tanks or anaerobic digesters. Alternatively, this could illustrate that grit load recording is considered unimportant, or that there is actually an issue with existing grit removal systems, which may become a problem in the long term as more development and investment continues to be made into downstream processes.

In the UK, the equation for grit settlement, used in contemporary design of grit removal systems, is based on Stokes Law. Since grit has a high density typically of around 2500 kg/m3, equipment for removing it is generally designed by attenuating sewage / reducing the velocity of flow so that grit settles, while less dense organic material remains in suspension and is carried forward for further treatment.

To remove grit, attenuation of flow is achieved by passing the sewage through a tank at constant velocity, generally considered optimal at 0.3 m/s. Typical designs of grit removal systems include cross-flow detritors, constant velocity channels, spiral flow channels and vortex tanks.

3.0 INDUSTRY PRACTICE / APPLICATION OF GUIDANCE

The WIMES applicable to Grit is WIMES 2.02 – 'Grit Removal and Treatment Equipment'. This identifies generic types of grit equipment as follows:

Grit Removal:

- *Cross Flow Grit Separators*
- *Vortex Flow Grit Removal - Powered*
- *Vortex Flow Grit Removal - Non-Powered*

Grit Transfer:

- *Solids / Grit Handling Pumps*
- *Air Lift Pumps*
- *Ram Pumps*

Grit Treatment:

- *Rake Classifiers*
- *Screw Classifiers*
- *Washer-Dewaterers (Vortex Type)*

WIMES 2.02 also includes Package Grit Plant but does not recognise / include constant velocity channels or spiral flow channels as these are principally non mechanical systems.

In the UK, conventional grit removal design aims to achieve 95% removal of grit particles greater than 0.2 mm in diameter with a specific gravity of 2.65 at the specified design flow rate. This is specified in WIMES 2.02 Section 5.0 (Performance Specification).

4.0 INDUSTRY PRACTICE / RECENT RESEARCH

The underlying concept of conventional UK industry design is based on the settling velocity of a standard grit particle size of 200 µm which is assumed to be a clean smooth silicate sphere. This assumption / standard is of unknown origin and is considered historic and arbitrary.

Research in the USA (and more recently in the UK) indicates that the characteristic of incoming grit is far more complex than previously understood. Sampled, calibrated and analysed grit has been found to be a variety of sizes and irregular shapes and is often coated with accumulated fats, oils, grease and other organics. This has a significant affect on the settling time of a grit particle, often resulting in increased buoyancy, thereby prolonging suspension within the flow leading to grit bypassing the removal system and on into downstream processes.

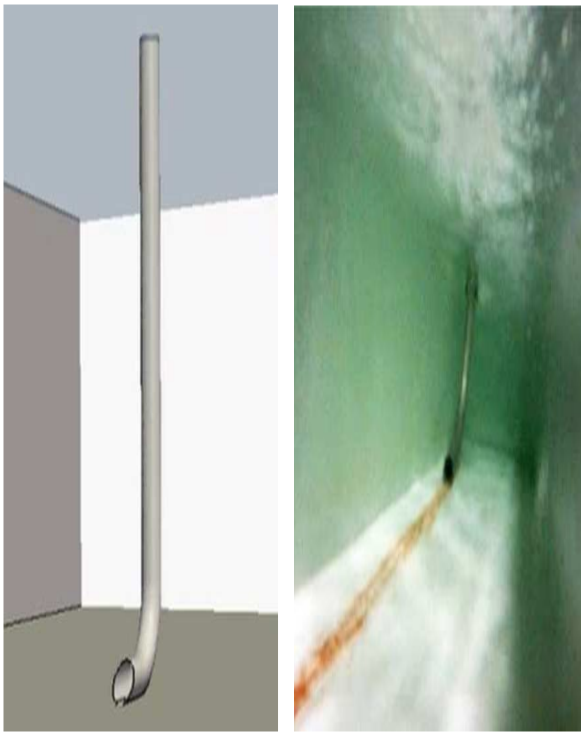
5.0 GRIT SAMPLING

In order to obtain a true representation of incoming grit, it is important to sample for all particle sizes distributed both vertically and horizontally across the channel flow. There are two leading methods for grit sampling:

- A *Vertically Integrated Slot* Sampler (VISS) incorporates an outer pipe with narrow slot and a smaller diameter internal suction pipe connected via flexible hose to a pump which then feeds to a grit settling tank / collection vessel. This method has a simple construction and is designed to sample the full depth of the flow being sampled. One disadvantage is that the greater profile of the VISS may cause disturbance to the flow and distort the sampling stream.

- A *Siphon Tube Sampler* features a single length of narrow pipe (e.g. 25 mm dia) with a bend at one end which faces into the influent flow, while the other end is connected via flexible hose to a grit settling tank. This method has also a simple construction and can theoretically be used with or without a pump. One disadvantage is that a single unit samples a single point at any instant (not the whole water column).

Vertical Integrated Slot Sampler (VISS)



Siphon Tube Sampler

6.0 POST SAMPLING ANALYSIS / RESULTS & OTHER STUDIES

Grit collected during a sampling exercise can be then graded though a number of calibrated sieves to produce various categories of grit sizes ranging from 6 mm down to 50 µm. Prior to laboratory analysis, Settling Velocity (SV) analysis can then be conducted on the various grit size categories.

Analysis already conducted at various WwTWs across the UK, indicate that most grit particles were found to have a lower settling velocity and behave more buoyantly than previously assumed. A 300 µm size particle of coated influent grit could display a low settling velocity equivalent to say a 150 µm size particle of clean silicate. This comparison is sometimes used as a design criteria known as Sand Equivalent Size (SES).

Other studies suggest a wide deviation in the composition of grit arriving at different WwTWs, with some tending to receive more fine particle grit in the sub 200µm range depending on catchment location and topology (for example coastal compared to inland sites). It is known that weather conditions also determine the magnitude of grit arriving at a WwTW, with significantly more grit (perhaps as much as 70% of annual load) received during wet weather periods. However, during such high flow events, corresponding high flow velocities often reduce the effectiveness of existing grit removal systems, and it has been estimated that perhaps only 20% – 30% of all grit entering some treatment works is captured at the removal stage.

7.0 THE IMPACT OF GRIT FOR INDUSTRY

As mentioned above, research has shown grit is not and does not behave as previously assumed. It is now believed that many grit systems at UK treatment works are significantly underperforming and consequently it is considered that current grit design standards are inadequate, outdated and require comprehensive re-evaluation.

The obvious costs to asset owners, as mentioned above, include reduced capacity, downtime for blockages, mechanical repairs, etc. It is believed that 60% of all energy demands at UK treatment works is attributed to aeration processes, and it is not inconceivable that a high percentage of these costs can be attributed to power consumed / wasted overcoming accumulated grit. These costs alone will not be insignificant to the industry. Grit can also have a significant impact on sludge treatment and anaerobic digestion processes, affecting biogas / renewable energy production.

8.0 FURTHER COLLABORATIVE WORK / RECOMMENDATIONS

More collaborative research is required across the UK Water Industry to develop an industry acceptable, standardised, grit sampling regime, with particularly emphasis on analysis methodologies to prove accuracy of results and validate protocol reliability through scientific repeatability.

A single number comparator, perhaps a Grit Capture Ratio (GCR), is required to identify / compare the efficiency of different grit removal systems, in a way that Screenings Capture Ratio (SCR) is used for Inlet Screens (see TRPM – TN001). Ultimately, re-evaluation of contemporary grit design is warranted and must be conducted to enable the sector to progress forward.