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STORM TANK CLEANING EQUIPMENT

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1.0 THE IMPORTANCE OF EFFICIENT STORM TANK CLEANING

Wastewater / Sewage Treatment Works (WwTWs / STWs) are not normally designed to provide full treatment for all flows received during storm events. Provision is usually made for storing flows in excess of the treatment capacity in either off-site (ie within the upstream catchment) or on-site storm tanks, for subsequent return to the treatment stream when conditions permit.

The usual point of separation for storm flows within a WwTW / STW can be either upstream or downstream (or both) of the inlet works thus it is not always guaranteed that screenings and grit will have been removed from the flows prior to storage. Tanks within upstream catchments are more likely to receive unscreened flows, and the successful cleaning of these tanks can often be more difficult if little or no washwater is available at remote locations.

Storm tanks, when full, overflow to the receiving watercourse. However, it is common at multi-tank installations to fill sequentially, with the first tank (which receives the first flush of strong storm sewage) not having an overflow. This is often referred to as a 'blind' tank.

Storm tanks can be circular or rectangular in plan, and can be purpose built or (as in many cases) can be converted from former primary tanks. Whilst the primary function of storm tanks is to provide storage for excess flows, it is inevitable that settlement of suspended solids will occur, often in conjunction with screenings. The presence of grit is less likely, given that storm flow separation structures are often side weirs in channel walls, which grit should pass by at a low level. Whilst storm tanks are often similar to primary settlement tanks in design and appearance, they often have to provide efficient settlement at extremely high flow rates and therefore with comparatively short retention times.

Storm tanks should be designed to facilitate emptying and returning the contents, including any settled sludge, to the treatment stream as quickly as possible in order that the tanks are readily available for the next storm event. It is important that the tanks are emptied completely after each operation to ensure that the full capacity is available for the next rainfall.

Following the emptying of tanks, however, sludge is often retained on the tank floor. Unless removed immediately, this can dry out and become difficult to remove. In many cases this can lead to odour issues, and in severe cases this can reduce the capacity of the tank, thereby increasing the risk of works consent failure.

The cleaning of storm tanks is therefore an important component of the overall catchment / treatment process, but as this is an off-line function with no direct impact on the treatment stream, such cleaning is often given low priority when compared to more pressing operational issues.

Until comparatively recently, therefore, little time or effort has been put into developing bespoke storm tank cleaning equipment, the traditional methods being manual cleansing, or at best primary tank style scraper bridges where scale offers justification of the expense.

The current and ongoing need to (a) reduce operational expense and (b) reduce manual contact with sewage flows and their constituents has however recently led to the emergence of several technologies intended to facilitate the automatic cleansing of storm tanks. These include pump, spray, scraper and flushing systems, and can be suitable for new-build installations and / or retro-fitting to existing tanks.

2.0 EXISTING KNOWLEDGE

With the exception of traditional techniques such as manual cleansing and scraper bridges, much of the storm tank cleaning equipment currently available in the UK Water Industry is comparatively new to market, therefore little knowledge is available regarding the operation and performance of such equipment.

Physical and practical comparative evaluations of differing technologies are generally impractical for reasons of scale and cost, thus any evaluation exercises to date have mainly taken the form of a comparison of supplier literature and / or basic collations of operational experiences from existing installations. These evaluations have often been conducted on a project-specific basis, with little cross-collaboration, thus in 2010, TRPM were appointed by a consortium of three UK Water Cos (Severn Trent Water, Thames Water and United Utilities) to develop generic selection and design guidance. This culminated in TRPM Report Ref TRPM-REP260 – "Storm Tank Cleaning Equipment – Options Review" dated January 2012.

Since the publication of that initial report, a number of reasons for a potential re-visit were identified, as follows:

- At least one UK Environment Agency (EA) region had expressed a desire for storm tanks to be returned within 48 hours. This period was to include the cleaning. Whilst this would obviously be discussed elsewhere and by others, it did represent a shift towards a much more onerous requirement compared to most current agreements, with implications on the method / type of cleaning equipment employed.

- With the adoption of catchment Pumping Stations and more general awareness of network installations, a new 'breed' of storm tank had emerged – often remote, often with limited (or no) power supply or washwater supply and thus often requiring a different way of thinking regarding cleaning.

- Technologies regarded as 'emerging' in 2010/11 were now more 'established' thus operational experiences gained in the meantime could be accumulated and taken into account. Even for well-established technologies, greater feedback from more locations, all across the UK, was now available.

- Further emerging and refined technologies were now available, there had been changes within the supply chain, and differing attitudes to manual interventions / H&S issues had emerged

- The total cost of owning and operating equipment (Totex) was to be a prominent consideration within AMP6. Any new equipment review should contain a significant Totex evaluation / comparison element.

In order to investigate the above, and also further develop available knowledge on storm tank cleaning equipment, a new consortium of four UK Water Companies (being Dwr Cymru Welsh Water, Severn Trent Water, United Utilities and Wessex Water) appointed TRPM to conduct a further review of available technologies.

The objective of this new was therefore to compare current and emerging technologies and develop generic guidance which would be of benefit when the future selection and design of storm tank cleaning equipment was required.

3.0 EQUIPMENT SELECTION – OPTIONS

As mentioned above, recent years have seen the emergence of several technologies intended to facilitate the automatic cleansing of storm tanks, including new or enhanced pump, spray, scraper, and flushing systems.

As much of the equipment available in the UK Water Industry is comparatively new to market, however, there is currently (January 2016) no Water Industry Mechanical & Electrical Specification (WIMES) documentation for such equipment.

The different types of Storm Tank Cleaning Equipment can however be sub-defined within the following generic types:

- Manual / Self Cleansing
- Scraper Systems
- Spray / Jet Systems
- Pump Systems
- Vacuum Systems
- Tipping Buckets
- Flushing Gates

Manual Cleansing is the traditional method of using manual labour to scrape or hose down debris from storm tanks. This is an unpleasant, labour-intensive task, involving Site Operatives entering tanks. Due to Health and Safety restrictions and many tanks being classed as confined spaces, tank entry can require specialist access equipment and trained personnel.

Over recent years entry into tanks has been seen more as a last resort and is often carried out by specialist contractors. As a result, with the exception of very small tanks where physical constraints would not permit the installation of any mechanical equipment, manual cleansing is no longer considered to be an acceptable means of cleaning storm tanks.

Self Cleansing Systems use various benching / structural configurations within the tank structure to encourage tank cleansing whilst emptying, and can offer a low cost alternative to manual cleansing, particularly within very small tanks.

The Key Issues (Advantages, Disadvantages and Design Considerations) for each of the above are discussed in further detail below.

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.1 Scraper Systems

Scraper Systems have traditionally been utilised to clean circular and rectangular storm tanks, and are similar to units used for primary tanks. Scraper bridge designs and types for circular and rectangular tanks vary, although all rely on the same principal to carry out the cleaning, with a series of rubber or similar material scrapers moving along the tank floor, directing any settled sludge / debris to a sump for removal for further treatment. The motion systems vary depending on manufacturer and bridge type, with rectangular tank scrapers lifting during the return travel.

A different type of Scraper System was introduced to the Water Industry in late 2013 from the agricultural industry. This consists of a rail / track secured to the tank floor, along which travels a 'rambox' with a scraper attached, driven forward by a hydraulic ram. Operation is repeated until the assembly reaches the end of the tank / track, then is reversed with the scraper in a raised position to ensure that sludge / debris is not moved back up the tank on the return travel.

Several manufacturers still offer traditional cable-driven and chain and flight Scraper Systems for rectangular tanks. These systems are however not generally considered for new projects, mainly due to breakdown and maintenance issues, so are not considered further in this report.

ADVANTAGES	DISADVANTAGES
Repeatable	Medium / high capital expenditure
Low / medium power requirement	Potential tank / confined space entry required
Minimal operator input	Failure leads to 100% loss of cleaning
No external water supply required	
No odour issues (tank full during cleaning)	
No 'aerosol' risk	
'Medium' maintenance liability	
Quiet operation	
Generally suitable for unscreened flows	

DESIGN CONSIDERATIONS
Suitable for circular and rectangular tanks Suitable for small, medium and large tanks Suitable for new and retrofit installations Tank personnel access required Inclined tank floor / collection sump preferred (rectangular tanks) Benched tank floor / collection hopper preferred (circular tanks) Control system required (level / timer) Tank size limitations: Circular – 50 m dia, Rectangular – 100 m x 16 m x 6 m

UK Suppliers of Scraper Systems include Ham Baker Adams, MEPS, M&N, and Tuke & Bell.

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.2 Spray / Jet Systems

Rotating / reciprocating spray heads can be installed within a structure such as a storm tank, and providing there is an adequate wash water supply, automatic operation is possible. Single or multiple head installations are possible, with multi head installations meaning that spray systems can be installed in almost any shape and size of tank. For maintenance access reasons, nozzles are usually installed on swinging arms from the tank side, whilst the reciprocating and rotational indexing movement of the heads is powered by the washwater supply.

A Jet System fairly new to the Water Industry on storm tank cleaning is the water cannon, which originate from the fire fighting industry, using what is know in that industry as a 'monitor'. This is designed to be adjustable and swivel in all directions. The operation of most water cannons to date is fully manual, although a self oscillating unit is available which may be adaptable for use on an automatic installation. The size of tank that water cannons can clean will depend on water pressure, as the distance the jet can reach increases with pressure.

ADVANTAGES	DISADVANTAGES
Low capital expenditure	External water supply normally required
Repeatable	Remote sites may need Abstraction Licence
No / low power requirement	Possible header tank / pumps required
Low maintenance	Risk of loss of rotation (Spray Systems)
Minimal operator input (Spray Systems)	Operator input required (Jet systems)
No tank / confined space entry required	Possible 'aerosol' risk
No civil works required	Possible odour issues (deposits in tank)
Still partial cleaning if only single unit failure	Pipework susceptible to low temperature
Suitable for unscreened flows	

DESIGN CONSIDERATIONS
Suitable for circular and rectangular tanks Suitable for small and medium tanks Suitable for new and retrofit installations Water supply pressure up to 9 bar per unit required Auto Systems require control (level / timer), plus valve actuation Inclined tank floor / drainage channel preferred Tank size limitations: Circular – 16 m dia (single unit), Rectangular – 20 m x 20 m (single unit), Unlimited (multiple unit installations). This varies with different suppliers – above typical

The main UK suppliers of Spray Systems are GEA Breconcherry and Bete Systems. The only known supplier in the UK of 'Jet System' water cannons is Knowsley SK. In addition to these, however, several bespoke systems have been installed, often designed by local site representatives and installed by local contractors. Many of these work very well, so it is important to realise that such a technology can be sourced independently from proprietary suppliers.

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.3 Pump Systems

Pumps can be used for the re-suspension of solids, in full or partially full tanks, or for after-event cleaning, with the cleansing water sourced from the tank sump. All Pump Systems incorporate nozzles to intensify and direct the flow provided from the pump while most systems induce air into the flow via a venturi air intake pipe to assist in re-suspending solids.

Oscillating nozzles are available although these have been found to be susceptible to 'ragging' failure, requiring tank entry to resolve. The pump section can be mounted on rails with lifting chains for removal from above, but the oscillating drive and nozzle are usually fixed to the tank floor. Other options include internal or external tank mounting, and chopper pump versions.

ADVANTAGES	DISADVANTAGES
No external water supply required	Medium / high capital expenditure
Minimal operator input	Unrepeatable
Minimal odour issues (tank full during clean)	High power requirement
Possible part oxygenation of flows	Tank / confined space entry required
Low civil modifications for retro-fit installations	Possible 'aerosol' risk
Partial cleaning if only single unit failure	Pump suction blockages – unscreened flows
Flexible layout / nozzle options	Failure often only evident when tank full
	Swing systems susceptible to rag / debris
	Degradation of tank structure due to jetting
	Adjacent pumps can create dead areas
	Tank Emptying Rate critical to avoid deposits

DESIGN CONSIDERATIONS

Suitable for circular and rectangular tanks
Suitable for medium and large tanks
Suitable for new and retrofit installations
Pump(s) installed in drainage sumps give extended suction / running / cleaning
Pump(s) installed in drainage sumps are generally easier to access for maintenance, etc
Discharge jets normally orientated to deliver upstream (ie away from discharge sump)
Control system (level / timer) required
Inclined tank floor required, collection / drainage sump preferred
Tank personnel access required
"No Clog" or Chopper pumps preferred
Tank size limitations: Circular – 16 m dia (single unit), Rectangular – 26 m x 12 m (single unit), unlimited with multiple units. This varies with different suppliers – above typical.

UK Suppliers of Pump Systems include KSB, Landia, P&M Pumps, Sulzer and Xylem (Flygt).

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.4 Vacuum Systems

Vacuum Systems can be utilised on storm tanks, sewers and other vessels. They can be installed as part of a new construction, or retro-fitted into an existing structure. Vacuum Systems require a chamber to retain the flush water, generally located at the opposite end to the outlet drain channel.

Chambers are usually of concrete or pre-fabricated stainless steel construction and fill as the storm tank fills. By differing means in different designs, a vacuum is created holding the chamber contents in place whilst the surrounding tank empties. When this vacuum is broken, either by automated or hydraulic means, the flushing water is released.

Manufacturers usually recommend a tank sump capacity of 1.2 times the volume of the flushing water to allow for the water and debris. Once empty Vacuum Systems cannot be refilled by an external water supply, and therefore cleaning cannot be repeated.

ADVANTAGES	DISADVANTAGES
No external water supply required	Medium / high capital expenditure
No / low power requirement	Unrepeatable
No tank / confined space entry required	Civil works req'd for retro-fit Vac-Flush units
Low maintenance	Potential loss of tank volume on retrofit units
Suitable for unscreened flows	Failure leads to 100% loss of cleaning

DESIGN CONSIDERATIONS
Suitable for circular and rectangular tanks Suitable for medium and large tanks Suitable for new and retrofit installations Inclined tank floor / collection sump required (rectangular tanks) Benched tank floor / collection hopper required (circular tanks) Control system (level) required, plus valve actuation and pressure retention (Vac Flush) Tank size limitations: Circular – 30 m dia (single unit), Rectangular – 150 m x 10 m (single unit), unlimited with multiple unit installations.

UK Suppliers of Vacuum Systems include CSO Technik and Hydrok.

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.5 Tipping Buckets

Tipping Buckets are pre-fabricated vessels suitable for cleaning most sizes of standard rectangular storm tanks. Tipping Buckets are not suitable for circular tanks. Tipping Buckets are trough-type vessels installed above the non-drain end of the tank, mounted on a pivot at each end. When the storm tank has emptied the buckets are filled, usually with final effluent. They are designed so that as they fill the centre of gravity moves away from the pivot point until the weight of the flushing water tips the bucket and discharges the contents.

Below the bucket, curved benching is required to direct the flow from the vertical to form a horizontal flushing wave, washing the debris down the slope of the tank floor. A sump is required to accept the flushing water and debris, and to prevent a back-flushing wave. Once empty, the bucket reverts to its original position for immediate re-filling / re-use if required, with the filling operation being fully manual, semi-automatic or fully automatic. Wide tanks require dwarf walls to be installed along the tank floor to create lanes suitable for cleaning using Tipping Buckets. Different manufacturers specify differing maximum lane lengths and widths for their particular products.

ADVANTAGES	DISADVANTAGES
Repeatable	Medium / high capital expenditure
No / low power requirement	External water supply normally required
Low maintenance	Possible odour issues (deposits in tank)
No tank / confined space entry required	Civil works required for retro-fit installations
Suitable for unscreened flows	Security of large SS components against theft
Manual & automated systems possible	Potential loss of tank volume on retrofit units
	Possible noise issues (bucket / return stop)
	Pipework susceptible to low temperatures
	Failure leads to 100% loss of cleaning

DESIGN CONSIDERATIONS
Suitable for rectangular tanks only Suitable for medium and large tanks Suitable for new and (some) retrofit installations Inclined tank floor / collection sump required Formed radius below discharge point required to maintain flushing velocity Manual control preferable, but automated control possible Tank size limitations: Rectangular – 75 m x 16 m (single unit), unlimited width with multiple unit installations, This varies with different suppliers – above typical. Sump Size – 1.2 x flushing volume

UK Suppliers of Tipping Buckets include CSO Technik, Hydrok, MEPS and Jacopa.

3.0 EQUIPMENT SELECTION – OPTIONS (CONT)

3.6 Flushing Gates

Flushing Gates share similar structural technology and operational methodology to Vacuum Systems (see Section 3.4 above) in that they require a flushing reservoir chamber to fill with the storm tank during a storm event. The supplier preference is for the chamber to fill first before overflowing into the main tank structure, but if this cannot happen then pumped 'make-up' water may be required. The contents within the reservoir chamber are then discharged to flush clean the main tank by the operation of the Flushing Gates. Flushing Gates can be designed for both rectangular tanks and circular tanks, although retrofit civil modifications may reduce the tank capacity and create consent issues.

Rectangular tanks have chambers at the non-discharge end. A sloping tank floor and a sump to accept the flushing water and debris, and to prevent a back-flushing wave are required. When the storm tank empties, the flushing gate holds back the contents of the chamber until sump level recedes sufficiently to accept the flush. The gate is opened instantaneously by hydraulic cylinder(s). Flushing Gates in circular tanks are made from pre-fabricated stainless steel sections connected together. A sloping tank floor to a radial drain channel feeding to a sump is preferred. The Flushing Gate opening is initiated as per rectangular tanks.

On either system, an external water supply can be piped to the Flushing Gate chamber to enable the system to be refilled and operated again if required.

ADVANTAGES	DISADVANTAGES
No external water supply required	Medium / high capital expenditure
Minimal operator input	Possible odour issues prior to cleaning
Repeatable (second fill from external source)	Maintenance tank / confined space entry req'd
No 'aerosol' risk	Civil works required for retro-fit installations
Low / medium power requirement	Potential loss of tank volume on retrofit units
No operator tank / confined space entry req'd	Failure leads to 100% loss of cleaning
Suitable for unscreened flows	Chamber make-up water may be required

DESIGN CONSIDERATIONS
Suitable for circular and rectangular tanks Suitable for medium and large tanks Suitable for new and (some) retrofit installations Inclined tank floor / collection sump required (rectangular tanks) Benched tank floor with peripheral drainage channel required (circular tanks) Control system (level) required, plus gate release control required Tank size limitations: Circular – 30 m dia (single unit), Rectangular – 150 m x 6 m (single unit), unlimited with multiple unit installations, This varies with different suppliers – above typical Sump Size – 1.2 x flushing volume

UK Suppliers of Flushing Gates include CSO Technik and Hydrok.

4.0 EQUIPMENT SELECTION – SUMMARY

In light of the above, the following broad assumptions can be identified:

- Manual Cleansing is generally no longer considered acceptable, whilst Self Cleansing should generally only be considered for small tanks due to the falls / gradients likely to be required.

- Scraper Systems, whilst being established technologies on all shapes and sizes of tanks, can be a high Totex option, from an increasingly limited number of suppliers. Whilst these cannot therefore be taken forward as a general recommendation, future purchasers and specifiers should consider the relatively low-cost option of the Scraper system introduced from the agricultural industry as that product develops and evolves into a more established option.

- Spray / Jet Systems can be considered for all shapes and sizes of tanks, subject of course to an appropriate water supply being available. They become cost effective for larger tanks on the assumption that the entire tank will be cleaned in stages or phases, not all at once. Spray / Jet Systems are especially suitable for retro-fit installations.

- Pump Systems can be considered for almost all shapes and sizes of tanks. Design differences exist between the various proprietary systems available, however, which need to be taken into account. Pump Systems can also be considered suitable for retro-fit installations.

- The differing types of Vacuum Systems give variable performances at differing Totex costs, thus specific equipment choice should be carefully considered. This option can also be considered as suitable for retro-fit installations in small and some medium storm tanks.

- Tipping Buckets operate successfully at numerous locations. They are not suitable for circular tanks, but should always be considered for new build rectangular tanks. Tipping Buckets are rarely suitable for retro-fit installations as the construction of the enabling civil works required is likely to reduce the effective volume of the tank, which may in turn cause Consent issues.

- Flushing Gates have failed to gain popularity in recent years following some initial installations within AMP4, and cannot be considered to offer a cost effective solution for any shape or size of tank. These cannot therefore be taken forward as a general recommendation.

ThompsonRPM have conducted circa 80 site visits / case studies during late AMP5 / early AMP6 investigating existing installations of Storm Tank Cleaning Equipment, and can use the findings from these to extend and further develop the above broad assumptions by means of detailed generic or site-specific Selection / Design Guidance. Selection matrices based on tank age, construction shape or size can be developed, along with detailed Totex Cost Comparisons.

ThompsonRPM would also hope to be involved should the WIMES Initiative ever be extended to cover Storm Tank Cleaning Equipment.