ThompsonRPM

THOMPSON RESEARCH – PROJECT MANAGEMENT LTD
HEDGEROWS
4 DARLINGTON ROAD
LONG NEWTON
STOCKTON ON TEES
TS21 1PE

TEL: (01642) 679411

www.thompsonrpm.com

COMBINED SEWER OVERFLOWS (CSOs) & CSO SCREENS

TECHNICAL NOTE REF	**:**	**TRPM – TN002**
AUTHOR	**:**	**BARRY THOMPSON**
VERSION	**:**	**5.0**
DATE	**:**	**JANUARY 2016**

I.0 INTRODUCTION

In the UK the development of sewerage systems has been based on the conveyance of domestic and industrial effluents and the surface runoff from catchment surfaces in underground conduits.

Three types of system are used:

- combined systems, where foul and surface waters are conveyed in the same pipe
- separate systems, where foul and surface waters are conveyed in different pipes, and
- partially separate systems, which are a combination of the combined and separate systems.

Of these, the most common type of sewerage system utilised in the UK is the combined system.

Combined sewerage systems incorporate combined sewer overflows (CSOs) to divert excess flows received during storm events into nearby receiving waters, thus relieving other hydraulic structures within the system and reducing the risk of flooding in urban areas.

Discharges from CSOs, known as intermittent discharges, contain both foul sewage and storm water and therefore contain large amounts of pollutants, including gross solids and finely suspended solids in solution. These pollutants can have a significant aesthetic, oxygen demand or toxic impact on the quality of the receiving water.

Estimates compiled in the early 1990’s indicated that there were approximately 25,000 CSO structures within the UK, and of these approximately one third were believed to have hydraulic or pollution performance characteristics that could be classed as unsatisfactory.

The EU Urban Wastewater Treatment Directive (UWWTD) of 1991 required member states to take action (by 1998) to limit pollution from CSO’s and improve unsatisfactory intermittent discharges (UIDs). This legislation, together with related directives such as the Bathing Waters Directive and the Shellfish Directive, led to significant industry-wide capital expenditure on improving recognised UIDs.

As a result, a significant amount of research into CSO related issues took place, which in turn led to many developments in the design of these structures.

2.0 CSO RESEARCH

CSO research in the UK has been largely industry driven, with research providers such as United Kingdom Water Industry Research (UKWIR), the Water Research Centre (WRc) and Foundation for Water Research (FWR) working with leading academic bodies such as the Universities at Sheffield, Bradford, Coventry, Sheffield Hallam, Abertay (Dundee) and Imperial College, London.

Of these research providers, UKWIR is funded directly by the UK Water Companies and specialises in one-voice research designed to meet the needs of the water & sewage service providers. As a result, and in response to the large number of unsatisfactory CSOs identified, UKWIR has funded / supported many CSO-related research projects.

The UKWIR CSO Research Group managed a varied programme of CSO-related research projects in the 1990's, using established research providers, academic bodies and specialist consultants as research contractors.

Many CSORG projects were focussed on the performance of CSOs (with and without screening equipment in place) in achieving the control of aesthetic pollutants in intermittent discharges. Other projects researched the use of flow control devices, scale effects, characteristics of sewage particles, the use of Computational Fluid Dynamics (CFD), an evaluation of event logging equipment, the effect of climate change on CSOs, and many other related issues.

The UKWIR CSO Research Group no longer exists as a formal collaboration, although CSO-related research work continues under the control of various bodies, with several former CSORG personnel or associates still actively involved in this field.

Several of the UK Water Companies have conducted large-scale, field-based evaluations looking into the performance of various CSO designs and / or screening equipment, and a major project, funded by the Engineering & Physical Sciences Research Council (EPSRC) and UKWIR entitled "Predicting Aesthetic Pollutant Loadings at CSOs" was concluded in 2001. The outputs from this project were later developed by consultants MWH Global into a commercially available design tool entitled "Grossim" (Gross Solids Simulator).

Based on hydraulic modelling, Grossim simulates flows to predict the quantity, temporal distribution and transportation of solids within urban catchments. The simulation tool was originally developed in the late 1990's and is based on mathematical relationships between physical parameters. The model was 'calibrated and verified' at that time, using only three sets of field data from solids collected / sampled from the sewerage system in Sheffield.

Models have inherent limitations, such as the required element of simplification and difficulties in accounting for the random behaviour and complex variability of gross solids in sewage. Physical processes in sewers are so complex that inevitably there is always likely to be some uncertainty in a simulation, hence it is reasonable and appropriate for MWH to acknowledge that Grossim is used to "*identify **potential** solids loading*" or "*to determine an **indicative** load".*

ThompsonRPM specialise in the management of research projects and continue to be involved with all aspects of CSO performance and research, utilising established working relationships with most of the key-contributors in this field of research.

3.0 CSO DESIGN

The design of CSO chambers within the UK has been driven by a series of laboratory studies and fieldwork evaluations conducted over the past 40 years. Initial work done by Sharpe & Kirkbride in 1959 was developed by many researchers during the 1960s, 1970s and 1980s. The first UK design guide for CSO chambers, entitled “ER304E – A Guide to the Design of Storm Overflow Structures” was published by the Water Research Centre (WRc) in 1988. This Guide gave recommendations for the hydraulic design of four types of CSO chamber, being the high side weir, stilling pond, vortex with peripheral spill and hydrodynamic separator.

Subsequent research, however, highlighted that the gross solids retention performance of these chambers was relatively poor, with solids simply dividing proportionate to the flow split during overflow events. As a result, a new report, entitled “FR0488 – Guide to the Design of Combined Sewer Overflow Structures” was published by the Foundation for Water Research (FWR).

Further full-scale research, conducted at the National CSO Test Facility, Wigan WwTW, (see below) again demonstrated that the solids retention performance of these chambers was little better than the ratio of the flow split. As a consequence, attention has since focussed on the development of screen technology and the design of chambers for use specifically with screens.

A wide range of many generic types of screens are now available in the UK, and site evaluation has shown that almost all can meet the UK Environment Agency “6 mm x 2D” standard, which calls for separation from the effluent of a significant number of solids greater than 6 mm in any two dimensions. Although other EA standards exist, including “10 mm x 1D” and “Good Engineering Design” the appliance of these has been limited, partly because of the anticipated poor solids retention performance of a chamber designed against these standards, and partly because screen design has defaulted to the most stringent of the standards likely to be encountered.

As a direct consequence of the increased use and interest in utilising screening equipment at CSOs, a further design guide, entitled “The Design of CSO Chambers to Incorporate Screens” was published in 2001 (and revised in 2006) by the Wastewater Planners Users Group (WaPUG). Although WaPUG have since been absorbed with the structure of the Chartered Institution of Water & Environmental Management (CIWEM), this “WaPUG Guide” remains in use in the UK as the Water Companies seek to improve CSOs identified as unsatisfactory.

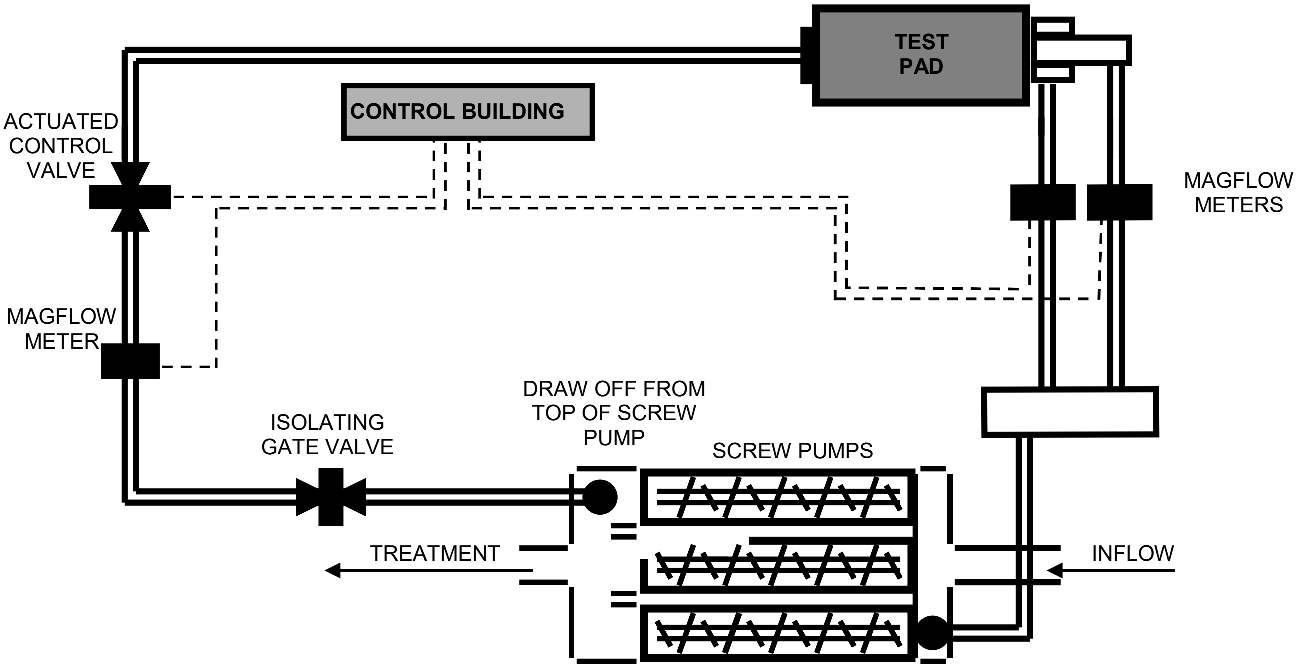
The WaPUG Guide focuses primarily on the design of a chamber to incorporate an appropriately designed screen. The Guide seeks to ensure that flow patterns are commensurate with effective screen operation, the chambers are compact and therefore more cost-effective, and the risk of sedimentation or blockage is minimised.

ThompsonRPM have worked with a number of UK Water Companies in developing CSO Design Guides. These guides are specific to each client’s individual needs and offer advice on screen selection, followed by the development of standard CSO chamber designs, using the WaPUG Guide as a basis then incorporating the particular requirements of each identified screen solution.

ThompsonRPM, working in conjunction with several of the UK Water Companies, have also developed a structured protocol covering the on-site assessment of CSO / Screen performance. This Post Project Appraisal protocol consists of a series of one-off site inspections reported individually, then summarised with conclusions, recommendations, etc, in a project end-report. For a detailed summary of Post Project Appraisals conducted in the mid-2000s by TRPM on over 200 CSOs, refer to Thompson RPM Technical Note Ref TRPM-TN003 – ‘CSO Post Project Appraisal’.

4.0 CSO SCREEN EVALUATION AT THE NATIONAL CSO TEST FACILITY

The NCSOTF was commissioned in 1995 and located within Wigan WwTW, North West Water (Now United Utilities). Between facility commissioning and closure (in 2006) over 30 different screens from various manufacturers in the UK and Europe were subjected to evaluation. A schematic process flow diagram of the NCSOTF is shown below.



The Facility was used to 'type-test' screens using the incoming sewerage flow from Wigan and the surrounding drainage area. The aim of this 'type-testing' was to confirm that screens meet minimum standards of process effectiveness during service. The intention was not to issue a 'pass or fail' certificate for a particular screen but to provide a quantitative measure of process effectiveness known as the Screenings Retention Value (SRV) - a value derived by sampling screen loads in the downstream continuation and spill flows.

The 'Average SRV' value for any particular screen has been accepted world-wide as the comparator for process performance when considering new screens. For example, the value is recognised by the UK Water Industry Mechanical & Electrical Specifications (WIMES) Initiative, and features in WIMES 5.04 – "Overflow Screens for Sewerage Systems and STWs".

Test results were reported immediately to the equipment supplier concerned and remained their property. Suppliers were however offered the opportunity to have their results included in occasional comparative reports published via UKWIR – the most recent (which included all testing up to Facility de-commissioning to make way for the construction of a new Inlet Works) being UKWIR Report Ref No 06/WW/08/14 – "NCSOTF, CSO Screen Efficiency, (1997 – 2005)

The screens included in this report are listed below. Supplier names have been updated, as far as possible, to reflect the current (January 2016) screen / supplier market position, and it should also be noted that some of the screens may no longer be available.

3.0 CSO SCREEN EVALUATION AT THE NATIONAL CSO TEST FACILITY (CONT)

• Jacopa (ex Ovivo) Copa Raked Bar Screen	Side Weir
• Hydro Int Hydro-Jet Screen Rotary Version	Stand Alone Unit
• Huber Rotamat RoK1 Stormscreen	Side Weir and Stilling Pond
• Jacopa (ex-Ovivo) J&A / Romag Stormscreen	Side Weir and Stilling Pond
• Hydrok Peak Screen	Stilling Pond
• Robbins & Myers R&M 6000 Belt Screen	Side Weir
• Jacopa (ex Ovivo) Copa Copacurve Crosswave Screen	Stilling Pond
• Hydrok Airmex Screen	Side Weir
• Hydro Int (ex Waterlink) CSO Screen	Stand Alone Unit
• Hydrok Steinhardt Hydroclean Brush Screen	Side Weir
• Longwood Stormguard	Side Weir
• NOV Mono Discreen	Side Weir
• Jacopa (ex Ovivo) J&A Storm-Flow	Side Weir
• Screen Systems Screentex Valley Screen	Side Weir
• CSO Technik Wave Screen	Side Weir
• Haigh ACE Stormer	Side Weir
• Hydro Int High Capacity Hydro-Jet Screen	Stand Alone Unit
• Hydro Int Hydro-Static Screen	Side Weir
• Jacopa (ex Ovivo) BG CS100 Stormscreen	Side Weir
• Jacopa (ex Ovivo) Copa Cyclone	Side Weir
• Ham Baker Adams Three Star Stormstar	Side Weir
• CSO Technik Pump Action Screen (PAS)	Side Weir
• Huber Rotamat RoK2 Stormscreen	Side Weir
• Hydro Int Heliscreen	Side Weir
• BWT (was Hydrok) Noggerath NSDS	Side Weir
• KLT Water Storm Flush	Stand Alone Unit
• NOV Mono Stormscreen	Side Weir

Testing indicated typical SRV values in the region of 45% to 65% for 6 mm Bandscreens, which in turn led some Purchasers to specify a minimum acceptable average SCR value of 50% for these screens.

Static Screens, often regarded as suitable for small CSOs where no power supply is available, generally achieved similar or slightly lower SRV values than those reported for the Bandscreens, whilst Brushed / Spiral Screens, where the force of the brush against the static perforated plate introduced the risk of screenings “extrusion”, generally achieved slightly lower SRV values, as could reasonably be expected.

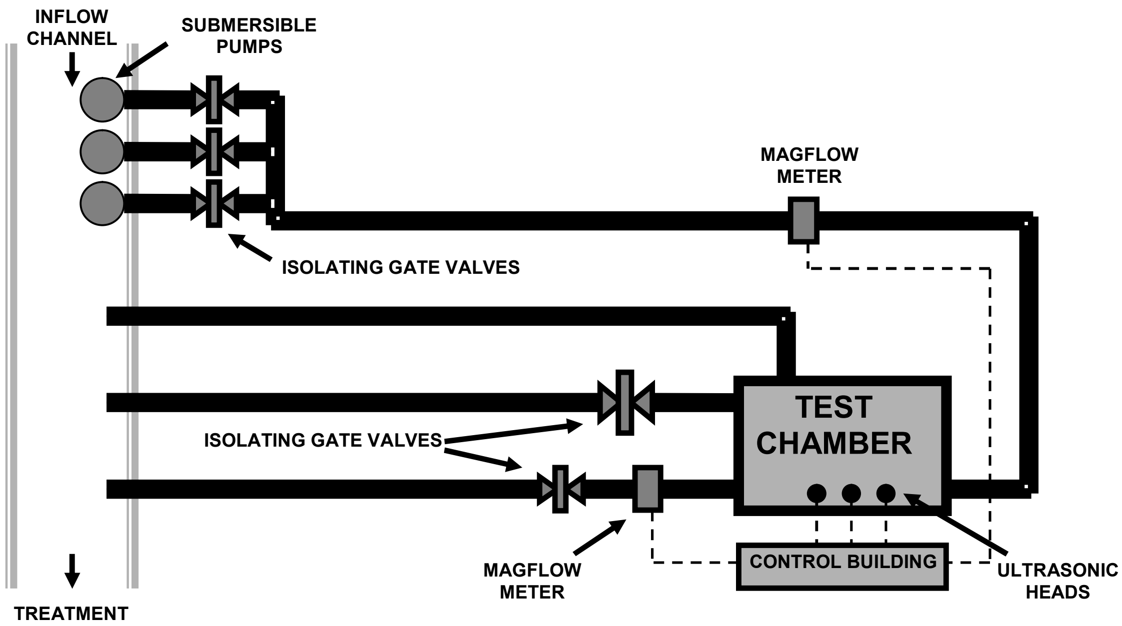
Bar Screens, because of the greater aperture size, generally achieved even lower SRV values, whilst the various “stand-alone” screens / devices achieved a wide range of SRV values, but were generally similar to the values reported for Bandscreens.

It should be noted that the SRV for a CSO Screen is an ‘added value’ – representing the extra efficiency added to the combined CSO / Screen arrangement by the addition of the CSO screen. Given the inherent separation efficiency of weir arrangements without screens, it is therefore extremely unlikely that any screen could ‘add’ an SRV of greater than say 70%.

5.0 WARRINGTON TEST FACILITY

The NCSOTF was decommissioned in February 2006 as part of the construction of a new inlet works at Wigan WwTW. The test facility components were transferred to Warrington North WwTW and placed in storage alongside the existing Warrington Test Facility, the intention being that the 'Wigan' test facility could be re-assembled here should sufficient interest exist. It was, however, possible to conduct 'Wigan style' screen testing using the Warrington test chamber.

Funding for construction of the Warrington Test Facility, completed in 1999, was provided by United Utilities who retained ownership. Incoming sewage into Warrington North WwTW is both fed by gravity and elevated by screw pumps prior to treatment. Using three submersible pumps located in the channel upstream of the inlet screens, a portion of this flow could be diverted to the Warrington Test Facility. At this facility, a fabricated steel side weir CSO test chamber was been constructed, sized to the WaPUG CSO Design Guide. A schematic process flow diagram of the Warrington Test Facility is shown below:



The Facility was originally designed and used by United Utilities for a series of 'in house' long-term CSO Screen evaluations, from which a test procedure known as the "100-Hour Test" was developed. Screens evaluated included the Huber RoK1 Stormscreen' Longwood Stormguard, Kier (now Hydro Int) Heliscreen and the NOV Mono Stormscreen.

Subsequently, TRPM used the Facility for the following:

- Ovivo Copa Cyclone — Flow / Headloss Assessments
- Fairwood Guardian Screen — 'Wigan' SRV Testing
- Hydrok MecMex (90^{O} & 180^{O}) — 100-Hour Testing
- WatSol Comb Separator — 'Wigan' SRV Testing

The Warrington Test Facility remains available for use / hire but asset condition has deteriorated within what was only ever intended to be a temporary structure, thus the scope of what work may be conducted there may be reduced compared to when it was first commissioned.

6.0 CSO SCREEN SPECIFICATION & PROCUREMENT

Screen Specification – The WIMES Initiative

The Water Industry Mechanical & Electrical Specification (WIMES) Initiative is funded by each UK Water Company and is steered by a group comprising representatives from each Company. The objective is to produce a series of standard specifications for use across the industry covering a range of mechanical and electrical equipment. To date, approximately 70 specifications have been published. The initiative is co-ordinated by The Pump Centre, based in Warrington, Cheshire.

ThompsonRPM are closely involved with the production and ongoing development of the following WIMES documents:

WIMES 2.02 (Grit Removal / Treatment Equipment)
WIMES 2.03 (Package Inlet Works)
WIMES 5.01 (Raw Water Intake Screens)
WIMES 5.02 (Coarse (1D) Screens for Sewage Treatment)
WIMES 5.03 (Fine (2D) Screens for Sewage Treatment)
WIMES 5.04 (CSO / Overflow Screens)
WIMES 5.05 (Sludge Screens)
WIMES 6.03 (Screenings Handling Equipment)

ThompsonRPM can facilitate Workshops covering awareness and implementation of various WIMES specifications and have produced Guidance Notes, working to a client's standard format, intended to aid understanding and encourage use of the specifications. In addition to this, ThompsonRPM have compiled client-specific specifications using WIMES documents as a start-point for numerous UK Water Companies, including for use as part of Framework Agreement exercises – see below.

Screen Procurement – Framework Agreements

"Framework Agreements" are a recognised procurement tool in the UK, with suppliers bidding to be framework suppliers for particular products, such as screens, over an agreed number of years. The general principle is that one large competitive tendering exercise is carried out at the start of an identified period of investment, with the successful tenderers being awarded Framework Agreements covering the supply of their products over that period.

Most UK Water Companies have several Framework Agreements in place with many suppliers, covering a range of their most required products. ThompsonRPM have worked with several UK Water Companies in conducting Framework Agreement exercises, for equipment such as Inlet Screens, Overflow / CSO Screens, Grit Removal / Treatment Equipment and Screenings Handling Equipment.

ThompsonRPM can offer technical assistance at all stages of the Framework Agreement Process, including OJ Advertisement placement, compilation and review of Pre-Qualification Questionnaires, compilation of Technical Specifications, technical reviews of received tenders, and recommendations regarding potentially acceptable FA partners. ThompsonRPM offer a genuine independent service and guarantee complete Client confidentiality.