Successful Commissioning of Water Systems

7775 FS 79818 EMS 533315

- Originally **PFI** project
- Insolvency of **Carillion**
- Trust took over **responsibility**
- Decision to have a **'clean slate'**

The Beginning.....

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Carillion collapse: Midland Metropolitan Hospital work resumes

14 February 2020

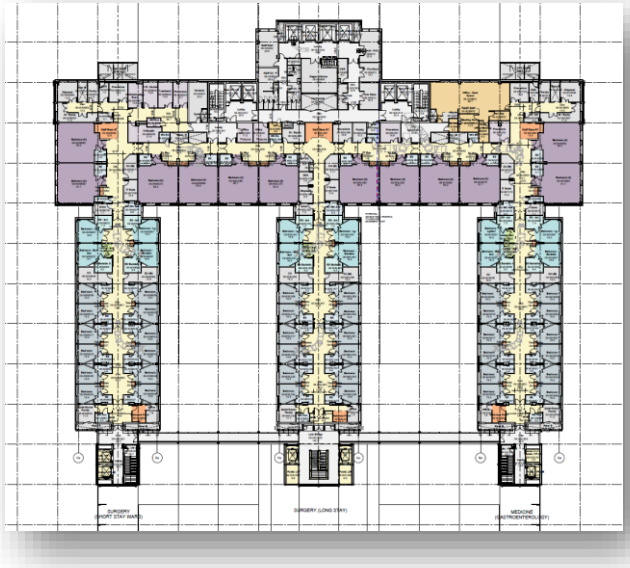
SANDWELL AND WEST BIRMINGHAM HOSPITALS NHS TRUST

The word "university" has been added to the hospital's name while it has stood empty

Construction work has resumed at a "super-hospital" thrown into limbo for two years by the collapse of construction giant Carillion.

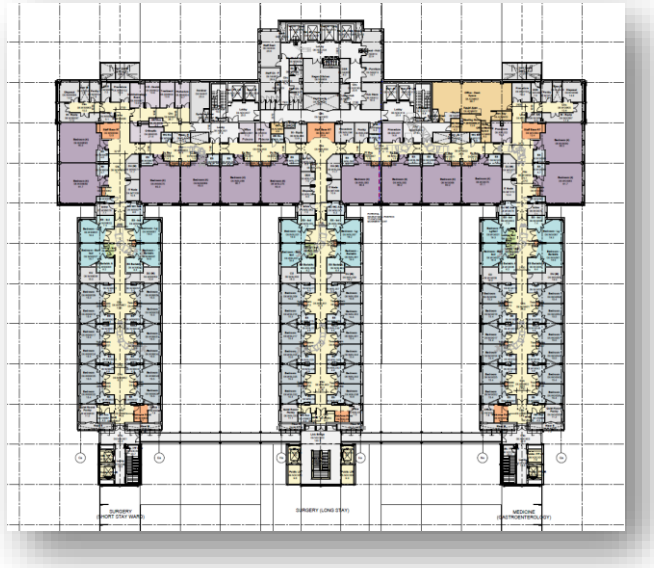
The newly-named Midland Metropolitan University Hospital, in Sandwell, was due to open in 2018.

- Derogation from 600L to 450L usage per bed day.
- Incoming treatment.
- Single tanked system for all cold water with electronic fill/capacity system.



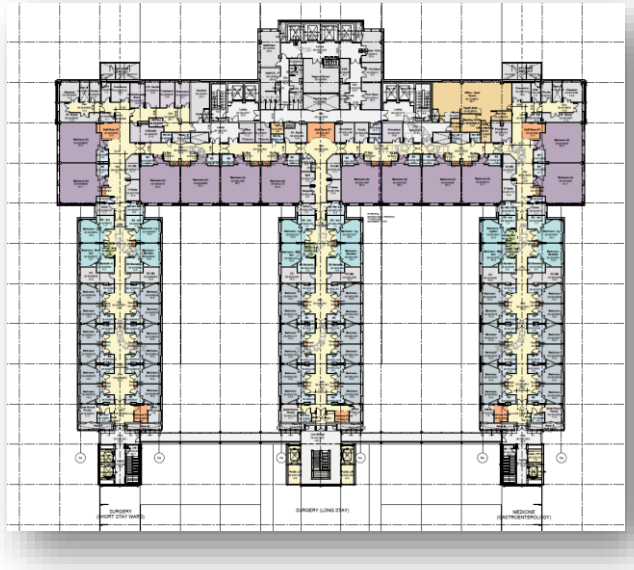
Design & Specification

- BMS on all critical systems.
- Automatic flushing taps – proven by other sites.



Design & Specification

- Copper pipework throughout.
- Hot water split to no more than 500 outlets per hot water system.
- Pipe sizing reduction resisted by designer.



Design & Specification

Water Research
Volume 46, Issue 17, 1 November 2012, Pages 5499-5508

Effect of shear stress and growth conditions on detachment and physical properties of biofilms

Etienne Paul [a b c], Juan Carlos Ochoa [a b c 1], Yoan Pechaud [a b c], Yu Liu [d], Alain Liné [a b c]

Show more

https://doi.org/10.1016/j.watres.2012.07.029

Abstract

Detachment is one of the major processes determining the physical structure and microbial functionalities of biofilms. To predict detachment, it is necessary to take the mechanical properties of the biofilm and the effect of both hydrodynamic and growth conditions into account. In this work, experiments were conducted with biofilms developed under various shear stresses and with various substrate natures. In addition, two cases were considered in order to differentiate between the effect of hydrodynamic factors and growth factors: the biofilms were directly grown under the targeted shear stress (τ) condition or they were precultivated under very low shear stress (0.01 Pa) and then exposed to high shear stress in the range of 0.1–13 Pa. An exponential and asymptotic decrease of the biofilm thickness and mass with increasing τ was observed in both cases. On contrary density, expressed as the biofilm dry mass on a known substratum divided by the average thickness increased with τ. Denitrifying biofilms

npj biofilms and microbiomes
www.nature.com/npjbiofilms

ARTICLE OPEN

Check for updates

The role of shear dynamics in biofilm formation

Erifyli Tsagkari [1✉], Stephanie Connelly, Zhaowei Liu[1], Andrew McBride[1] and William T. Sloan[1]

There is growing evidence that individual bacteria sense and respond to changes in mechanical loading. However, the subtle responses of multispecies biofilms to dynamic fluid shear stress are not well documented because experiments often fail to disentangle any beneficial effects of shear stress from those delivered by convective transport of vital nutrients. We observed the development of biofilms with lognormally distributed microcolony sizes in drinking water on the walls of flow channels underflow regimes of increasing complexity. First, where regular vortices induced oscillating wall shear and simultaneously enhanced mass transport, which produced the thickest most extensive biofilms. Second, where unsteady uniform flow imposed an oscillating wall shear, with no enhanced transport, and where the biomass and coverage were only 20% smaller. Finally, for uniform steady flows with constant wall shear where the extent, thickness, and density of the biofilms were on average 60% smaller. Thus, the dynamics of shear stress played a significant role in promoting biofilm development, over and above its magnitude or mass transfer effects, and therefore, mechanosensing may prevail in complex multispecies biofilms which could open up new ways of controlling biofilm structure.

npj Biofilms and Microbiomes (2022)8:33 ; https://doi.org/10.1038/s41522-022-00300-4

INTRODUCTION

There are many scenarios where scientists and engineers aim to control the structure and function of biofilms that are fixed to a surface in moving stream of water[1–5]. Thus, for example, enhancing the transport of nutrients to the surface is known to promote the growth of biofilms[6–10]. To counter this and limit the thickness of a biofilm, drag from the flow pressure and shear stress is controlled by varying the fluid velocity to induce the detachment of biomass.

Whilst the sloughing of biofilm in response to hydrodynamic forces is undoubtedly a major factor in controlling biomass there are reasons to believe that the role of shear in biofilm formation may be more complex. For example, in multispecies biofilms the diversity of species is affected by shear stress[8]. Single species biofilms have been observed to alter their metabolism in response to increases in shear stress such that they dissipate more energy[11] and the binding of adhesive proteins that contribute to cell attachment can be stronger when formed under higher shear conditions[12,13], which might suggest the ability of bacteria to sense and respond to the stress. This potential for mechanosensing has been reinforced in a number of studies where enhanced concentrations of signalling molecules have been observed in single-species biofilms that are attached to surfaces and subject to shear[14–16] and a quorum sensing response to these molecules is the expression of genes that play a role in adhesion. In addition to these ecological and biochemical reactions to shear, rheotaxis, where bacteria move in directions that are a function of the magnitude and orientation of shear gradients, is thought to be a purely physical response that occurs in both bulk liquids and in the colonisation of surfaces where the magnitude of the wall shear the production of extracellular polymers (EPS) but also the nature of the fluid shear experienced at the site where the biofilm forms.

Most experimental designs presuppose that it is the fluid flow's effects on mass transport that dominate the formation and growth of biofilms. In doing so they neglect the fact that wall shear forces may also have an effect that will vary in time and space, for example, fluctuating in response to any coherent flow structures that are propagated. Thus, it is unclear how much the differences in the wall shear stress dynamics contribute to biofilm structure over-and-above the effects of changes in the mass transport. Teasing these effects apart could influence the way we design infrastructure, whether in biofilm-carrying media for biotechnologies[21] or in antibiofouling strategies[22]. Here we addressed this by measuring the properties of biofilms that accumulated over four weeks on the walls of flow chambers under seven different laminar flow regimes observed over two sets of experiments, summarised in Table 1.

In the first set of experiments, the aim was to compare the biofilms that formed under two flow regimes where mass transfer to the walls was enhanced by passively induced vortices of different sizes, Large Vortex Flow (LVF) and Small Vortex Flow (SVF), with a third where unform steady flow (SF) regime imposes a wall shear stress equivalent to the time-averaged mean for the vortex flows. Each of the three flow regimes was replicated in triplicate flow channels and the volumetric flow rate was the same in all nine experiments. The experiments were run in parallel and fed with the same tap water to ensure that the channels were exposed to similar drinking water microbiota. A variety of different flow regimes could have been selected to enhance the mass

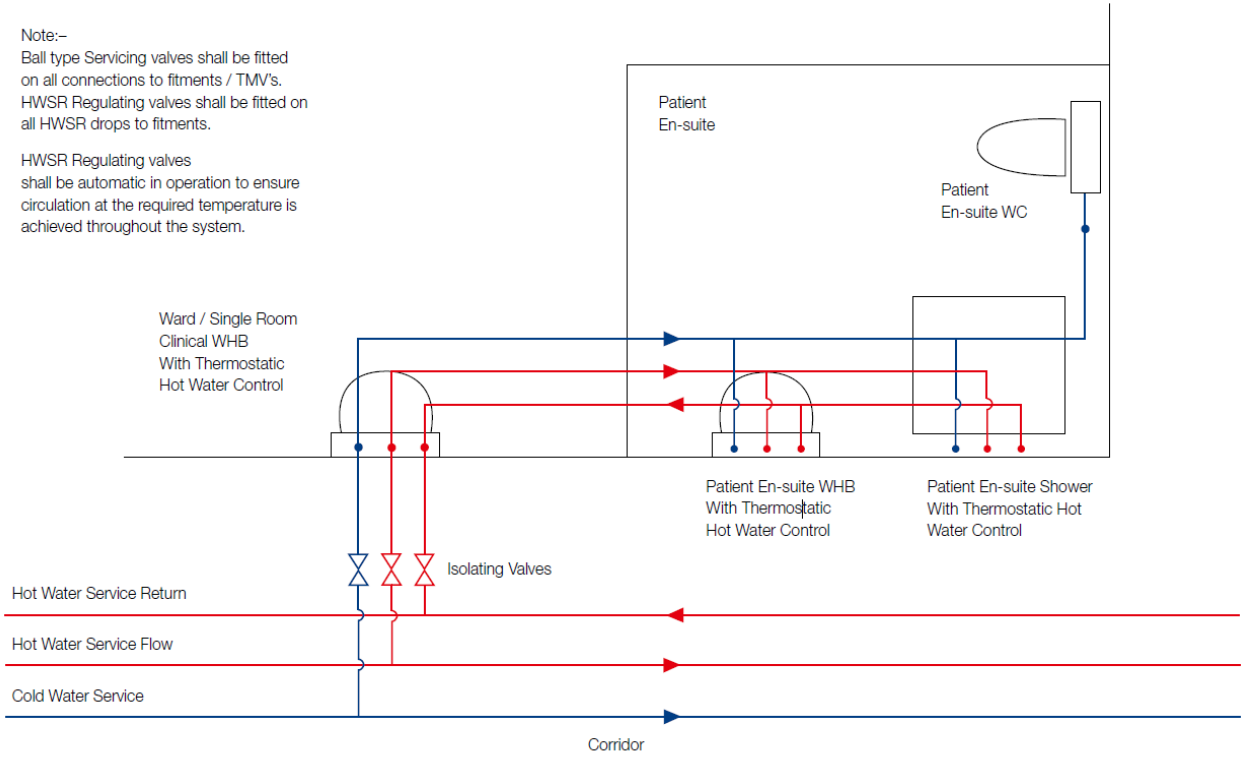
- Pipe sizing – deadlegs from 1 to 3 outlets/connections – WHBs, WCs etc, should have 12mm pipework in line with BSEN 806-3:2006, not 15mm.
- BS 806 is what designers design to.

Table 3.2 — Copper

Max. load	**LU**	**1**	**2**	**3**
Highest value	LU			2
d_a x s	mm	**12** x 1,0		
d_i	mm	10,0		
Max length of pipe	m	20	7	5

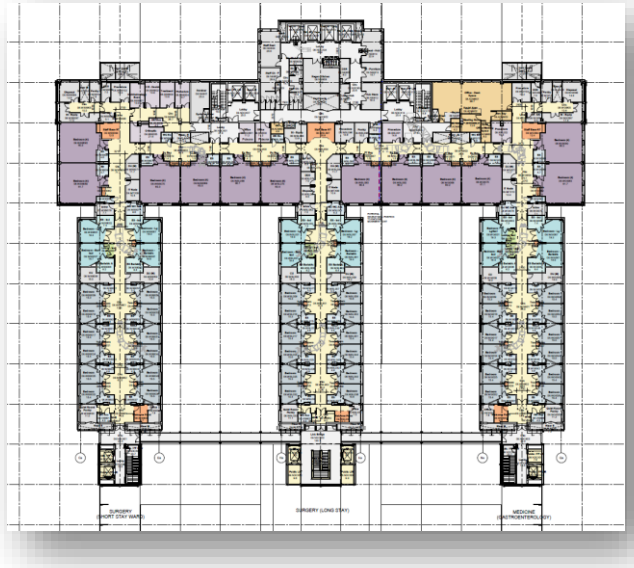
Proposal

Install small diameter pipework to get velocity to biofilm shear velocity (>1m/s) and remove tertiary loops from designs.


Note:–
Ball type Servicing valves shall be fitted on all connections to fitments / TMV's.
HWSR Regulating valves shall be fitted on all HWSR drops to fitments.
HWSR Regulating valves shall be automatic in operation to ensure circulation at the required temperature is achieved throughout the system.
Patient En-suite
Patient En-suite WC
Ward / Single Room Clinical WHB With Thermostatic Hot Water Control
Patient En-suite WHB With Thermostatic Hot Water Control
Patient En-suite Shower With Thermostatic Hot Water Control
Isolating Valves
Hot Water Service Return
Hot Water Service Flow
Cold Water Service
Corridor

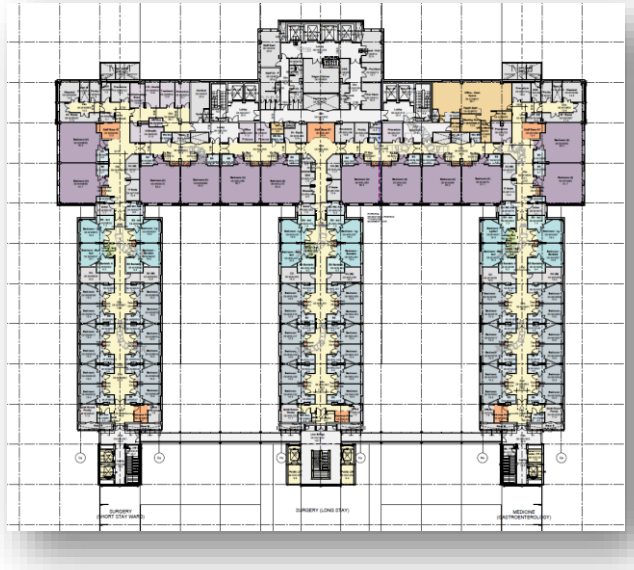
Thermal Balancing Valve

- Review of design through design acceptance.
- Informed Client.
- AE involvement throughout process.
- 12 hours onsite storage.



Design & Specification

- Boosted system with N+1 Booster sets.
- Resilience throughout (N+1).
- Heat gain considered and in derogation schedule with mitigation – lagging, automatic flushing and separation of hot and cold systems.



Design & Specification


DANGER
THIS AREA IS
NON LIVE
BOOSTED COLD
WATER SERVICE

- Toolbox talks for fitters.
- Weekly AE visits during fit-out (pipework removed when not capped).
- Routing and installation checks throughout.
- Jointing materials.
- Old blending valves replaced (onsite 4 years).

Installation

- Detailed Written Scheme – 6 months before first fill.
- Sampling brief from IP&C and Consultant Microbiologist.
- Agreement on pass/fail levels for sampling – levels and percentages.

Commissioning - Management

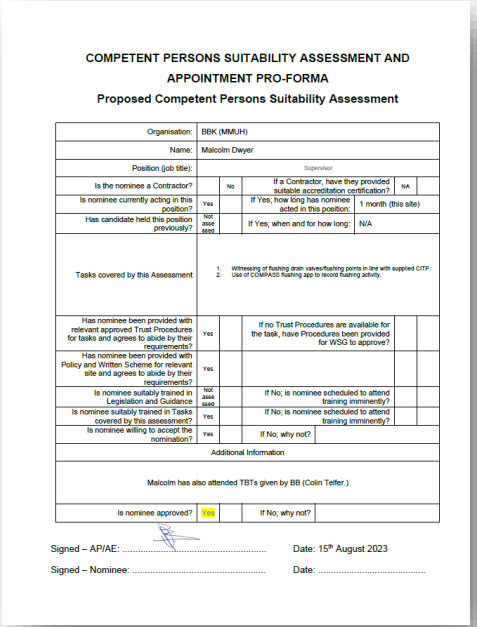
- Clinical risk assessment including high risk areas.
- Water Safety Plan defined and contracted document.
- Commissioning Manual includes Commissioning Inspection and Test Plans (CITP's).

Commissioning - Management

- Training of all RP's, AP's, and CP's.
- All records required real-time electronic logbook.
- Water Safety Groups – Weekly and Monthly Strategic.
- NEC supervisor.
- FM involvement throughout.

Commissioning - Management

- Sampling at each fill stage as defined by commissioning brief.
- Defined procedure for air testing.



COMPETENT PERSONS SUITABILITY ASSESSMENT AND APPOINTMENT PRO-FORMA

Proposed Competent Persons Suitability Assessment

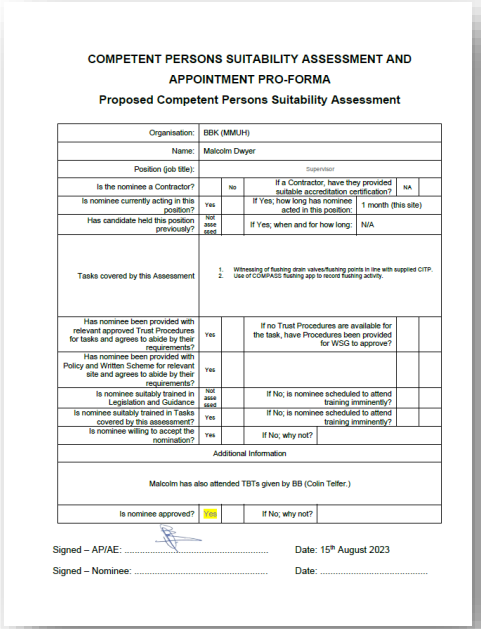
Organisation:	BBK (MMUH)				
Name:	Malcolm Dwyer				
Position (job title):	Supervisor				
Is the nominee a Contractor?		No	If a Contractor, have they provided suitable accreditation certification?	NA	
Is nominee currently acting in this position?	Yes		If Yes; how long has nominee acted in this position:	1 month (this site)	
Has candidate held this position previously?	Not assessed		If Yes; when and for how long:	N/A	
Tasks covered by this Assessment	1. Witnessing of flushing drain valves/flushing points in line with supplied CITP. 2. Use of COMPASS flushing app to record flushing activity.				
Has nominee been provided with relevant approved Trust Procedures for tasks and agrees to abide by their requirements?	Yes		If no Trust Procedures are available for the task, have Procedures been provided for WSG to approve?		
Has nominee been provided with Policy and Written Scheme for relevant site and agrees to abide by their requirements?	Yes				
Is nominee suitably trained in Legislation and Guidance	Not assessed		If No; is nominee scheduled to attend training imminently?		
Is nominee suitably trained in Tasks covered by this assessment?	Yes		If No; is nominee scheduled to attend training imminently?		
Is nominee willing to accept the nomination?	Yes		If No; why not?		
Additional Information					
Malcolm has also attended TBTs given by BB (Colin Telfer.)					
Is nominee approved?	Yes		If No; why not?		

Signed – AP/AE: ..... Date: 15th August 2023

Signed – Nominee: ..... Date: .....

Commissioning - Methods

- Tanks and dosing equipment commissioned before fill of building.
- Online dosing using chlorine dioxide of all water used for fill and flushing 1ppm.



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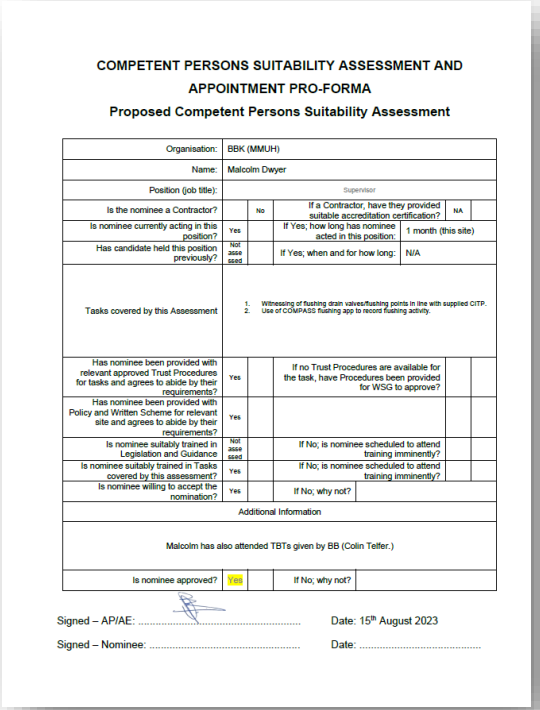
Signed – Nominee: ..... Date: .....

Commissioning - Methods

- System FULL BORE FLUSHED before TMV's connected.
- Systems tested at each stage tested microbiologically before moving to next stage.

Commissioning - Methods



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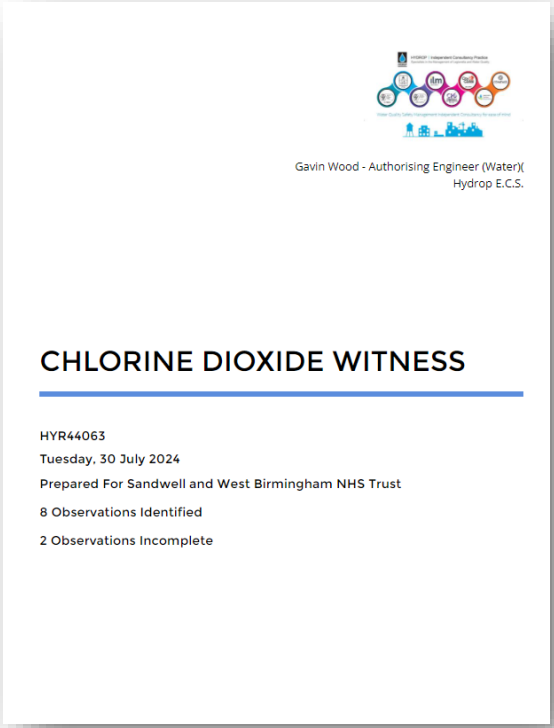
Stage	Systems	Method	Why	Maintenance of water quality
Initial Mains connection	Mains incoming to tanks	High range chlorine	Ensure mains connection pipework disinfected to provide fill supply for heating and chilled process	System usage, and temperature (underground services)
Mains and tank services commission	Underground mains to booster sets	High range chlorine	Disinfection of pipework and tanks following system fit.	Daily flushing and chlorine dioxide reserve
Filled system passive disinfection	All filled cold systems & Hot Systems (while cold)	Daily flush to achieve >1mg/l chlorine dioxide	Passive disinfection process	Daily flushing and routine PPM
Hot system ongoing maintenance	Each hot system	Heat – all tertiary loops >55°C	Maintenance of recirculating water	Daily outlet flushing for turnover and routine maintenance of temperature control
Outlet commissioning	Each commissionable outlet	EndSystems Domestic Water Validation / RADA Commissioning process	Disinfection of mixers and outlets	All Outlet flushing

- Each CITP jointly written by builder, Trust and Authorising Engineer (Water).
- PPM fully running before handover.
- System filled as late as possible.

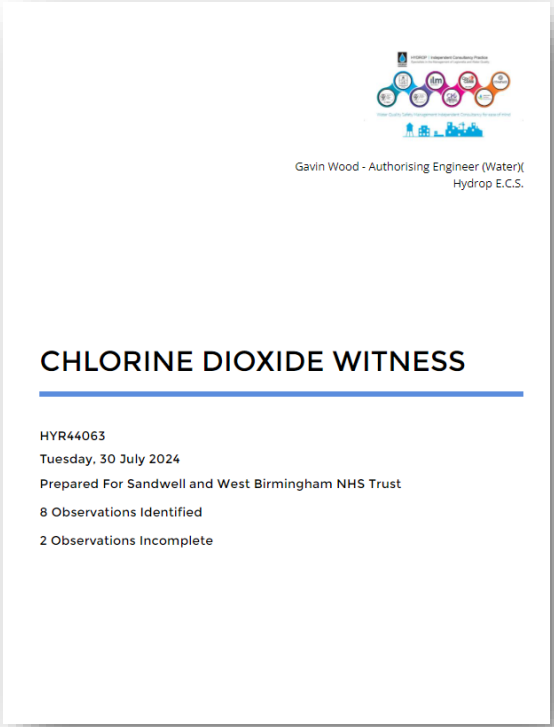

Gavin Wood - Authorising Engineer (Water)(
Hydrop E.C.S.

CHLORINE DIOXIDE WITNESS

HYR44063
Tuesday, 30 July 2024
Prepared For Sandwell and West Birmingham NHS Trust
8 Observations Identified
2 Observations Incomplete

Commissioning - Methods

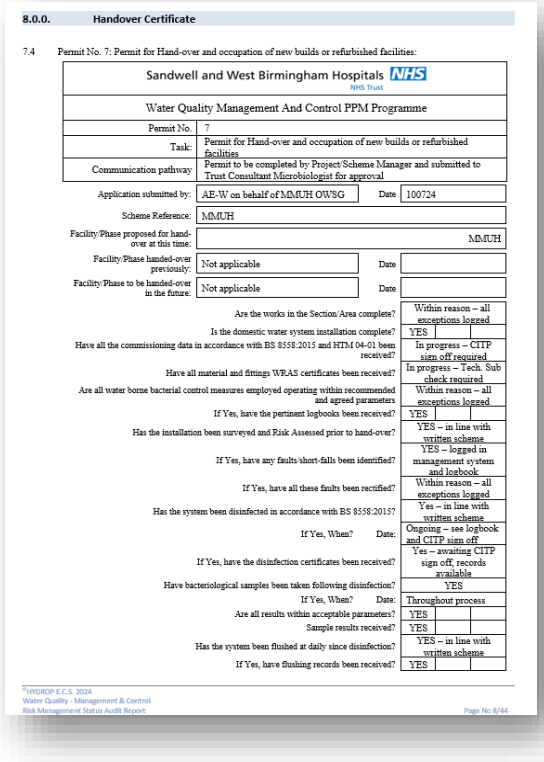
- Hot water system backflushed until heat available.
- Fill, then commission of small sections at a time.



Commissioning - Methods

- Accepted Design.
- NEC confirmation of fit-out meets design.
- Electronic Logbook.

Handover Documentation



8.0.0. Handover Certificate

7.4 Permit No. 7: Permit for Hand-over and occupation of new builds or refurbished facilities:

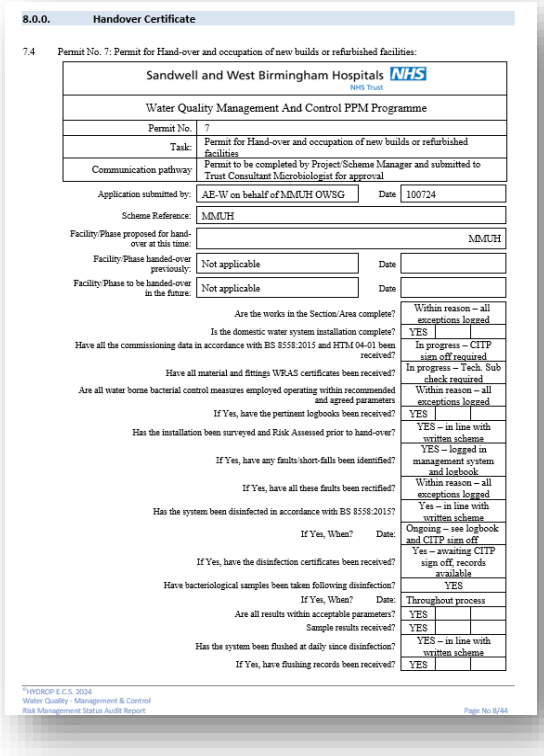
Sandwell and West Birmingham Hospitals NHS NHS Trust	
Water Quality Management And Control PPM Programme	
Permit No.	7
Task:	Permit for Hand-over and occupation of new builds or refurbished facilities
Communication pathway	Permit to be completed by Project/Scheme Manager and submitted to Trust Consultant Microbiologist for approval

Application submitted by:	AE-W on behalf of MMUH OWSG	Date	100724
Scheme Reference:	MMUH		
Facility/Phase proposed for hand-over at this time:			MMUH
Facility/Phase handed-over previously:	Not applicable	Date	
Facility/Phase to be handed-over in the future:	Not applicable	Date	

Are the works in the Section/Area complete?	Within reason – all exceptions logged
Is the domestic water system installation complete?	YES
Have all the commissioning data in accordance with BS 8558:2015 and HTM 04-01 been received?	In progress – CITP sign off required
Have all material and fittings WRAS certificates been received?	In progress – Tech. Sub check required
Are all water borne bacterial control measures employed operating within recommended and agreed parameters	Within reason – all exceptions logged
If Yes, have the pertinent logbooks been received?	YES
Has the installation been surveyed and Risk Assessed prior to hand-over?	YES – in line with written scheme
If Yes, have any faults/short-falls been identified?	YES – logged in management system and logbook
If Yes, have all these faults been rectified?	Within reason – all exceptions logged
Has the system been disinfected in accordance with BS 8558:2015?	Yes – in line with written scheme
If Yes, When? Date:	Ongoing – see logbook and CITP sign off
If Yes, have the disinfection certificates been received?	Yes – awaiting CITP sign off, records available
Have bacteriological samples been taken following disinfection?	YES
If Yes, When? Date:	Throughout process
Are all results within acceptable parameters?	YES
Sample results received?	YES
Has the system been flushed at daily since disinfection?	YES – in line with written scheme
If Yes, have flushing records been received?	YES

- Fully detailed as-fitted drawings as reviewed by Authorising Engineer (Water).
- Water Safety Group Minutes.
- AE recommendation report.

Handover Documentation



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Sample results received?	YES		
Has the system been flushed at daily since disinfection?			YES – in line with written scheme
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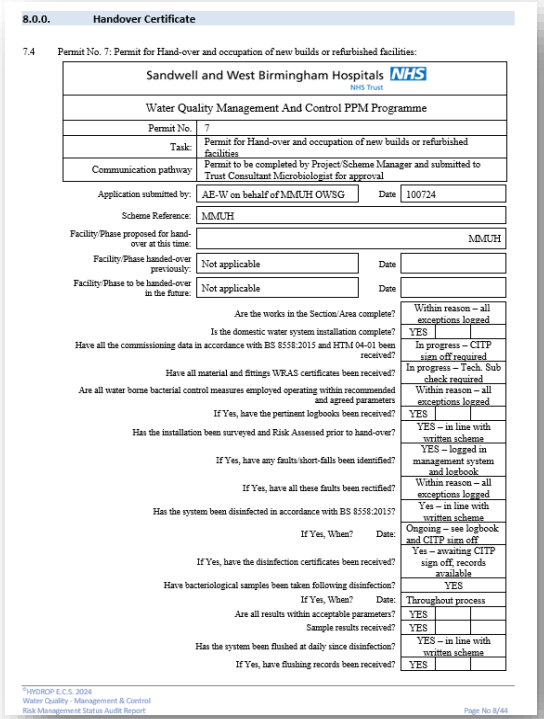
- Flushing programme set up and running before handover.
- Soft landings to FM contractor (fully detailed PPM plan with electronic logbook populated).

Handover Documentation



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If Yes, have flushing records been received?	YES

- Weekly and monthly groups continued to address non-conformities.
- Audit of PPM process.
- Pseudomonas Risk Assessment.

Post-Handover Plan

Water Quality

Legionella and Pseudomonas aeruginosa

Management & Control

Risk Management Audit Report

In compliance with:

- *Legionnaires' disease - The Control of Legionella bacteria in water systems Approved Code of Practice and guidance on regulations L8 (Fourth Edition) 2013.*
- *Health and Safety Guidance 274 Parts 1-3 2024.*
- *Department of Health - Water Systems Health Technical Memorandum 04-01: Safe Water in Healthcare Premises: Parts A, B, C & Supplement: 2016.*
- *Department of Health - Health Technical Memorandum 00: Policies and principles of healthcare engineering: 2014.*

Client:	Sandwell and West Birmingham Hospitals NHS Trust
Site:	Midland Metropolitan University Hospital
Audit Commissioned by:	Kevin Reynolds
This Audit Ref. No:	HYR43754
This Audit Date:	8th - 10th July 2024
This Audit Carried-out by:	Gavin Wood of HYDROP ECS
This Audit Consultancy by:	Gavin Wood of HYDROP ECS
Date of last Audit:	First Audit
Ref No. of last Audit:	Not applicable
Last Audit Carried-out by:	Gavin Wood of HYDROP E.C.S.
Report Prepared and Issued by:	Gavin Wood
Signature:	
Position:	Compliance Policy Lead / Authorising Engineer – Water
Date:	11th July 2024

- Update Legionella Risk Assessment.
- Continuation of Authorising Engineer (Water) services weekly during defects period.

Post-Handover Plan

Water Quality

Legionella and Pseudomonas aeruginosa

Management & Control

Risk Management Audit Report

In compliance with:

- *Legionnaires' disease - The Control of Legionella bacteria in water systems Approved Code of Practice and guidance on regulations L8 (Fourth Edition) 2013.*
- *Health and Safety Guidance 274 Parts 1-3 2024.*
- *Department of Health - Water Systems Health Technical Memorandum 04-01: Safe Water in Healthcare Premises: Parts A, B, C & Supplement: 2016.*
- *Department of Health - Health Technical Memorandum 00: Policies and principles of healthcare engineering: 2014.*

Client:	Sandwell and West Birmingham Hospitals NHS Trust
Site:	Midland Metropolitan University Hospital
Audit Commissioned by:	Kevin Reynolds
This Audit Ref. No:	HYR43754
This Audit Date:	8th - 10th July 2024
This Audit Carried-out by:	Gavin Wood of HYDROP ECS
This Audit Consultancy by:	Gavin Wood of HYDROP ECS
Date of last Audit:	First Audit
Ref No. of last Audit:	Not applicable
Last Audit Carried-out by:	Gavin Wood of HYDROP E.C.S.
Report Prepared and Issued by:	Gavin Wood
Signature:	
Position:	Compliance Policy Lead / Authorising Engineer – Water
Date:	11th July 2024

4.0.0. RISK MATRIX

RISK ASSESSED CRITERIA	Risk Weighting	SYSTEMS ASSESSED: Primary Water Supplies	Cold Water Storage Plant	Hot Water Generation Plant	DWS Services	Other Plant and Equipment	Fountains/ Water Features/ Irrigation Systems/ Water harvesting	Process Plant and Systems	"Wet" AHU/ Adiabatic Coolers	Cooling Towers
SEVERITY										
CONTAMINATION										
Legionellae contamination	2	0	0	0	0	0	0	0	0	0
Bacterial contamination	1	0	0	0	0	0	0	0	0	0
Unsuitable primary supply	1	1	0	0	1	0	0	0	0	0
Fire systems sharing supplies	1	0	0	0	1	0	0	0	0	0
AMPLIFICATION										
Poor conditions	1	0	0	0	1	0	0	0	0	0
Non WRAS materials	1	0	0	0	0	0	0	0	0	0
Poor temperature and/or biocide levels	1	0	1	1	1	0	0	0	0	0
Water stagnation	1	0	1	1	1	0	0	0	0	0
Undesirable fittings	1	0	0	0	1	0	0	0	0	0
MANAGED MITIGATION										
Poor monitoring and maintenance	1	0	1	1	1	0	0	0	1	0
Poor management documentation	1	1	1	1	1	0	0	0	1	0
Poor Log-bookkeeping management	1	1	1	1	1	0	0	0	1	0
Poor level of training of personnel	1	1	1	1	1	0	0	0	1	0
Poor inter-department involvement	1	0	0	0	0	0	0	0	0	0
Severity Total:		4	6	6	10	0	0	0	4	0
LIKELIHOOD										
TRANSMISSION										
Level of aerosols forming and spreading	0-5	0	0	1	5	0	0	0	0	0
EXPOSURE										
Likelihood of aerosols being inhaled or aspirated	0-5	0	0	5	5	0	0	0	0	0
HOST SUSCEPTIBILITY										
Vulnerability of the exposed population	0-5	0	3	3	5	0	0	0	3	0
Likelihood Total:		0	3	9	15	0	0	0	3	0
RISK RATING:		0	18	54	150	0	0	0	12	0

RISK RATING

Likelihood	Severity: No Risk	Insignificant Risk	Low Risk	Moderate Risk	High Risk	Extreme Risk
None	0	0	0	0	0	0
Extremely Unlikely	0	9	18	27	36	45
Unlikely	0	18	36	54	72	90
Likely	0	27	54	81	108	135
Very Likely	0	36	72	108	144	180
Almost certain	0	45	90	135	180	225

RISK RATING RANGE	None 0-8	Insignificant 9-26	Low 27-44	Moderate 45-80	High 81-143	Extreme 144-225

COMPASS

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complete peace of mind

A fully integrated, Electronic Water Quality Risk Management System
Manage Risks - Improve Efficiency - Save Time - Drive Transparency

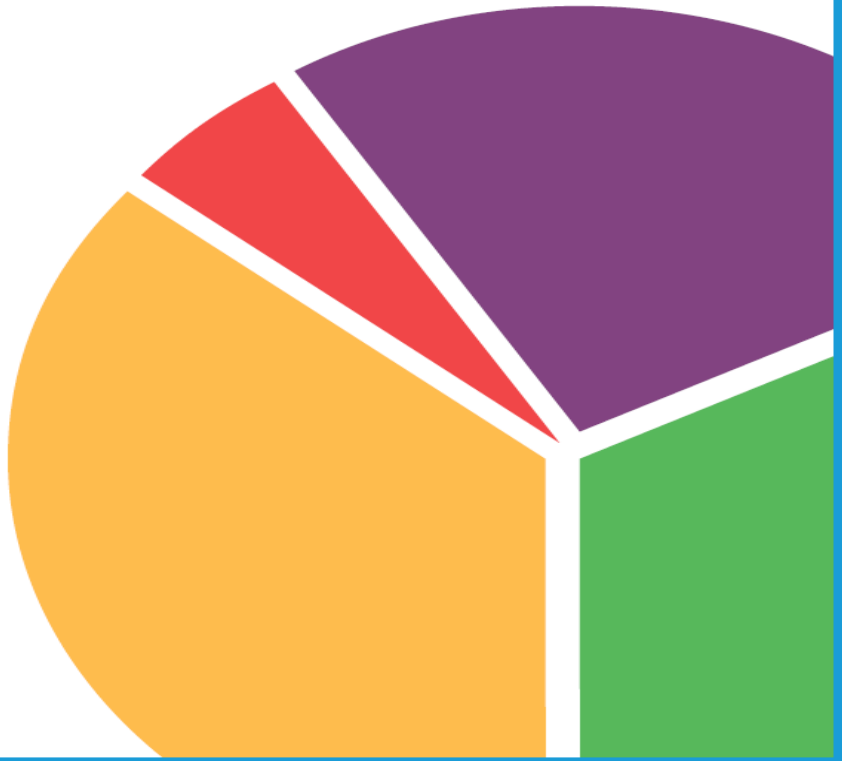
Asset and Fault Management

Live Risk Assessments

PPM Task Management

Usage Evaluation and Flushing

HYDROP | Independent Consultancy Practice
Specialists in the Management of Legionella and Water Quality



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Thanks!

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