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Hydraulic services design for health care installations

DRAFT EDITION – VERSION 001

D. W. CREASEY

Written by
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ABOUT THE AUTHOR

The author David William Creasey was born in 1936 in the Royal Borough of Kensington London England.

In 1948 David took the examination for entry to a technical college and joined Wandsworth Technical College as a full time student of construction industry trades, one of which being selected after the first year of general study.

In 1951 after completing the Technical College Course for Plumbing David joined the firm of Dent & Hellyer as an apprentice.

The, UK apprenticeship system was Trade Union controlled and a four day work week was in place ,with one day at Technical Collage plus three evenings 6pm to 9 pm night school was an integral part of the system for 5 years.

Having completed a Full time Technical College course David entered year two of the apprenticeship training. In year 4 David acquired a First Class pass City and Guilds Intermediate for Plumbers work. In year 5 the Final City and Guilds First Class pass, also the City and Guilds Sanitary and Domestic Engineers Final First Class an examination in theory only and subject which embraced Building Construction Civil Works and Architecture.

At this point in 1955 the apprenticeship had not expired, the CEO of Dent & Hellyer enrolled David into the then new Ordinary National Certificate Course for Building at Brixston School of Building.

In 1957 at 21 David was required to undertake two years National Service in the RAF and enjoyed the time as a radar operator, complete change of training which provided a useful and interesting insight into the world of electronics and electromagnetic forces.

In late 1959 David applied to D Rudd & Partners (who were probably the first all building services Consulting Engineers) for a position with the practice in their Sydney office. It took two years to complete the move and in that period David married and also completed the Higher National Certificate for Public Health Engineering at Willesden Technical College prior to leaving London and joining the Sydney office in December 1961.

Much of the Rudd time in London was spent designing the plumbing services for the Hong Kong Mandarin Hotel for Roger Preston, the New House of Parliament in Lagos Nigeria, also Mona Vale and Port Kembla Hospitals, the Reserve Bank Building and also the State Office Block(then to be the tallest building in Australia at the time).

Arriving in Sydney in 1961 to complete the State office block design and site supervise the Reserve Bank Building plumbing construction for D.Rudd and Partners Consulting Engineers where he eventually became an associate director .

Creasey and Associates was formed in 1975 and it became Creasey Murray and Partners in 1980. The company survived for 19 years until the trade recession aggravated by property development ventures with high debt gearing and high interest rates.

David joined the LHO Group for 8 years, and then SKM for a further 8 years, semi-retirement in 2011, and currently enjoying being back in a smaller consulting practice of A Squared Pty Ltd.

With a career spanning 6 decades, the list of projects (which includes the hydraulics component of the first edition of TS11) is long. The most formidable challenge was without doubt the *fast track, method built* Westmead Teaching Hospital that was completed in 3 years on budget and on time .The most interesting and different was the 1988 Sydney Aquarium .

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CHAPTER 1

1.1 A PHILOSOPHICAL OVERVIEW

The following design notes have been gathered from 60 years of experience and are assembled to raise interest in a few new ideas and question some existing design dogma and also assist the Hydraulic Services Designer as a guide to the task of resolving the specialised design requirements of hydraulic services for health care buildings.

It has been assumed by the writer that the reader has a good understanding of hydraulic services as currently practiced in Australia; the following chapters do regrettably reflect a bias to New South Wales Practice and health standards such as TS11 and for that I apologise, there is reference to overseas practice where this may be of interest and of innovative ideas, where these might stimulate interest to pursue, or reject.

Each chapter of the following (Other than the Notional Hospital) broadly deals with a part of the range of hydraulic services requirements for health care installations that a designer may meet, some issues are raised to question the status quo and promote a new approach, and move beyond the scope of AS/NZS3500.(And the 150 Page National Construction Code Series Volume Three Plumbing Code Australia 2011) Which are, after all is said and done, are the very minimum standard that a designer may provide?

Data on health care from three continents suggests that the hospital is a danger zone for acquired infection, among other issues that are related to the service we design. The availability of hand rinse basins for both staff and patients may reduce the probability of bacteria transfer by contact.

The World Health Organization (WHO) estimates that in developed countries as many as

1 in 10 patients are harmed while receiving care in well-funded and technologically advanced hospital settings. [1]

In the U.S.A 2 million patients will be harmed and 120,000 people will die this year because of preventable adverse events in hospitals. In the UK, the National Health Service estimates 850,000 will be harmed.[2]

The 1995 Quality in Australian Health Care Study (QAHCS) found an adverse-event rate of 16.6% among hospital patients.[3]

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[1]World Health Organization

[2]*Building a Safer NHS for Patients*, Report of the UK Department of Health, April 2001

[3]*Quality of Australian Health Care Study 1995 4* US National Safety Council, 1996

1.2 THE FUTURE

The 21st century, almost certainly will see astounding technological breakthroughs in robotics, biotechnology, nanotechnology computer science, materials development and the generation and use of energy.

The late 20th century economic crisis that still reverberates in our society might be considered as a manifestation of the focus on markets driven by a "Profit First" motivated society, a society that has embraced built in obsolescence and minimised the acceptable life expectancy of plant and products that should and could last the life of the building.

In recent history the construction industry has undertaken large health care projects in concert with governments as P.P.P contracts, the Private Public Partnership involves a tendered conceptual scheme design by consultants followed by a construction phase for the building which is financed and then owned by the Private Consortium who lease the building to the public health system for 25 years and then private ownership is relinquished .In the lease period all running costs and maintenance is provided within the rental cost

There are three aspects of this arrangement which are of interest, the first being that the system is expedient; it gets things moving quickly, the second is that governments do not have to find the investment dollars to satisfy a pressing need for health facilities.

The third and most interesting to the designer, is the renewed appreciation that engineering design to be cost effective, must also be durable, and have a 25 year, or greater life expectancy.

The impact of the 25 year maintenance cost commitment of the initial PPP projects has after a very short time frame emerged and has underlined the real "After cost" of cheap design and products.

It is time that design leans towards incorporating innovation and the core values of:

- The durability of trade skills.
- Design cleverness based on high education standards.
- Incorporating in design as standard practice, monitored consumption data from existing projects.
- Questioning established dogma and industry standards that were framed to aged criteria.
- Losing the fear of innovation in design.
- Adopting design criteria of new materials that may differ from familiar practice.
- Learning from mistakes.

1.3 OTHER DISCIPLINES

Other service disciplines are drawn to the reader's attention in this discourse because it is considered thatat this point in time the interface with other services and computer technology will (Has?) change the manner in which most complex building installations designs are resolved.

Currently in Australia Hydraulic Services are an independent free standing service industry; this is not the case in the UK where the "Building Services Engineer" has been evolved as the Chartered offspring of the Heating and Ventilating industry.

In Australia Hydraulics Consulting has for 50 years drawn its personnel predominantly from the plumbing trade and there are reasonably clearly defined boundaries to the Hydraulic designers scope and technical expertise; the boundaries become a little blurred with Civil Engineering and Mechanical services and Architecture at some interfaces.

A hydraulic service, or Plumbing Designer: - needs to understand a grab bag of Hydraulics Hydrostatics Drafting Computer Science Thermal dynamics Geology Civil Engineering Material Science Landscaping Chemistry Public Health Law and Occupational Health and Safety issues Taxation Public Relations' and not least Management , there are probably a few more that I have forgotten.

The evolution of Hydraulic services design has emerged from the Tradesman's much respected skill. Many of today's Hydraulic Consultants have been harvested from a Plumbing Trade back ground; this bestows an inherent and pragmatic understanding of the construction industry. The increased amount of technical knowledge now required by the hydraulic services designer to deal with, such technology as three dimensional drafting renders it improbable that this situation of recruitment from trade origins will survive. Because other service design disciplines are more advanced in coordination and design presentation technology it becomes more important that the hydraulic services designer becomes intimate with all aspects of the building and the other systems that serve it.

Design innovation and considering the broader aspects of energy utilisation between services should be more than a value management seminar to save dollars.

Regrettably in the consulting industry the reality is that it is a "Challenge" to be an innovator, a minefield of potential litigation and maybe an unwelcome intrusion into the established commercial interests of the market place.

1.4 DISCLAIMER

The views expressed in these chapters are those of the writer, or the contributors, they areoffered without prejudice, in the final analysis the individual hydraulic services designer is solely responsible for the design undertaken and its performance.

Recommendations relating to design or specification as may be noted in the following are based on the writers experience in applications or situations that may differ from those being considered by the reader, no responsibility is taken by the author or implied in respect to the recommendations given or the opinions expressed

1.5 PROBITY

The following material will contain references to manufactured items by name, the writer is expressing his own preferences, not making or implying a recommendation, other than noting a product type, or design, or material. .

1.6 CRITERIA AND AUTHORITIES

The current design standards for Hydraulic services are nominally controlled by the Building Code of Australia and Australian Standard 3500.

The writer uses "nominally" to qualify the recent Sydney Water move to relinquish its historically traditional overseeing role in favour of the NSW Department of Fair Trading and the publication by the Australian Building Codes Board (ABCB) GPO Box 9839 Canberra ACT 2601 of the National Construction Code Series Volume 3 Plumbing Code of Australia 2011.

This may be seen as a move to protect the consumer rather than the prior philosophy which was inherently to protect the Public Utility.

Care should be taken in using AS/NZS 3500 a standard offering little
information concerning trade waste and predominantly focusing on residential buildings and which surprisingly has State and Federal (ACT).

CHAPTER 2 THE HOSPITAL

2.1 HOSPITAL CLASSIFICATION BANDS

Hospitals can be public or private funded, or a combination of both, they vary considerably in size, for the purpose of hospital energy and water consumption and for peer to peer comparison, the NSW Health Department has in place Hospital designations which divide by size and activity as reported via the NSW Health data recording systems. Hospitals fall into one of three bands.

A Large Hospital is defined as those that consume more than 50 million litres of water each year.

A Medium Hospital. A hospital using less than 50 million litres of water each year and is subject to NSW Health internal environmental (Water saving) plans .

The final band comprises, Other Health Facilities, the installations that do not fit into the classic hospital definition.

As a sample, the three Southern Sydney bands of facilities are as follows:

Large Hospital Sites

RPA Hospital

Concord Hospital

Liverpool Hospital

Campbelltown Hospital

Bankstown Hospital

Medium Hospital Sites

Balmain Hospital

Bowral Hospital

Camden Hospital

Canterbury Hospital- Fairfield Hospital Queen Victoria Hospital.

Other Health Facilities

Aged Care and Rehab

Community Health - Dental Health

Drug Health

Mental Health Croydon Health Centre

Marrickville Health Centre

Institute of Forensic Medicine

The designations range from Cottage to Teaching and may have combination of functions such as a Teaching General Hospital that is also a Disaster Hospital and may be attached or affiliated to a university or Clinical Research Centre.

2.2 TYPES OF HOSPITAL

Disaster Hospital

General Hospital

Children's Hospital

Teaching Hospital

Rehabilitation Hospital

Tropical and /or Infectious Diseases

Mental

Military Hospitals

Hospice for terminal cases and geriatric

Maternity

Cancer Care

Prison (Forensic) Hospital

Sports Medicine

2.3 HOSPITAL DEPARTMENTS

The following may be found in a large hospital; however the list is not comprehensive or limited or fixed in time, it will change.

Administration

Child and adolescent mental health unit

Psychiatric emergency care centre (PECC)

Adult mental health acute inpatient unit

Rehabilitation and Allied care unit

Ambulatory Care Unit

Sterile Supply Unit

Cardiac Care

Clinical Information Unit

Ambulatory Mental Health unit

Mental Health (May be a free standing hospital)

Community Health

Drug abuse unit

Day surgery /Procedure unit

Oral Health unit

Emergency Unit

Inpatient accommodation Unit

Multi-purpose service unit

Intensive Care General

Intensive Care Neonatal/Special care nursery

Medical Imaging General

Hospital Morgue Autopsy unit

Woman’s Health and maternity unit

Operating Unit

Oncology

Pediatric /Adolescent Unit

Pathology Unit

Pharmacy Unit

Renal Dialysis unit

Education

Library

Wards (These vary in treatment and occupant types)

Outpatients (Methadone clinics will be separated)

Infectious diseases (Viral Hemorrhaging)

Hydro therapy (Therapy pool)

Clinical and Pathological Research

Accident and Emergency

Nuclear Medicine radiation Oncology & Radiology

University Clinics

Brain Injury Unit

Children's Research Unit

Coroners Court (May be attached)

Forensic Medicine and research (Medicine related to the results of crime, this may be a free standing facility)

Vivariums / Pathogen Free Animal House or compound

Child Minding centre

Care Flight facilities

Supply facilities

Laundry

Kitchens

Thermal Station

Waste station

Building Management Centre and Engineering Maintenance

Decontamination station

Retail marketing

Car parking

The above may be separate defined buildings, or departments within a multi floor high rise installation.

2.4 HEALTH CARE ACRONYMS

The medical profession utilizes nomenclature, acronyms and abbreviations that it is helpful to be familiar with.

The following are taken from the Australian Health Facility Guidelines HCAMC in association with UNSW November 2007.

There is a trend in Health Care terms to embrace new abbreviations, and there can be local differences, it is prudent to review the terms of reference for each project.

ADMIN Administration

ADL Activities of daily living

ANAES Anaesthetic induction room

CBR Chemical biological and radiological agents

CCU Cardiac or Coronary care unit

CLEAN Cleaners room

CLN Clean up room as in an operating suite

CSSU Central Sterilizing supply unit

CT Scan room

CU Clean utility

DIN Dining

DU Dirty Utility (Bed pan urinal bottle washing)

ED Emergency Department

END Endoscope (Any instrument used to obtain a view of the interior of the body Most endoscopes consist of a tube with a light at the end and an optical system /video .Where operating rooms specialize in this procedure hand washing facilities may be required within the OR space and a special endoscope washing bay may be included as an anti-room to the OR)

ENG Engineering and Maintenance

ENS En-Suite

ENT Entrance

EQUIP Equipment room or bay

EWIS Emergency Warning Intercommunication System

GEN general as in GENERAL x ray

HDU high dependency unit

HOLD holding room or bed bay

HVAC Heating Ventilation and Air conditioning

ICU intensive Care Unit (Requirement for RO Water for persons requiring dialyses treatment may be needed at some bed locations)

KIT Kitchen or catering

LDR Labour delivery recovery room in a birthing unit (Placenta disposal unit in Dirty Utility)

LDRP Labour Delivery Recovery Post mortem room within a birthing unit

LIN Linen room or bay

MAMO Mammography X ray examination of the female breast

MATV Master Antenna Television

MRI Magnetic Resonance imaging room (Metal pipes may be critical to screening)

NICU Neonatal Intensive care unit

OR Operating Room (Generally free of sanitary fixtures or floor wastes ,no
pipes permitted in the air space that may need service maintenance or be in conflict with medical lighting or medical gas pendants)

PACU Post Anaesthetic Care Unit within the operating suite, or day procedure unit, or day surgery unit.

PATH Pathology (Waste disposal unit removal of human remains is not permitted)

PPE Personnel protective equipment

REC Records

SCRUB: - Scrub up room in operating unit (Local TMV control by user considered desirable, maintenance access from outside the sterile / medication zone preferred, stainless steel wash trough with two or three positions and scrub timing clock typical. Sensor activated taps a controversial subject, it is recommended to seek user group consensus)

TSSU Theatre Sterilizing Unit

RAD Radiology

ULT Ultra Sound

XRay –X-ray room.

Note: - Abbreviations in Health Care tend to vary and be fashionable; the list given is not comprehensive and may over time change, in design documentation where services drawings show line type with identification of the service, care should be exercised not to duplicate the medical abbreviations noted, or those of other services. It is unfortunate that in Australia we do not have a comprehensive and coordinated legend that encompasses all engineering service disciplines and architecture.

2.5 HOSPITAL ARCHITECTURE

These Chapters target recent vintage and new hospital construction.

However it is possible that designers will encounter older hospital architecture, even those based on the pavilion principle as popularized by Florence Nightingale in 1860.

The Nightingale concept with long wards with a central isle and windows in adjoining walls for cross ventilation, services, toilets and back of house facilities being one end of the ward. The design reflects the Crimea war military approach and the charitable origins of health care as founded in AD1100 by Augustinian monks.

Historically the fundamental criterion of health care was to maximize the institutional efficiency, rather than the predominant concepts of today which considers the health care and wellbeing of the patient as the first priority.

Modern hospital wards, other than specialized wards such as oncology, recovery or intensive care, generally comprise a floor plan with a Centre core for the logistic support features and ward wings at the external walls. Few hospitals in Australia could be considered High Rise most are below or just about at the 25 metre level which coincides with fire service design criteria changes.

Much like the symbolic church cross plan, the effective supervision and essential traffic flow of the high rise hospital wards tends to drive a plan resembling the H with the center zone being the lift core and services risers.

It is an observation that the hospital design is nearly totally driven by the health care needs of the patients, visitors are a tolerated by-product, you may share lifts with patients, or be required to stand aside for the patient's priority. Visitor amenities in hospitals are improving as a commercial enterprise that helps the hospital budget, it brings to the hydraulics designers issues of metering consumables, separation of maintenance and possibly the eventual practicalities of plant removal within the scope of leased property agreements.

The external wing wards of many recent history hospitals, will have a floor plan allocated as 4 bed 2 bed or single bed wards, the current policy is single bed wards with en-suite accommodation that provides added hand washing facilities and an improved containment of infection by human contact from the room environment.

Most ward plans have two inboard corridors of bed transportable width, each side of the center zone area, service access to en-suite toilet service ducts and center zone support hydraulics being from the corridors. Each ward is provided with a en-suite and a ward basin for staff and patients use, corridors will be provide with strategic recesses for medical basins, medication trolley bays and similar support items. The ratio of staff to hand wash basins has grown in recent history as a measure to combat transferred infection by contact.

Fire stairs may be located at the extremities of the central corridors; the center core usually of two wards wings, will accommodate the arterial service ducts and minor local plant. The back of house center zone may house, a flower room, cleaners facilities, staff toilets, assisted bathroom, clean and dirty utilities with sterilizers, bed pan washers, flushing sink, the nurses' station which may incorporate a pneumatic tube station for specialized treatment wards, wellness room's with balconies and beverage facilities for patients and visitors, possibly accommodation for overnight on call staff, fire escapes, and fire hydrants and fire hose reels, at the midpoint, lifts for bed patients and conventional traffic. A lift to a roof helicopter landing zone may be included.

The ward bed head consul in wards will be a matrix of services connections ranging from communications of all types including TV, medical telemetry, medical gases, medical air and suction, possibly tool air, possibly ultra-pure water for dialysis treatment and a waste point also for dialysis waste products, in cardiac care wards for critical care cases a bedside fold away toilet with integral basin may be provided to service a patient connected to telemetry monitoring systems.

Consulting rooms and treatment rooms will be fitted with a medical basin.

Operating theatres are surprisingly baron of all but the ceiling mounted articulated multi service pendant and operating light fitting. O.R. Plumbing fixtures may include a medical basin, but often fixtures are contained in the adjacent surgeons scrub up area, and pre-operation area, the exception to this may be specialised operating theatres for colostomy and other specialised surgical procedures.

An unconditional apology is made to the Architectural fraternity for the writer's attempts in this field in the Notional Hospital Chapter.

Footnote: - When undertaking a site survey of an existing hospital, the investigation may require entry into congested duct areas or similar such services voids, hospitals that provide methadone treatment tend to attract anti-social patients with behaviour problems; these include the concealment of hypodermic syringe needles in a manner that can result in a needle stick injury for the unwary investigator.

2.6 AUSTRALIAN STANDARD 1668 PART 2 FLOOR AREAS PER PERSON M²/PERSON

Line	Area type	M²/ Person	Notes
1	Foyer	2	
2	Hallways	2	For shops Restaurants Utility rooms Kitchens
3	Single and dual bedrooms	6.6	Bathrooms refer to AS1668 Hotels
4	Wards	5	
5	Food service centers	5	
6	Operating rooms	-	Area varies for specialised operations
7	Delivery rooms	-	Not defined by the standard
8	Ready rooms Recovery rooms	-	Not defined by the standard
9	Amphi theatres	1	
10	Physical therapy areas	5	
11	Autopsy rooms	10	

12	Incinerator service areas	-	
13	Laboratory Light duty no chemical	10	
14	Laboratory chemical	10	
15	Laboratory heavy duty	10	
16	Laboratory Radio isotope /biological	10	
17	Machine shop	10	
18	Dark room .Spectroscopy rooms	10	
19	Animal rooms	5	For staff areas

2.7 FUNCTION OF A DISASTER HOSPITAL

The designation disaster Hospital can be applied to any large hospital that has a broad spread of health care capacity and is geographically suitable to serve large population centers; the Disaster role is recognising and preparing for eventualities that will be an inevitable public reaction in situations such as described in the following.

Earthquake (Earthquake Code AS1170.4 refer to seismic restraint)

Bushfire

Extreme weather conditions (Flooding**)**

Civil unrest

Aircraft, Road or Rail disaster

International pandemic

Terrorist attack

In disaster events were there could be high numbers of injured or sick, the Hospital becomes the focal point for assistance and it requires considered reserves in its services to perform this function.

The Government of NSW, probably other states as well, has recognised this potential need and the service increase that would be placed upon the hospital system and its resources.

The location of the Disaster Hospital will be determined by the Central Health authority, the hospital will be accessible to population centers, and in some cases industrial areas where high hazard industries pose a risk to public health.

The disaster hospital will require the hydraulic services listed below that may not be required in other hospitals.

Decontamination bay

Domestic Hot and Cold Water Storage.

Water storage for critical plant cooling (Data systems)

Rain water harvesting.

Solar collection.

Emergency on site waste water treatment and re-use.

Emergency Power Generation from natural gas with options for onsite fuel (LPG. Diesel Oil) with waste heat utilisation for critical services.

Stand-by power to critical plant. (Not to be confused with Essential supplies for Fire and Life safety as determined by the BCA)

Viral haemorrhaging diseases and similar, isolation facilities.

The decontamination bay provision could be considered a facility at any hospital that is located near an industrial area, chemical works or similar potential risk. The decontamination bay will comprise a dedicated bay for hosing down ambulance vehicles and deluge showers with eye wash facilities for washing down Para-Medics in protective clothing.

The waste line from the dedicated bay should not act as drainage for rainwater, if unavoidable in a retro fit situation consideration could be given to the use of a Fox diversion valve drainage outlet.

The waste water from a hose down bay must be directed to an intractable waste holding vessel which should be free standing and not interface with ground water, the vessel must be equipped with sample test connections, high level alarm warning, a valved connection to the sanitary drainage system that is locked closed and may only be activated to open with approval from the Public Utility who is responsible for the sewer.

A minimum 65mm diameter pump out connection is required as a tanker connection to remove and dispose of waste water that, subsequent to testing, is not considered acceptable for discharge to the sewer system. Contamination may be Chemical, Biological or Radiation. Impracticable waste vessels must be chemically resistant and suitable for high dose chlorine sterilization and sized in accordance with the number of vehicles and staff to wash down; consideration of the tanker vehicle size for waste removal is also required. Storage volumes of 10,000 litres are common. Integral pumps are not recommended.

2.8 VIRAL HAEMORRHAGING FEVERS (V.H.F)

VHF

Ebola

Hanta virus pulmonary syndrome

Small Pox

SARS or similar

Multi-resistant Tuberculosis

Potential bio-terrorist organisms

The above group and possibly others that remain to be discovered are reported to Health Authorities as quarantinable infectious diseases and Viral Hemorrhagic fevers that are treated in Ultra Isolation Facilities and are built as a level 6 intensive care units.

Ebola: - was co-discovered in 1976 by Peter Piot. First located near the Ebola River valley in Zaire, Africa. The disease is a virus infection that originates with a week of fever and diarrhoea followed by a scabby rash and mass bleeding and the breakdown of all major organs. Ebola kills 90% of persons infected and is one of the most lethal infectious pathogens known.

The rapid movement of air travel has broadened the potential range of this virus. Selected Hospitals, probably a Disaster designated Hospital are equipped with a Viral Haemorrhaging disease isolation suite to contain the spread of this infectious virus.

2.9 THE ISOLATION SUITE

The isolation suite / ward will have negative air pressure air conditioning to ensure a flow of clean air into the patient's area; the hydraulics designer must check that the trap seal depths are sufficient to resist imposed air conditions and that any condensate drainage from fan coil units serving the room are drained to a system connected to the virus destruction process. The patient's bodily fluids and waste products, AC condensate from room air and nursing staff wash water is subjected to high temperature sterilisation prior to disposal to the sewerage system.

A sterilisation system may comprise three jacketed grade 316 or better stainless steel waste water container cylinders, duty filling –duty sterilizing – standby, are required.

The contents of each container are heated to 85 degrees Celsius for a predetermined time frame and released via a system of stainless steel waste pipe (Blucher) that will ensure cooling prior to discharge; a confluence with a reliable ambient temperature waste water flow may be required. Ventilation of the sanitary system is critical to avoid air borne virus release.

The air flow entering the waste system must be in one direction only.

The air inflow is to replace the exit of the sterilised water volume leaving the system.

The potential air outflow is when the cylinders are filling, this displaced air must be UV or Activated carbon filter treated or captured by inflating collapsible plastic vent bags that automatically deflate on the water volume exit, expert medical advice regarding transfer of air borne infection is recommended.

Floor drains and the added pipe of local branch venting should be avoided.

Expansion and contraction of metal and heat resistant plastic pipes and plant reacting to high temperatures require careful consideration, as do control systems and the O.H &S issues of maintenance.

The system must be fail safe and automatic in operation, valves in the waste system should be knife edged gate with pneumatic activating cylinders, and temperature monitoring and alarms are required.

Readers should note that at the time of writing the **Ebola system use is a rare event** and has only been used in Australia for suspect cases to date

The Waste sterilisation system will be a by-pass hydraulics arrangement allowing more conventional use of the isolation ward.

To ensure that the system is available for emergency use a test routine should be in place.

Signage warning of Infection danger and high heat are required, if used the waste water authority should be informed of the event and the risk potential.

CHAPTER 3 SCOPE

3.1 HYDRAULIC SERVICES SCOPE

The following list of services is a broad outline of the various sub-systems that can comprise the work of the hydraulics designer and the Plumbing contractor.

Sanitary Drainage

Sanitary Plumbing

Fixtures and Fittings

Trade Waste plumbing and drainage

Rainwater collection and harvesting

Hot Warm and Cold water services

Energy and conservation, solar, waste heat recovery.

Ultra-Pure Water

Therapy pools and hydrotherapy, this will be dependent on the designer's experience

Pathogen Free animal breeding and vivariums services

Irrigation (Irrigation may be a feature of large campus hospitals elsewhere the landscaper should utilize drought resistant indigenous planting) .

Construction phase services Comprising Soil erosion measures and containment of surface water pollution by construction debris.

Fire hydrant services for the construction period and site workers sanitary accommodation and amenities, the diversion of existing public utilities have not been included.

Final Fire hydrant and fire hose reel services have not been included.

Medical gases have not been included.

3.2 SCOPE CREEP

An interesting observation of the scope of a hydraulic services design is its inclination to expand informally under the influence of a time and the fee consuming phenomena known as "Scope Creep".

The Hydraulic Consultant is advised that any Fee proposal should be accompanied by confirmation of the work to be undertaken as a contract obligation and which is included in the "Designers Professional Indemnity Insurance" cover, also confirm the consumables (Documents) to be supplied.

Itemise any departures from things that may be considered Industry practice and ensure that the tender offer gives notification of the exclusions that are not included in the offer.

Generally the conditions of the commission will set out the document production methodology, the design, as a document package is sold at an agreed fee return; the “Intellectual Property” that comprises the design remains the designers, unless otherwise agreed in the contract.

Industry practice varies; in the experience of the writer following services could be considered added value and not a standard inclusion of a hydraulic services design fee return, unless such is agreed

1) Site environmental protection during the construction stage is not an automatic inclusion of the design work to be undertaken.

2) Sanitary fixtures are located, selected and specified by the Architect .The responsibility for space compliance is the responsibility of the architects. E.G. Disabled persons access

3) The storage and security of the supplied sanitary ware and brass ware (taps) is the sole responsibility of the Building Contractor.

4) Gutters and down pipes are within the contractual scope of the Roofer and the design scope of the Architect.

5) The provision of accurate levels on site is the Building Contractors responsibility; the provision of levels and dimensions on drawings is the Architects responsibility.

6) The determination of ground water levels and the rate of seepage water removal that will be required is the Work of the Geotechnical Engineer and Structural Engineer

7) The Design of On Site Detention volumes and maximum discharge rates to the Public Utility Stormwater Drainage System is Civil Engineering work and the construction Builders work.

8) The determination and design of Overland Flood Paths, is the work of the Civil Engineer

9) The Design of Rainwater harvesting storage vessels is Civil Engineering work, the installation Builders work.

10) The Design of structure to support the imposed load of hydraulics plant such as tanks is the responsibility of the Structural Engineer

11) The location and dimensioning of perforations for services through structure and building fabric

12) The location of access doors in building fabric for maintenance purposes and more significantly the inspection of fire collars.

13) The Design and statutory approval of Grey or Black water treatment plant is the work of the Environmental Engineer. The installation responsibility Specialist Contractors appropriately qualified

14) The provision of Electrical Energy and Control systems including Building Management systems and sensors is the work of the Electrical Engineer.

15) The discharge and consumption requirement of Evaporative cooling systems is the responsibility of the Mechanical Services Engineer.

16) The determination of Gas loads required by Comfort heating systems or other processes is the responsibility of the Mechanical Services Engineer.

17) The Design and Installation of Fire Services including Construction Stage protection may be by the Fire Services Engineer or the Hydraulics Services Consultant dependent on the nature of the system.

18) The determination of water quantities and the distribution system design required for irrigation purposes is the responsibility of the Landscape Gardening Architect.

19) The final agreement and provision of Process data for Trade Waste pre-treatment approval and Payment of all charges is the responsibility of the building owner

20) The Design of Therapy Pool water treatment and Distribution systems is Negotiable.

21) The Design of Water Features is Negotiable.
22) The Design of Ultra-Pure Water Systems is Negotiable.

(23) Redesign .It is important to secure an agreement in respect to Frozen Architectural Drawings and abortive design work that becomes a cost penalty of late change .The restructuring of completed design work can have extensive cost implications.

3.2 SCOPE CREEP COMMENT

The forgoing is a prodigious list, and there may be other items not included.

However in the real world beyond these Chapters the Hydraulics Designer has to wrestle with the dichotomy of presenting an attractive tender offer that appears competitive and pro-active.

The desire not to alienate the clients good will with lists of negative issues may be considered, and reasonably so, not to be a “Good look”

In the final analysis the consultant’s judgement on his ability should be based on his qualifications, and his professional indemnity cover, in marginal areas of expertise it can be prudent to include an extension of insurance cover to include a sub-consulting fee for expert advice in concept design, an example, far removed from Health care, is the design of Aquariums and marine biology where having an expert on board was a major PR advantage.

3.4 THE WASHING HABIT

In the residential environment, where most of us spend our leisure time, the washing habit is, very much a habit, a regular and consistent event being fairly well regulated, there are probably few priorities in hygiene, it’s a total system, one would expect that washing after using the toilet would rate high, if priorities do exist, the important need to breach the bacteria path from the bodies waste exit path and food entry path, and to minimise the contact transfer of bacteria, such as “e” coli to yourself and others.

In the Hospital environment, more bacteria than “e” coli are lurking as potential contacts looking for transport to a new venue.

Washing after working , after ,and before sleeping , cleaning teeth after eating ,washing after defecation and urination ,washing prior to contact with food ,or the utensils used for cooking food , and washing clothing and cleaning the habitat ,are well established routines in our society.

The hydraulic system that supplies the water for residential use can be dormant in the pipes and water heater for long periods of the day; everybody in the residence is somewhere else, working, learning, or whatever they do including some washing.

The hydraulic system has peaks and troughs down to zero loads, the means of predicting the peaks, or the most probable peak use, is the system "diversity".

In plumbing services design, diversity is calculated by application of formula historically evolved from original work by Dr Roy Hunter and also Bull based on the prior and broader application work by a French Mathematician.

The AS/NZS3500 fixture loading unit system that we currently use is I believe based on the work noted, it appears to be focused on residential based design data.The conflict found in site measured flow rates of buildings constructed in the 1960 to 1975 era, compared with design rates would appear to result from systems designed prior to the AS/NZS 3500 Loading Unit system? Because of the significant discrepancies, it was considered desirable to investigate diversity history and compare the various systems results when applied to a Notional Hospital, this was undertaken by Roger Gibson who gave the Loading System a clean Bill of Health, at least until more data is available.

Most research shows that residential hydraulic cold services are seldom undersized for the building, but there can be problems of limited supply in the individual dwelling hot water system. (As we discover when relatives stay over) this being driven more by economics than hydraulic sizing diversity. In Health Care the washing dogma noted for residential also applies. However there is in health care another much bigger and very well catered for, washing load, this difference may only affect the average flow rate and not the peaks?

In health care, the need exists to remove bacteria contact between patients and staff, also the need to sterilize bed pans and urine bottles utensils and instruments. (Refer to Clean Steam)

The need exists to remove bacteria from hands after using a dirty Utility facility.

There is a need to be fastidious in Laboratories dealing with bacteria and the same need to be fastidious when undertaking medical procedures of any type.

The hospital sanitary fixtures are provided in a much greater ratio to the people using them, than is the case for residential.

The Chapter dealing with the **Notional Hospital** includes a diversity comparison between various systems of calculating diversity. The Notional Hospital is hypothetical not covered by AS/NZS 3500 any part

To ascertain a significant difference between the peak demands of Hospitals and Residential Buildings would require measurement and survey studies of many sample buildings, a task which is regrettably beyond the scope of this publication.

CHAPTER 4 SANITARY DRAINAGE

4.1 NATIONAL PLUMBING AND DRAINAGE CODE AS/NZS 3500

The regulations that currently control Sanitary Drainage design in Australia and NZ are AS/NZS 3500 and State variations which are published as the Australian Building Codes Board (ABCB) GPO Box 9839 Canberra ACT 2601 of the National Construction Code Series Volume 3 Plumbing Code of Australia 2011 (Note The ACT ACTEW Authority has local variations to The National Plumbing Code)

As noted previously, recent legislation has altered the administration of Plumbing Drainage and hydraulic services regulations from Sydney Water to The Department of Fair Trading. These notes give some pointers regarding overseas projects**.** However for overseas work the designer must research the requirements of the local authority, the ex-colonies and protectorates of prior imperial development have often inherited the Public Health rules of European countries, in some cases these rules have been modified to meet local conditions, the two pipe system being a typical example.

4.2 DEFINITION OF DRAINAGE AND SEWERS

There is often some confusion on drawings as to which pipe is a drain and which is a sewer .The historical definition of drainage pipes are those pipes, which reside below the surface of the ground. Modern practice has a broader understanding which includes aerial drainage

Sydney Authorities permit Drainage Principles to be used above ground to a maximum of four levels. The basis of this demarcation is not given by the standard.

Drainage venting rules can be more cost effective than sanitary plumbing rules, also because of the larger production volume, the market cost of 100 mm diameter PVC pipe and fittings is lower than 65 mm diameter ,the permissible gradients for 100 mm diameter drainage are less , the potential to add fixtures is significantly improved ,the noise emission potential is lower and the potential to clear blockages in a 100 mm diameter pipe is better ,there is a good commercial and practical case for using 100 mm pipe as standard where PVC is the selected material.

The definition of a sewer and drain is considered to be a valid issue because the term is often generalised in error. A sewer is a sanitary drainage system that conveys waste water from more than one property; sewers may be private or publicly owned by a Public Utility. Domestic sewers contain about 3% of their volume as solid organic matter

4.3 SURVEY AND DATUMS

It is an extremely useful drainage cross reference for the drainage system design on very large projects to relate to an internationally, or at least nationally recognised grid survey system of X –Y and Z references Also referred to as Easting's Northing's and Datum point, these vary considerably locally and Nationally, this information could be correlated in the National Plumbing and Drainage Code, regrettably this is not the case.

The survey grid system may be based on the NATO military Geo-ref world grid , or a similar satellite originated civil system of 100 metre squares sub divided by the metric method into ever decreasing grids and with the NATO system using a NATO Phonetic Alpha/numeric reference E.G. Charlie Gulf 4.5 - 3.6

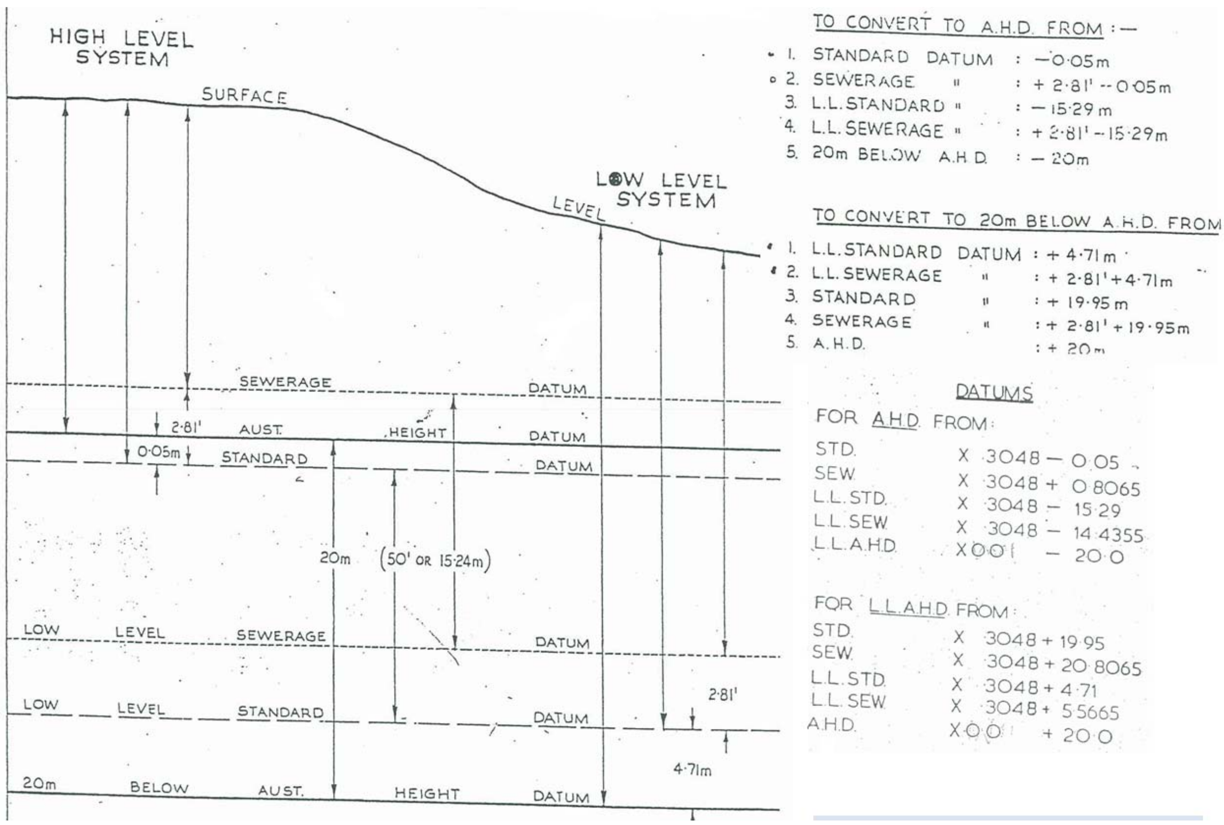
Where the Architect has used a discrete and geometrically convenient structural / architectural grid and RL (Reduced Level) that is serviceable only within the boundaries of the architectural envelope it will be necessary to resolve a conversion system (By C.A.D) that will translate those levels and grids to the levels used by the local authorities for property sub-division and services distribution in the public domain.

4.4 SYDNEY DATUM HISTORY

The Datum system used in Sydney varies considerably having evolved historically before being standardised, conversion data is available.

The North wall of the Lands Department has a brass plug Bench mark (A reference Datum) which has a primary value of 8.775A.H.Datum The zero point for AHD is the adjusted mean sea level defined by tide gauges around

the Australian Continent in 1971, this is 0.893 above the Standard Datum
that was defined by the tide gauge at Fort Denison in 1897 and as used by Military Topographical (NSW) Department of Main Roads (Obsolete name) Public Works Department (Obsolete name) Dam Construction. Department of Railways (Obsolete name) since 1940 Lands Department Survey branch and Sydney Water Board (Obsolete name) between 1-1-1963 & 1-5-1974) The Hydro graphic Zero datum NSW Maritime Services Board Indian Springs Low water Primary ref from 1-1-1954 For a graphic representation of this data refer Relative Value of Levels Primary reference station Sydney M Higgins Survey Branch Drafting manual Engineering survey plans diagram 22 Drawing WBS 1623 dated 1982 Metropolitan Water Sewerage and Drainage Board Sydney NSW .



4.5 FUNCTION OF SANITARY DRAINAGE

Sanitary Drainage is a water based transport system for organic waste comprising human excreta urine and the associated hygiene products such as toilet paper and in hospitals the probability of some surgical dressings, other waste material entering the drainage system may originate at kitchens or other Heath Care processes

When non domestic wastes are discharged to the drainage system / sewer, they are described as Trade Waste .It shall be noted that health care Trade Waste is dealt with in these notes; regulations are not contained within the scope of AS3500 National Plumbing code.

To maintain the operation of the hospital drainage system it requires good physical access for the remove chokes, also drainage must be of a minimum diameter. Traditionally drainage is 100-mm believed to originate from the practical consideration to facilitate the entry of the human hand and cleaning tools, theoretically drains run half full to provide the optimum water depth for transporting solids materials.

4.6 DRY DRAIN PHENOMENA

Reductions in WC Pan flushing water volumes (9 to 3 litres) are considered to be related to the Dry Drain phenomena and an increased incidence of drain chokes in hospitals, this subject has been investigated by the late. DrJ A Swaffield and Dr R H Wakelin and B S T Marriot it was presented as a research paper at Brunel University 1977. (And more recently in 2011 at the Sydney Opera House by a group from the U.K)

The Swaffield / Wakelin paper is recommended reading, the testing procedure targeted a hospital situation where dressings enter the waste system, in this case a maternity pad 300mm long 50 x 30 mm cross section absorbing 300 cc of water, three zones of influence were recognised ,and the tests identified the need to fine tune the design of the flushing hydraulics.

Dry drain is associated with the following undesirable design features in the drainage system ,notably the use of obvert entry junctions and 92.5 degree level invert junctions ,recommending that these configurations should be avoided.

Note: -92.5 degree entry junctions is not normal Australian practice.

Bearing in mind the recent trend to harvest roof rain water and use this captured water for flushing WC pans, there would seem to be a need to re-focus on the priorities of this aspect of hydraulics systems, and the other possibility and feasibility of recycling treated grey or black water as a viable pathogen free flushing system water source.

Refer Royal Children's Hospital Melbourne Building Services Tri Generation and Energy Efficiency Norman Disney & Young Presented by Ashley Marriott November 18 2010.

4.7 HYDROSTATICS

Drainage is in effect a hydrostatic system, the driving energy being gravity promoted by the inclination (Grade or fall) of the pipe.

There is an important relationship between the air and water content of drainage systems. Drains for the removal of solid material, should run half full, at a self-cleansing velocity (0.6 metres/second) for maximum efficiency.

Bearing in mind that much of the drainage system may not be accepting solids materials, there may be a reasonable argument for reducing the grades of drains which accept only waste water from waste fixtures. E.G. Laboratory wastes.

The National Plumbing and Drainage code lays down minimum grades and loads for pipes of various internal diameters.

Generally 1.6 % (1in 60) is considered the minimum acceptable grade to convey suspended solids in a 100 mm diameter wastewater drain , in waste only systems where solids are not present 1% grade would appear more logical .

4.8 PLUMBING AND DRAINAGE A BRIEF HISTORY

Rudimentary plumbing has been evidenced by archaeological discoveries back to 10,000 BC In the Outer Hebrides, our current systems are descended from sewers which became relevant in the cities of Western Europe at the beginning of the 18^{th} century ,discovered by statistical research as a means to improve hygienic conditions in dense populations' and eradicate bubonic plague and cholera. The writer suspects that 100 mm (4 inch) diameter drains evolved from the practical relationship with access and the human hand, generally the principle of. "If it's working well", don't fix it, served small bore drainage and plumbing well for two centuries.

In more recent history the drainage systems in the UK, prior to 1936 comprised a two-pipe system of drainage and plumbing above ground, waste products being separated by gully traps from soil fixtures such as WC pans and urinals.

The principle of the two-pipe system is a means of minimising the soil system which has a content of organic (human excreta) matter that contain dangerous e coli pathogens.

The Two pipe systems have been replaced all most universally (UK. USA. NZ.Australia) by the one pipe system with 75 mm water seal traps (Other than pans) and venting variations.

The two pipe system is currently standard practice in the .United Arab Emirates (UAE) the consideration of containing grey water for recycling has motivated this, it is probable that this logic will extend more universally into design practice as the pursuit of water conservation becomes more of an issue and the proposition of utilizing black or grey water in conjunction with membrane, or reverse osmosis purification technology can be considered substantially risk free and commercially viable.

NOTE PORT MACQUARIE HASTINGS RIVER COUNCIL RETICULATES MEMBRANE TREATED BLACK WATER VIA AN IRRIGATION MAINS SYSTEM TO SERVICE PUBLIC AND SCHOOL PLAYING FIELDS AS A MEANS OF EFFLUENT DISPOSAL FROM A SEWERAGE TREATMENT WORKS OF SIGNIFICANT CAPACITY.

The apparent advantage of treating grey water over Black water with membrane technology is more related to cultural resistance than an engineering reality, the recent Royal Children's Hospital Melbourne has utilized black water plant on the basis of a plant that will process 180,000 litres/day (500 l/bed/day) for 357 beds and an estimated 35700 admissions per year 166000 outpatients. The water produced by the plant is high quality, in deference to prudent design the water is used for flushing and secondary water supply systems .The designers Norman Disney & Young are to be congratulated for their skill, and confidence.

4.9 ACCESS TO DRAINAGE

Access generally and to the drainage and plumbing pipe in a hospital is an essential and fundamental requirement of hospital architecture that hopes to facilitate with ease and modest cost, future drainage modification and maintenance.

Slab on ground construction that entombs drainage below structurally sensitive concrete may be appropriate for commercial driven residential development but it is a design anathema to buildings that need flexibility with minimal disruption.

The area below services to medical areas should be of a utility nature such as car parking or, low priority support areas, or a services crawl space with arterial tunnels to facilitate major distribution and escape paths in an emergency. (Westmead Teaching hospital is a typical application of this approach).

For maintenance, below ground drainage to WC pans should have access from at least one end of the connection, that connection should be as straight as possible.

For high level suspended drainage, maintenance personnel cannot work in compliance with OH&S requirements from a ladder to remove inspection doors in flooded pipes that are at high level in the ceiling space or even in a duct, of an occupied floor.

The design must recognise where in a plumbing system a choke is probable and where in the system will a flooded pipe be first expressed , for any branch soil pipe the space between the WC pan junction and the stack is the probable choke zone and the shower or floor waste is the point where the choke will be revealed .P trap WC pans with above floor access are desirable but not always practical ,a clean out cap adjacent to the WC is a practical proposition but the cap may be an impediment to cleaning .

The use of a Floor drain with the removable water seal that gives rodding access to the drain is considered the most practical resolution of access ,the floor waste or shower outlet being located to maximise access for rodding the system to the stack.

It is noted that the access is best provided in a mechanically ventilated toilet space which minimises air borne contamination to the patient care zone.

The traditional Inspection manhole shaft with step irons and open channel drains, is a confined spaces hazard that can be avoided by designing systems to accommodate Closed Circuit television inspection systems, mechanical cleaning and choke removal systems and in the case of severe damage, relining systems .

Access from the surface designed to complement modern robotic technology has superseded man access, however our current design practices have not quite come to terms with this eventuality.

4.10 DRAINAGE SURCHARGE

Surcharging due to a choke in a branch drainage system will, as noted, in most cases be first expressed at floor wastes, because in most systems they are the lowest fixture connection.

In the main drain surcharge should be expressed at the ORG (overflow relief gully), the drainage design code embodies protective clauses intended to limit surcharge to an exit path external to the building and for this reason the ORG must be located externally, preferably joining the drainage system in a location which will a choke in the sewer and / or the drainage system, the ORG flood level being lower than any internal surcharge flood path. Where the building levels prevent compliance with the Relief Gully rules, the Code permits the installation of a reflux valve. Note: - Reflux valves for this purpose are not accepted by the Drainage authority in Canberra refer to rule 21 The Federal Capital Authority not accepting a Federal Code could be considered a strange anomaly?

It is not considered good practice to pass WC pan drainage through Reflux valves unless this is unavoidable.

Designers should consider a reflux valve serving the low and surcharge vulnerable floor wastes; the flooding level of the WC pan will in many cases be compliant with the Code, therefore it is desirable to limit reflux valve protection only to the vulnerable floor wastes.

4.11 STACK SURCHARGE

Where vertical plumbing stacks serving upper floors join drainage it is considered dubious practice to also join that drain with ground floor fixtures that could in the event of a choke be pressurized by the waste water flow from stacks and fixtures on floors above.

The NSW Code requires reflux valves at pump wet well and ejector installations to protect basement pumped fixtures from the discharges from upper levels, how this rule works in practice to prevent flooding from the discharge up stream of the closed reflux valve is not addressed in the standard, it is probable that the reflux valve will be the cause of more problems than it prevents.

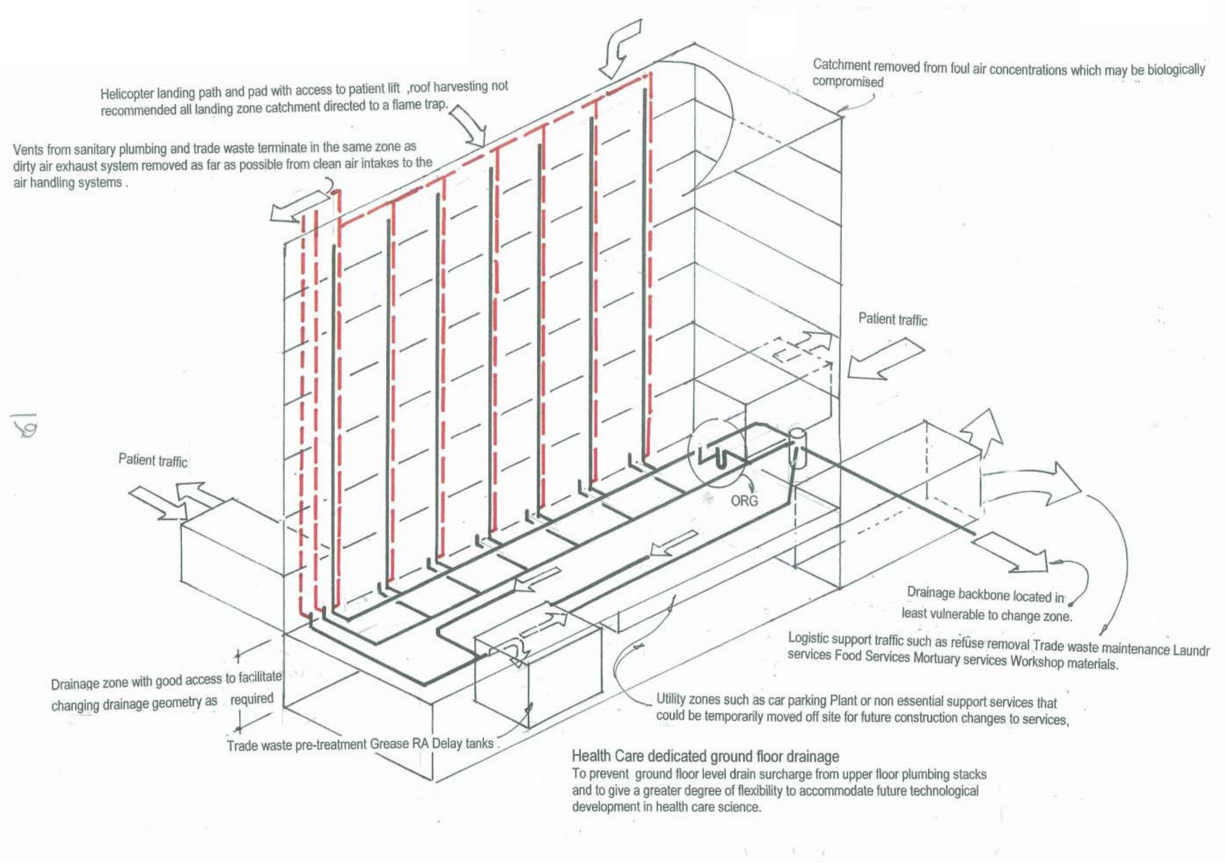
The writer considers it good design practice to separate ground floor drainage fixtures from any stacks and upper floor fixtures by means of a dedicated drainage line, if possible branching from the combined main drain in close proximity to the ORG.

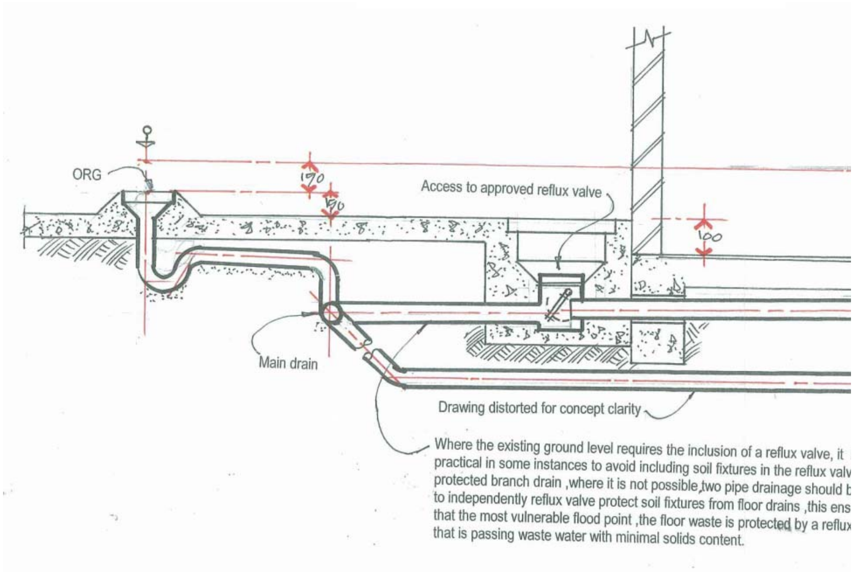
Ground floor drainage being separated and vented at the drains extremity to join a vent stack at a minimum one floor level above the ground, this arrangement removes the hazard of surcharge at the vulnerable ground floor fixtures.

Note:-Regulations in the UAE require that drainage shall be similar to the manner described.

4.12 COOLING TOWER DRAINAGE SURCHARGE

Where the building has a large cooling tower it will require a bleed drain and total drain down facility ,the cooling tower is processing a phase change cooling effect of evaporation from a liquid to a vapour ,in this process any salts in the water remain in the reduced quantity of the condenser water system ,the condenser water system may be a direct system not using a heat exchanger and using mild steel pipe work which is vulnerable to corrosion and may require chemical additives to control this .In addition the cooling tower is a devise that processes water at warm ,near blood heat temperatures ,it is a vapour generator , it is particularly vulnerable to Legionella contamination and if infected will effectively distribute the Legionella bacteria over a considerable area .The condenser water system and cooling tower may need chlorine treatment to eradicate biological activity in the water content ,it may need draining over a short time frame ,in anticipation of these events and the chemical and biological hazards associated with the waste condensate water ,the hydraulic services designer must consider the trade waste issues and health risk has been addressed by a suitably sized drain that will not cause surcharge ,and the chemical content that must be diluted effectively .





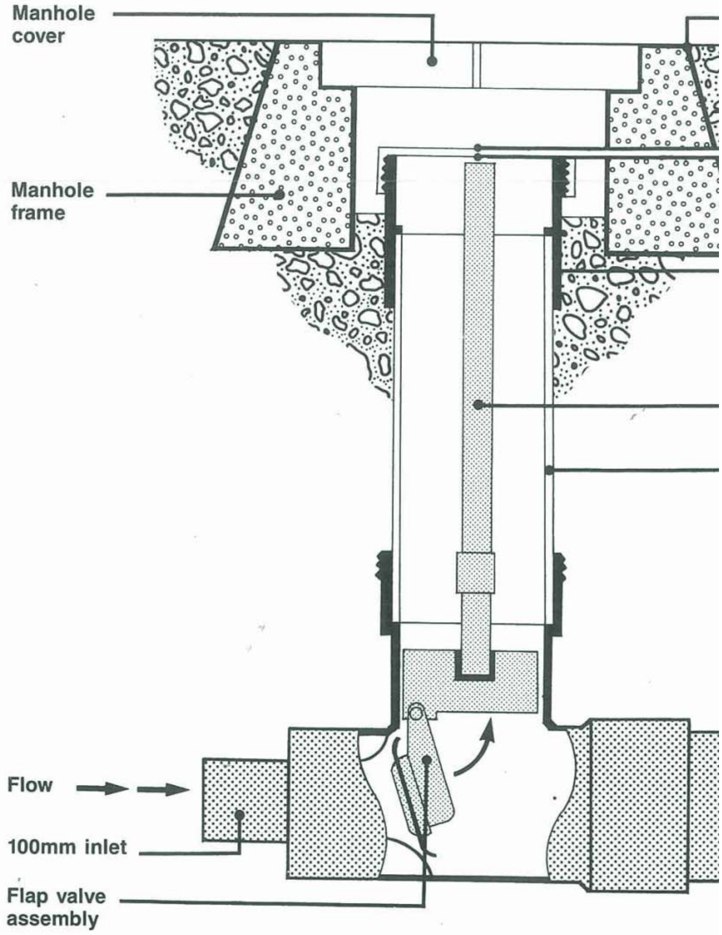
Health Care Drainage Flood vulnerable floor drains

Hardie iplex MK II Reflu

Cat. No. ZRV5100100 Pat. No. 55

The MK II Hardie Iplex reflux valve is designed to make even easier the removal of the flap valve assembly for plumbing maintenance. Simply remove the inspection cap and pull out the valve using the handle attached to the flap valve assembly.
NO TWISTING IS NECESSARY.

Insertion of the
simple and can l
direction. The MK
installed as sup
ground level by
instructions belov



- ☐ Remove 150mm threaded cap.
- ☐ Solvent weld length of 150mm sewer pipe into socket.
- ☐ Finish with 150mm threaded coupling.
- ☐ Extend handl pipe. Cut to 150mm threa
- ☐ Replace 150n

059

4.13 U.K PRACTICE

Where sanitary drainage work is being designed for an overseas project the local regulations should be checked and complied with.

It is probable that in Commonwealth Countries and former colonies and protectorates the Public Health regulations are based on former or current UK Practice and British Standards.

Sanitary Drainage in the UAR is split as a two pipe system soil and waste to the outfall, dedicated drains are required for ground floor dependent upon the number of upper floors. In practice this means that drainage can comprise four pipes, the soil system and waste system from the ground floor and the soil system and waste system for the stacks from upper floors.

Sanitary Drainage Practice for drainage in the UK is similar in concept to Australian practice, there are however some differences.

Drainage in the UK is generally more accessible to the surface, drainage pipes run from surface access pit to surface access pit, all branch connections to the main drain enter at a surface access pit. This approach might be attributable to the more dense buildings and higher proportion of paved surfaces ,the UK proposition of access chambers at all junctions and direction changes certainly changes the geometry of drainage compared with that compliant to AS/NZS3500.

Recent developments in the UK America and Australia of mechanical cleaning tools and closed circuit television survey equipment and relining methods, coupled with stringent O H & S regulations to protect personnel entering and working in confined spaces is considered to be sufficient motivation to move away from man access.

4.14 EUROPEAN PIPE SIZES

VCP manufactured to European Standard BS EN 295:1991 and British Standard BS 65:1988 and BS 65:1991

Crushing Strength kN/m

100-mm Joint type E 40 kN/m 2.0 Bending moment resistance kN/m Strength Class

150-mm 40 5.0

200-mm 48 7.4 240

225-mm 45 9.0 200

250-mm 60 - 240

300-mm 72 - 240

Note: - Metric sizes such as 200-mm and 250-mm diameter are not dealt with in the current (2003) AS 3500 Drainage Standard, designers should in the interim extrapolate from current Standards and recommended fixture unit loads /and surface areas of pipe.

4.15 SCHEDULE OF EUROPEAN DRAINAGE SIZES

EXTRAPOLATED FIXTURE UNIT LOAD TABLE FOR 200-AND 250 DIAMETER EUROPEAN DRAINAGE SIZES

Grade %	size	Area	mm²/Fu	AS3500 FU	Load source FU
1.65/ 1:60	100	7855	47.6	165	AS3500:2
1.45/1:70	125	12273	25.3	485	AS3500:2
1.25/1:80	150	17673	16.99	1040	AS3500:2
1.00/1:100	200	31420	12.85	2445	extrapolated
1.00/1:100	225	39765	8.8	4500	AS3500:2
1:00/1:100	250	49093	7.5	6545	extrapolated
1.00/1:100	300	70695	6.2	11400	AS3500:2

4.16 DEPTH OF FLOW

Full or ½ full bore diameter x 0.25

3/4 Depth of flow diameter x 0.30

2/3 Depth of flow diameter x 0.29

1/3 Depth of flow diameter x 0.19

¼ Depth of flow diameter x 0.15

The approximate maximum velocity of water in a drain is obtained when the pipe is flowing at a depth equal to 4/5 of the internal diameter .The minimum self-cleaning velocity of flow is 0.8 m/s, there is no upper limit for self-cleaning .

4.17 GREASE TRAPS

The Grease trap is a Trade Waste pre-treatment process and this is reviewed under that heading, it is also included under drainage because in health care kitchens this device and its critical back of house location can have an impact on the general drainage system design.

Grease traps in Sydney have an upper limit of 5000 litres volume, above this capacity the trade waste authority in Sydney may require a Dissolved Air Floatation unit D.A.F which comprise the addition of an agglomerating flocculate chemical which together with grease and other floatable is raised as a layer marginally above the top water level of the DAF by a layer of infused compressed air, the layer is mechanically removed by a surface scraper.

Careful consideration of grease trap or D.A.F routine maintenance is required, as a back of house issue is important, the grease trap should not be located too far remote from the cooking process and the generation of grease, also consideration of the loads imposed on other systems by cooking through the night is considerations.

D.A.F waste products may be considered recyclable for use by other industries.

A grease trap is required by most authorities to remove the grease content of kitchen waste water where food is prepared on a commercial basis.

Grease removal systems, or pre-treatment, have a number of variations in design globally

The enzyme units used the USA and UK being a chemical process.

The rectangular grease trap with high labour cleaning requirements is used in the UAR.

Up to 5000 litres volume the Australian grease trap endeavours provide a cooling effect and a phase change separation of the floatable oils and grease content.

For larger volumes than 5000 litres installations a dissolved air floatation system and mechanical skimming conveyor can be used, however these are rare in hospitals and tend to be used in food factory processing where the grease is recovered as tallow for re-use in industry

The NSW boat shaped grease trap is effectively a cooling device, most of the heat being released from the surface area ,very little heat being released from the sides of a buried concrete or fibre glass grease trap ,the heat will over time raise the temperature of the material of construction ,it is a minimal and slow process .

Surface heat loss from the grease trap can be improved if the grease trap is fitted with mechanically assisted ventilation system The City of Sydney Ventilation Code once covered mechanical ventilation to grease trap chambers, now the BCA will prevail which adopts AS 1668. (Page 50).

Unfortunately AS 1668 gives little guidance only indicating that a grease trap enclosure ventilation system can be combined with other Group 6 systems in Table 5.2. The Sydney Vent Code used to suggest 10 air changes per hour which stimulated an air flow at the water to air interface of the grease trap, this will for a period accelerate the cooling affect; however the grease layer will eventually become an effective floating thermal insulator preventing surface heat loss.

The by-products of decomposing organic matter below the surface grease layer may produce hydrogen sulphide gas which is particularly aggressive to copper pipe, plastic vent pipes / or ducts are considered the best option.

Pumping grease and water mixed is to be avoided, centrifugal pumps will emulsify the oil and separation becomes a problem, most oil and water pumping systems utilize diaphragm pumps, it should be remembered that when pumping grease the friction loss is considerably greater than the resistance of water ,copper pipe is not only vulnerable to corrosion from the by products of degradation ,it may also have insufficient pressure rating particularly at silver soldered joints ,for grease trap pumping a minimum 75 mm pipe size should be used(The friction drop for grease is high)and galvanized mild steel pipe or stainless steel pipe should be considered .

4.18 DRAINAGE MATERIALS

Hospital plumbing and drainage discharges generally have a much the same corrosion impact on materials as do the flows from other buildings, there is a higher probability that heated water will enter the pipe system from sterilizers and clean in place systems for RO reticulation, also surgical dressings may enter the drainage system.

Low volume flushing systems and very low drainage gradients should be considered with care. Hospitals will also involve laboratory waste (Trade waste is dealt with under that heading) which will require consideration of chemically resistant materials such as plastics HDPE and borosilicate glass. (Corning or Shott systems)

Detergents used in conjunction with hospital kitchen dishwasher may also contain a high alkaline content, the corrosion effect is accelerated by the heat of the waste water which becomes corrosive to the invert of cast iron pipe work , Grade 316 stainless steel (Blucher) or HDPE pipes that are both heat and corrosion resistant are desirable.

Radiation treatment with Isotope i 131 for Thyroid Cancer treatment , the
patient will release radioactive waste product which will require shielding consideration (Dense pipe material such as lead or cast iron) and Instant recognition signage of the dangerous contents of drains and plumbing pipes to maintenance personnel.

T.S 11 restrictions for the use of (PVC) related to the production processes of the thermo plastic manufacture which may require Certification of the Manufacturing Process to gain approval for the installation in NSW Health projects. Generally the manufacturing costs of 100-mm and 65 mm PVC pipe favours the larger diameter because of production efficiency of scale.

Sanitary Drainage materials have evolved from those local materials that are readily available. In areas of the world which have limited natural resources, and where shipping costs and fuel /energy costs do become a more significant issue, the designer should in addition to considering trade waste chemical and heat damage to pipe also consider the impact of surface loads by heavy earth moving equipment on small sites and those products that are locally available, or that have minimal import costs.

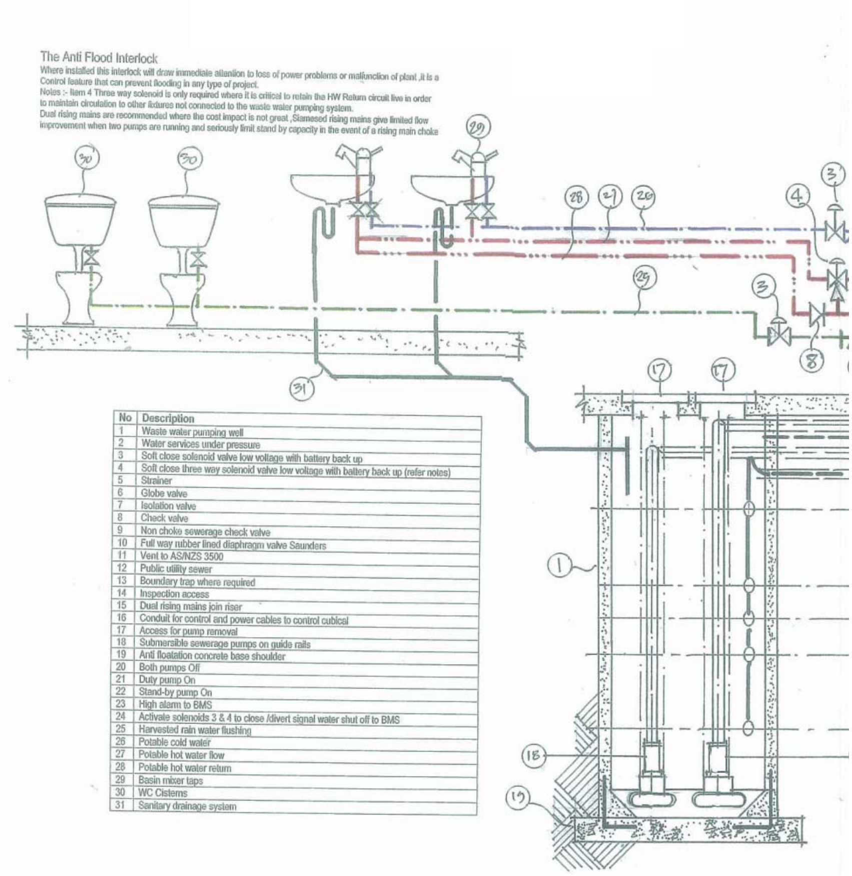
4.19 PUMPING DRAINAGE

Technical advice from manufacturers regarding specific pumping plan suitability will often be required on most projects. There should be a logical desire to standardise on a common manufacturer for maintenance reasons and to enhance purchasing power.

Pumping is generally limited to that part of the drainage systems that is serving the lowest areas of the installation that cannot gravitate.

Pumping sanitary drainage should be avoided if possible and should not be used as a means of saving costs where a gravity option is available but expensive by virtue of excavation depth or similar issues; some easement to this principle may be considered acceptable where the drainage sump overflow can gravitate at a secondary path and in doing so activate an alarm.

Relaxation of the non-pumping principle may also be considered acceptable in situations at upper floor levels where a non-essential fixture, such as a beverage sink can only be drained by gravity at excessive cost.



4.20 PUMPING STORM WATER IS NOT RECOMMENDED

Note: - Seepage drain pumping should be dealt with in conjunction with the Civil Engineer. Ground water inflow rates and water tables and membranes required to prevent ground water infiltration are not considered to be within the scope of a hydraulic services engineer.

It is noted that the circumstances that require pumping low sanitary fixtures often has a similar effect upon the ingress of ground water into basements and sub floor levels.

Where a gravity drainage path is not available for sanitary drainage there is also a high probability that gravity a path will not be available to remove ground water.

Where high water tables exert hydraulic pressure on the underside of basement floor structures and retaining walls it is probable that the basement will be protected by a waterproof membrane.

(Ground water pipes located below this membrane and that are below the water table will in effect be serving to dewater the sub-strata, this has significant geological implications and is not considered to be a hydraulic services issue.)

In circumstances where seepage / ground water systems are below the water table it is essential that the responsibility for the design integrity is accepted by engineers suitably qualified and indemnified.

To prevent water table entry into the building it is essential that seepage pump well and the pipes that discharge to it do not perforate the water proof membrane and in doing so compromise the integrity of the containment waterproofing. The practicality of locating a pump well outside of the building with access from ground level, may be dependent on the topography and involve deep excavation and high cost.

It is essential that the sanitary drainage system, including the pump well and drainage pipe system is contained within the membrane. The option of sealing multiple perforations through a water proof membrane is a doubtful means of sealing against ground water infiltration; such systems are in practice vulnerable, and they are considered to constitute a design that would be difficult to defend in the circumstances of litigation.

With the sanitary drainage system contained within the waterproofing envelope any ingress of ground water can be clearly identified as a membrane fault.

Where pumping sanitary drainage is the only option, care should be taken to minimise the depth of drainage pipes and the load, those fixtures that can gravitate being separated from those fixtures that cannot gravitate, in many instances a smaller local to load pumping station is an cost effective option, such systems can be interlinked with a level overflow and alarm to add fail safe security.

4.21 FLOOD PREVENTION CONTROL INTERLOCK

As an added fail safe protective measure the fixtures drained to a pump well, should have the hot and cold water services fitted with isolating solenoid valves that are electronically linked by a control system to the drainage system sump high level float switch (Near flood) water level, to signal the solenoid valves to isolate the inflow water supplies as an alarm and flood prevention measure. (Drawing provided)

4.22 DE-COMPRESSION CHAMBER

In the UAE Pump discharges to sewers must discharge to a vented decompression chamber of a pump cycle volume prior to entering the drainage system ,this is required to prevent pumping pressurization of the public utilities sewer main to the detriment of other connections.

This would seem a reasonable proposition to the writer, regardless of the pump duty .the sewer can only accept the minimum gravity flow via the connected drain.

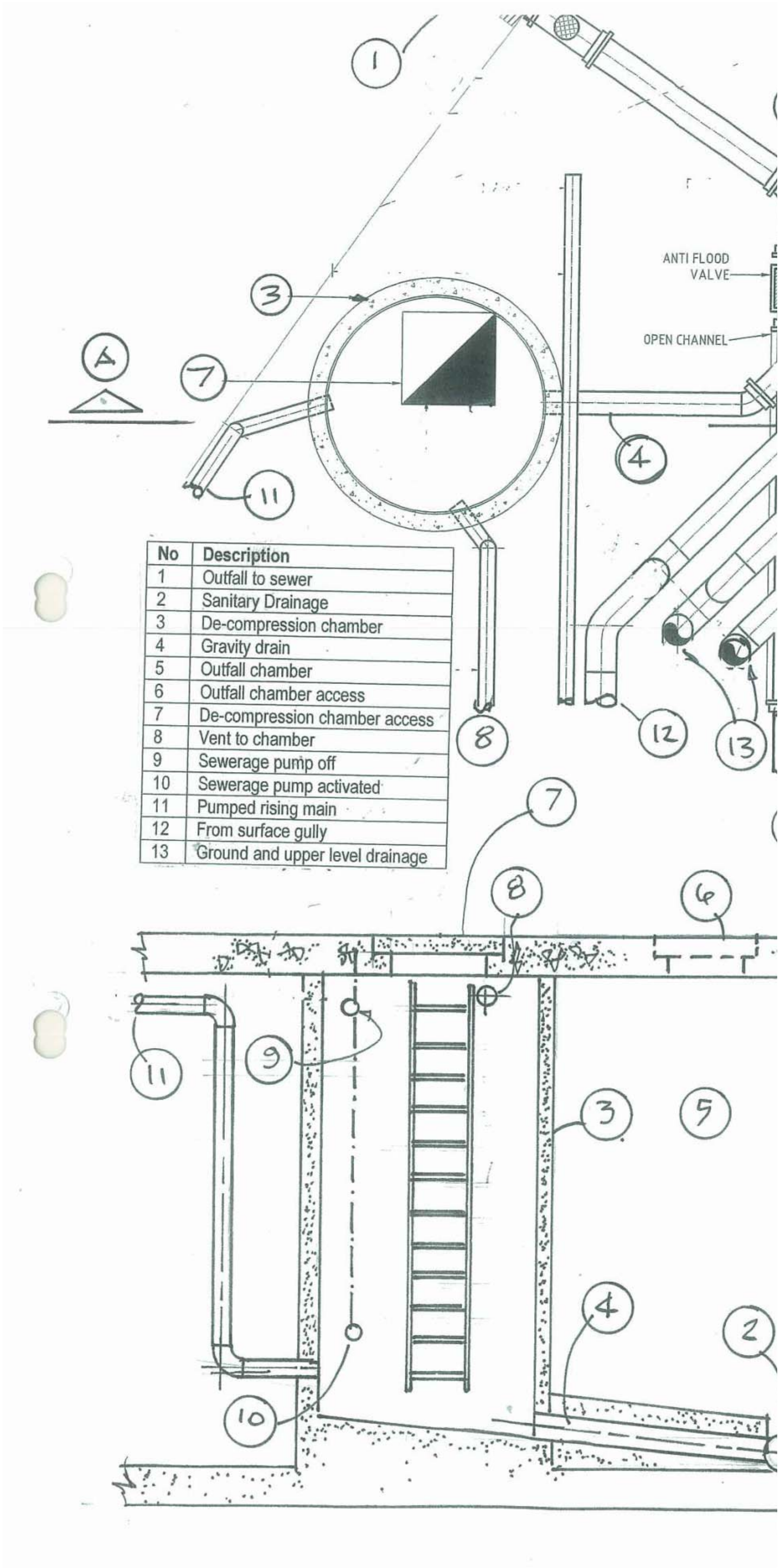
The chamber is located inside the property line and downstream of the mandatory flood prevention reflux valve in the side line to the Public Utility sewer. This design feature ensures that the Public utility sewer will not be subjected to sewerage pump head pressure; the pumping cycle volume will enter the sewer at a flow rate that is consistent with a gravity discharge.

In health care buildings the discharge from sanitary drainage pumping systems should join the system downstream of any sanitary drainage reflux valve.

Note: - AS 3500 allows connection of pump rising mains to vented drains.

Pumping systems that service an entire health care drainage installation are considered to be unusual, other than in rural areas of Australia.

Major sewerage pumping plant would in most instances be part of the Public Utilities sewerage system infrastructure; however this may not be the case in overseas projects (Drawing provided)



No	Description
1	Outfall to sewer
2	Sanitary Drainage
3	De-compression chamber
4	Gravity drain
5	Outfall chamber
6	Outfall chamber access
7	De-compression chamber access
8	Vent to chamber
9	Sewerage pump off
10	Sewerage pump activated
11	Pumped rising main
12	From surface gully
13	Ground and upper level drainage

4.23 PUMP WELL VOLUME AND PUMP DUTY

The determination of a sewerage pump well volume and pump delivery rate is relevant to the following.

The priority of the fixtures served**.** Priority may be determined by the impact upon the use of the fixtures served, an essential laboratory, or animal facility should preferably be removed from the need to pump, however the sensitivity of animals to noise and vibration tends to be accommodated by the construction requirements of basements, this also releases other above ground areas for human activity.

Priority may also relate to the proximity of other non-pumped facilities available for use in reasonable proximity if the pumped system should fail).

The fixture peak inflow generated by the fixtures served.

Where fixtures or population loads are **not known** an estimate can be determined by the population served as based on **the NSW Code of Practice 2005 3.20.2 150 EP /day residential, ra**nge plus any known contributing process waste.

For other than single residential buildings .Max response time x Average Daily Flow x Equivalent population.24 hours (Population served by the pumping system)

or MRT x ADF x EP/24 Average flow for this application 150 litres/EP/day with a grinder pump system (NSW Code)

The capacity of the receiving drainage system, which might be the public utility, must be checked, to confirm that it has capacity accept the calculated peak pumping load.

Should the maximum discharge acceptable be limited, the pumping system may require incorporating peak load detention (Max 2 hours detention) and / or controlled pump outflow which can be achieved by variable speed pumping.

With regard to the use of variable speed centrifugal pump systems.

The performance band of viable flow regulation with centrifugal pumps is limited by the performance curve of the pump, for a direct speed to outflow relationship a positive displacement pump, such as the moving cavity helical screw stator rotor pumping system should be used (Mono Pumps) in conjunction with a digital speed regulation level control.

The reliability of the electrical services is critical, local generation of stand-by power is recommended as a facility to service pumping stations that serve essential facilities.

The minimum **centrifugal pump** run time to prevent pump motor starter overheat.

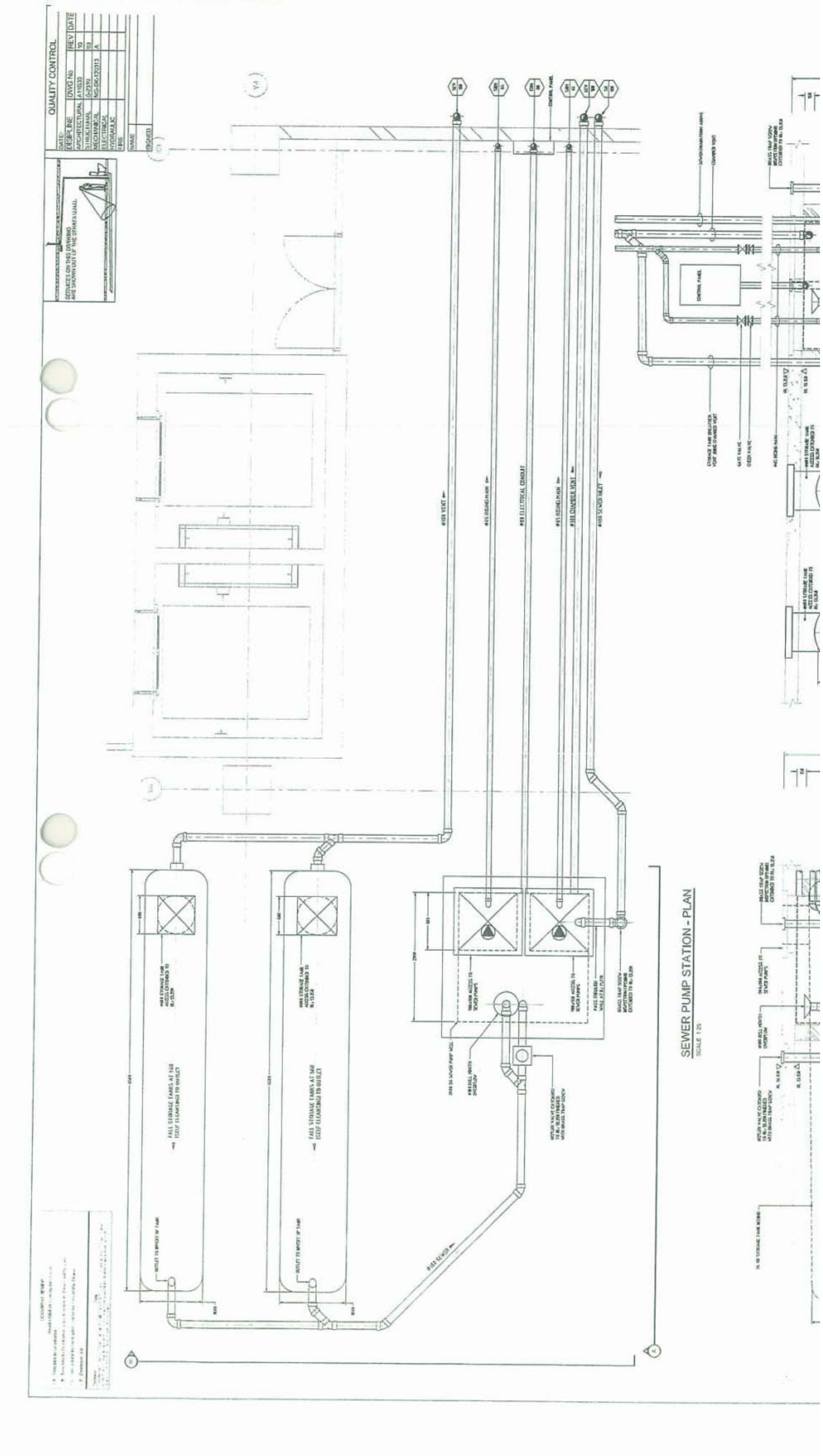
As determined by WSA101 Clause 6-6-3 Motor Selection

Pumps <15 kW 12 Starts per hour (5 minute minimum run time).

Pumps >15 kW   8 Starts per hour (7.5 min run time)

The pump well reserve storage capacity must be sized to be compliant with statutory requirements related to the number of pumps and the calculated hour's capacity based on population served

Drawing basement level 3 Detail sheet 1
This drawing deals with reserve storage for an underground sewerage pumping statio
using two "SPEL" Fibre Reinforced Plastic storage cylinders with a marriage pipe and
dispose of the displaced air in filling and emptying ,the cylinders are held in reserve b
valve until all of the wet well storage is consumed and all alarm levels have been activ
,drain back is automatic.



4.24 SEPTIC SEWERAGE

The dwell time of sewerage in the system **if prolonged over 2 hours can result in s**eptic conditions**.**

The sewer authority may have regulations in respect to this, regulations may also relate to the confluence with other gravity flows of waste water **and the** type of pumping system.

1) Grinder submersible.
2) Moving cavity with macerator.

Smaller Health Care Installations in rural areas may be remote from reticulated sewerage systems and have long rising mains ,or they may provide only a 9 to 5 weekday service ,both situations have the potential to leave significant quantities of sewerage in wells or rising mains for extended time frames.

In the case of the long rising main the Interference fit stator rotor moving cavity pump with integral or adjacent macerator has the advantage of pumping sewerage through relatively small diameter pipes, and developing very high heads to overcome the resistance of macerated sewerage passing through a small diameter pipe line, the pipeline in such cases can be hydrogen sulphide resistant HDPE. The smaller volume of the smaller diameter pipe obviously reduces the volume of material to become septic.

Where a 5 day week operation is normal practice, the pumps should be activated and run to the low level limit, then a charge of fresh water with a volume equal to the rising main content should be pumped through the system automatically at close of business each week, or day if the problem warrants.

As standard design practice the drainage discharge to the well should direct the inflow to a point as close to the pump suction as is practically possible, this is remove the possibility of solid material being isolated in the well to become septic, the pump cycle volume should be controlled to minimise the contained volume within the pump well so that the well is limited to a minimum capacity most of the time, this preserves stand by capacity and prevents long dwell times**.**

Septic sewerage is essentially degradable organic material which will decompose at a rate relative to oxygen supply and temperature. The bacteria and microorganisms that do the decomposing work cease to work, or work slowly without heat, hence the preservation of foods in freezers and pre-historic Mammoths captured and flesh preserved in glaciers.

Sewerage at ambient temperatures with a limited oxygen supply will decompose slowly by an anaerobic process (Without oxygen) ,at the public utilities sewerage works such sewerage is significantly more oxygen demanding , in addition such sewerage releases hydrogen sulphide which is an aggressive gas capable of causing serious damage to drainage and sewerage works installations.

Oxygen injection is used for very long pumped rising mains that would not normally be included within the hydraulic services scope, being more probably a local utility installation

For hospital sanitary drainage systems where pumping is unavoidable, submersible centrifugal grinder pumps can be used, where the load profile of the system might include an infrequent but major use an option is to use variable speed pumps, or conventional drive pumps, each capable of portion of the maximum load and pumping simultaneously in high peak situations.

It is noted that storage and pump running times are not the same thing, it should also be noted that it may be practical to install a pump well overflow to a gravity sanitary drainage system with an alarm.

Independent rising mains from each pump are considered an advantage as are rubber lined full flow diaphragm valves for flow isolation or Knife edged gate valves for low pressure side isolation and No choke check valves of a roll back ball design (Flygt) Refer to local regulations in respect to these issues)

MINIMUM PUMP RUN

Minimum run times are critical .Most Submersible pumps use the pumped fluid for motor cooling; the pump should remain below the lowest water level of the pump well. The minimum pump run duration **should be of sufficient duration to prevent electrical starters overheating**, (nominally 7.5 minutes run time.)

MAXIMUM PUMP RUN TIME

The nominal duty flow rate for a sewerage pump will relate directly to the sanitary fixtures that join the system and the calculated probable simultaneous demand of hot cold and flushing water to those fixtures.

The diversity of supply to fixtures (For most published systems) is (As noted) based on the Dynamic Law of Probability, in most cases diversity calculations are generous, the larger systems tapering off to a 20% minimum probability ,this is the calculated peak flow, and the peak can be quite short . Industry standard also generally accept that the average flow x 3 = The peak flow

The maximum run time is in most cases not critical, the pumps will stop at the lowest level determined by water cover to the pump or the point of vortex generation and the duty pump will start when a minimum pump run time water volume is available.

The stand-by pump will cut in when both pumps can run for the minimum time frame. Prudent design will determine both pumps can evacuate 3 x the average inflow.

Because the pump well may have a total volume that is calculated to contain 12 hours use in emergency there is a large factor of safety .It is necessary to understand the probable load profile of the system.

It is important that the designer is not totally reliant on published recommendations of diversity, and with self-confidence and with the application of common sense reviews how the system being considered will actually be used in practice.

E.G. 20 Staff showers may at the change of shift all be used at the same time, educational lecture theatres will have high toilet loads at the end of a teaching session, gymnasiums and therapy pools with group sessions have similar use characteristics.

Probable use and determination of peak loads requires a common sense approach.

4.25 WELL CAPACITY

The minimum run time has been established by the pump motor starter capacity, however if a VSD pump were to be used to minimise power consumption, the starter characteristics relative to overheating are different.

The maximum run time is based on the volume difference between the probable inflow and pumping outflow rate of one pump.

Any deficit of one pump out flow discharge will determine the level in the well at which the stand by pump is activated to run.

With duty and stand-by pump running together the maximum inflow should be removed and the well water level should lower. Should this be impractical to meet a known peak period, under these conditions the pump well storage reserve must buffer the peak providing the peak estimated inflow rate calculation is reliable, a margin of error should be considered where conditions are critical or not well established data is available.

Should the level rise the peak inflow has exceeded the outflow capacity and
it will absorb some of the free well volume for the duration of the peak .Or it is possible that a pump has failed, if this is the case the alarm should be activated.

The space or storage volume between the alarm and the flood level of the system is the maximum well capacity which may include a minimum statutory storage volume as noted.

When the flood reserve level is reached an alarm signal should be activated, should the water level continue to rise to a system flood level, a float switch shall activate the electronics to shut down the automatic flood prevention solenoid valves in the water supply systems.

The effect of water loss will create a more significant reaction than the prior early warning alarm; it will also prevent the health hazard of sanitary waste water, or biological laboratory waste water flooding.

Consideration must be given to the following.

Emergency showers .The cold water flow must not be compromised.

Fire hose reels. The cold water flow must not be compromised.

Medical procedures such as hemodialysis which could be life threatening in the case of

Laboratory research and diagnostic equipment that may be essential to preserve life.

WHERE THE ABOVE CIRCUMSTANCES ARE RELEVANT, THE HYDRAULIC SERVICES DESIGNER SHOULD SEEK ADVICE AND CONFIRMATION FROM THE MEDICAL AUTHORITY IN RESPECT TO THE LEVEL OF HAZARD THAT IS ACCEPTABLE DESIGN CRITERIA, WHERE LIFE THREATENING RISK IS INVOLVED SIGNAGE GIVING ADVICE AS TO THE APPROPRIATE ACTION TO TAKE WILL BE REQUIRED.

Note AS3500 Requires Reflux valve protection on branch drains to pump wells presumably to prevent surcharge. However the reflux valve will not prevent flow in the drain from backing up from upstream discharge,

4.26 PRIORITY

The priority of the fixtures served will require determination by the Hydraulics designer in collaboration with the systems user groups.

It could be considered poor planning to rely on pumping plant to service any health care facility where pumping failure could be life threatening, should this be the case the designer should draw attention to the issue to promote a more viable option.

The volume of the pump well storage volume will be relevant to the availability of standby power and the estimated inflow load, the local Codes EG NSW Code and the estimated time frame to implement repairs in a worst case failure scenario.

4.27 PUMP CONTROL

Hospital Sewerage pumping systems should have a 100% capacity duty and standby arrangements with the stand-by pump at least connected to the standby power system. The provision of both pumps to be activated to run by the sump water level control input ,for high variation load system three or four pumps may be used,

where space is limited consideration may be given to variable speed drive
pumping (VSD). However increased system complexity is generally associated with increased maintenance.

NOTIONAL PUMPING CONTROL SEQUENCE.

Level 1 Low level. All Pumps OFF, at a level to ensure all submersible pumps are submerged.

Level 2 Duty pump 1.”On”.

Level 3 Alternated stand-by Pump 2 “On”

Level 4 High level alarm This will be the level at which waste water enters the reserve buffer volume

Level 5 Automatic interlock shut down of water supply to fixtures that join the pumped system. (Note: This will prevent flooding and is important where nuclear medicine discharges are radioactive)

Pump duty or standby role should be alternated at each pumping cycle, the control system should not equally proportion the pump run time, this will promote a similar wear and life expectancy to each pump, an eccentric run time is desirable which will allow the maintenance team to predict the probable failure date of the stand by unit from the hours run time meter,

Level 5 The Automatic shutdown of water supplies to all fixtures that discharge waste to the pump system will prevent surcharge of sewerage that can be a major health issue where an ORG is not feasible (Generally the case with pumped drainage) The shutdown requires the installation of a soft close solenoid valve in the domestic cold service and the domestic hot water flow, a check valve in the domestic hot water return may also be needed.

4.28 WASTE WATER PUMPING PLANT

Waste water pumping in any project may include local to load pumps in basement areas that cannot drain by gravity and may be also have drainage conflict with heavy structural floor slabs designed to resist ground water ingress .Such systems will be often found serving plant spaces , work shop areas ,beverage bays ,essentially waste water . In all cases duty stand-by pumps with dual rising mains are recommended .and above ground accessible check and isolation valves are AS/NZS 3500 required .The conventional 100 mm chamber vent may in most cases be replaced by a 50 mm vent applied in the same manner as for a sanitary fixture. As noted, the emergency high level float switch should also isolate water services to fixtures that generate the waste water (A low voltage solenoid valve).

4.29 PUMP ELECTRICAL CONNECTION

In hospital pumping applications a local isolator and demountable 3-phase plug connection will overcome trade practice demarcation problems and the need for calling both a plumber and an electrician to resolve a minor maintenance problem or pump removal / replacement.

4.30 SEWERAGE PUMPS

Sewerage pumps may be dry well or wet well, in most cases the very heavy construction concrete Y configuration three chambers, two wet and one dry well pumping system which has been favoured by public utilities is not used in smaller load private pumping stations.

The dry / wet well arrangement is considered a durable system with component repair and standby capability.

The traditional three chambers comprises two wet chambers each with a valved inflow pipe ,the third chamber being dry houses duty and standby centrifugal pumps ,each valved to a wet chamber ,the pump discharges rising vertically with reflux valves and isolation valves to a common rising main ,the pump interconnecting pipe work being drainable for maintenance work.

This type of centrifugal pump would be equipped with an impellor designed specifically to accept solids material, this type of centrifugal pump has a very low Net Positive Suction Head and requires a flooded suction. The pump motor may be attached horizontally, but it is more probable to be a vertical drive for space and motor removal considerations.

The motor to pump drive shaft can be extended where the pump well is very deep; this allows the electrical components including the motor to be mounted at ground level where they are not vulnerable to leakage and water damage, or the accumulation of combustible sewerage by-product gases. Pumping stations of this type are heavy engineering construction.

4.31 POSITIVE DISPLACEMENT PUMPS

The moving cavity helical screw interference fit, soft rubber stator and stainless steel rotor pump linked to a macerating unit has been used for sewerage pumping with considerable success for 50 years or more, this type of pump has excellent suction capacity and can be used to service pump wells of modest depth, as will be found in most building drainage systems. there is considerable advantage in the smaller diameter rising mains that can be used ,and the near constant head generated by this type of pumping system, the pressure rating of the rising main should be checked against the maximum head pressure that the pump can develop ,if rubber bellows vibration pipe connections are used they require limit of movement wires . This type of pumping system is manufactured by at least three companies Mono Pumps probably being the best known established in Australia.

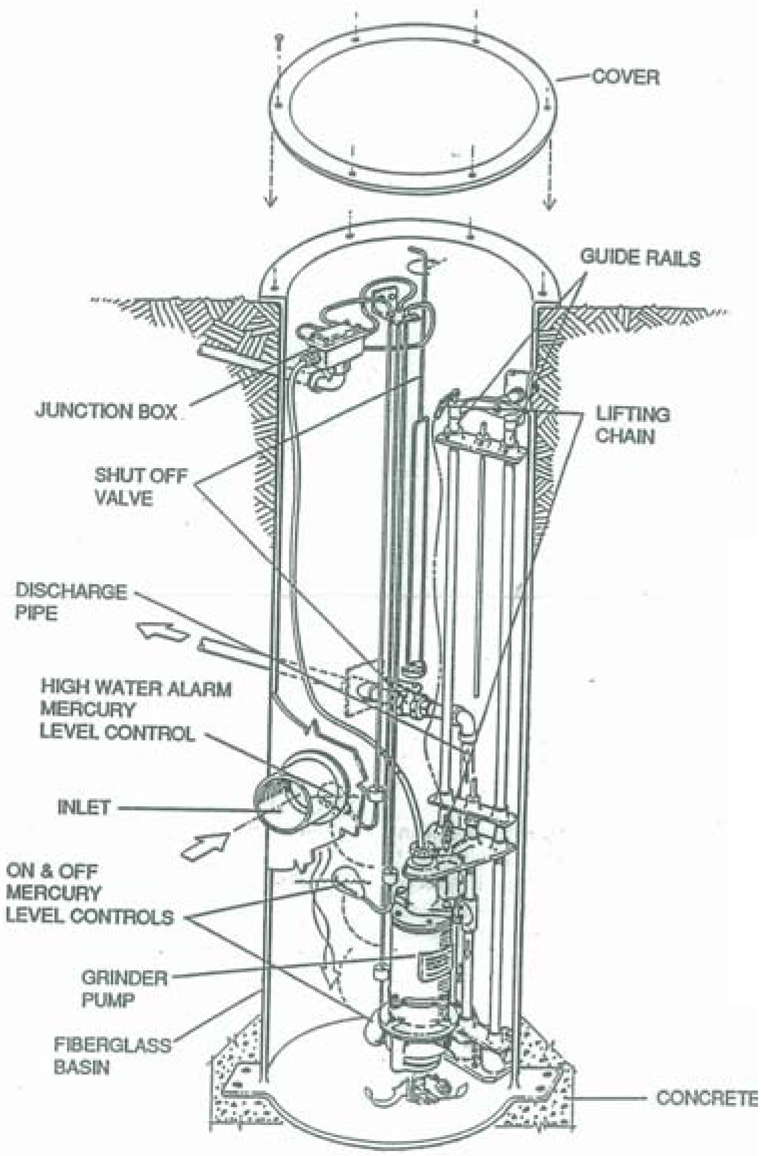
An interesting characteristic of this type of pump is the direct speed to flow rate relationship, the pumps are usually down geared from motor speeds of 1450 RPM, such pumps would respond well to VSD for flow control, or constant pumping through filtration systems where the pressure drop gradient of the filter media would affect the flow rate of a centrifugal pumping system.

4.32 SUBMERSIBLE PUMPS

The most common type of Waste water pumping plan for hospital waste is the submersible grinder pump, a well-engineered product that is cooled by the liquid pumped, oiled for life, and cooled and noise insulated by being immersed in water which is essential for most types of submersible pumps ,however some dewatering pumps can operate on the snore.

For flood prone areas water cooled jacketed submersible pumps are manufactured.

Submersible sewerage pumps of the grinder type provide a pre-suction inlet macerating effect. Submersible pump features, such as rubber lined impellors and guide vanes vary with manufacture.



Submersible moving cavity pumps

This unique submersible version of the stator rotor interference fit moving cavity pump is a speed pump with grinder that will efficiently move low flow rates against very high heads , pumping system to consider for smaller loads remote from sewers and gravity drainage connection.

4.33 IMPELLOR PULSE

Pumps that are suitable for pumping solids content liquids have an impeller design that will generate a strong hydraulic pulse pressure effect requiring robust construction in the rising main to resist the destructive effect .This pulse feature will not affect most systems and only becomes evident if such pumps are used for non-standard applications or used in conjunction with poor welding, or substandard fabricated items which cannot be tested.

4.34 SUBMERSIBLE PUMP MOUNTING.

For sewerage pumping the submersible pump that is slide column mounted
pump with automatic rising main coupling and that is lift chain removable from the surface is considered an advantage in that it will minimises human entry into the well for maintenance, and permits rapid replacement.

4.35 SUBMERSIBLE MOVING CAVITY PUMP

The submersible moving cavity pump, or helical screw interference fit rubber stator stainless steel rotor pump coupled to a water proof motor are a recent market development of a well-established above ground pumping system.

This type of pump has a rubber stator that is removable and that has a known wear rate and life expectancy ,removal of the worn component and replacement is a site maintenance task. There are advantages that this pump has compared with a more conventional centrifugal pump.

The pump operates at low speed 1450 RPM

The pump has a direct speed to output ratio, at 30% speed the output flow is also 30%

The pump will deliver low flows at very high head, it is suited to long **low flow** high pressure rising mains.

Pumps of this type handle solid material well.

Contrary to some opinions this type of pump will emulsify grease and water

4.36 SEWERAGE EJECTOR

The sewerage ejector comprises a pair or three cylinders (300Litres approx.) with inlet and outlet connections at the base; each connection has a reflux valve. A float arrangement inside the cylinder activates by mechanical linkage the opening of a compressed air flow which displaces the water volume in the cylinder to rise up the discharge rising main .Many sewerage ejector units are in operation at existing facilities, they are seldom specified now.

4.37 DOUBLE DIAPHRAGM PUMPS

The Double Diaphragm Pump first manufactured in 1955, is an air operated positive displacement self-priming pump, which operates with two diaphragms driven on a single shaft by means of a motor cam, or by compressed air pressure pulsed to the driving diaphragms by a ported air valve.

Diaphragm pumps are seldom used, they do have an advantage in that they are submersible, they do not emulsify grease or oil with water and they remain relatively free of corrosion in long periods of inactivity. The pumping output can be varied by modulation of the air pressure and pumping speed,

The pumping unit may be submerged

May be used in explosive environments

This type of pump delivers moderate discharge quantities, is manufactured in a wide range of materials for chemical resistance and is appropriate for specialised application such as

Aggressive chemicals

Radio Active waste

Food pumping

Food pumping or similar substances

Non-emulsifying to an oil and water mix

Slurry or grease transfer

(Will pump to empty, without damage to the pumping unit Manufactured by Wilden Pump Engineering Co)

4.38 MECHANICALLY DRIVEN DIAPHRAGM PUMPS

This type of pump is specialised for pumping low volumes, in the order of 1500 litres /hour of water and oil through laminar flow separation plates.

This type of pump does not emulsify the oil and water .An electric drive motor with a simple slow speed cam action pump drive is typical and often favoured for plant pumping recovered hydro carbon water mixture.

4.39 ISOLATION VALVES

Valves for sewerage systems should be located above ground rather than in a below ground pit or the pumping chamber. Attention is drawn to the requirement for a disconnecting joint adjacent to flanged valves in below ground pits or chambers for any pipe system.

4.40 VALVE TYPES

Water service Gate valves are used for waste water .A Knife edged lever (Lever action valves are primarily for rapid closure, these valves are space consuming.) or screw activation for low pressure use and Saunders rubber lined diaphragm for pressure or flow regulation applications are considered superior .

Check valves for sewerage should be a non-clog design comprising a moving sphere which seats on a rubber seal under back pressure and moves out of the flow line in the pumping cycle. Valves should be Victaulic jointed, where pipes are located below ground. Where below ground pipes are flanged the connecting pipe work must have a disconnecting joint to allow the compression of the flange insert material and replacement of the valve in the reduced space resulting from compression of flange insert material.

4.41 RISING MAINS

Pump rising mains in Hospitals will in most cases be relatively short, where this is the case it is desirable to join the sanitary drainage system downstream of the boundary trap and the reflux valve, if provided, this will prevent the possibility of internal surcharge.

4.42 DEDICATED RISING MAINS

Rising mains should *where practicable* be dedicated to each pump and not, *as is common dollar driven practice*.Siamesed to two pumps as duty and standby through one common pipe, should a peak load condition require both pumps to work simultaneously, the flow increase in a Siamesed system is not doubled, it is proportional to resistance and reduced in the order of 20%, this is not the case with independent rising mains which will provide a 100% flow increase.

4.43 MATERIALS

Rising mains constructed of pipe materials such as Blucher Stainless steel,
rubber ring jointed cast or ductile iron that does not have joints with inherent linear strength and will require thrust block restraint at all direction changes and tee junctions, in much the same fashion as recommended for water mains. Materials with linear secure joints are recommended. HDPE, Polypropylene with fusion or flanged joints with fusion jointed flanges. Where plastic pipes are used below ground a stainless steel wire bond shall be located in very close proximity to the pipe as an electromagnetic source for surface detection Note :- Where flanged pipes of any material is used below ground ,it is important that at isolating valves a disconnection joint is provided . In the installation process the flange insertion material is compressed sufficiently to render subsequent removal of the valve and its replacement with ease impossible without a disconnection joint.

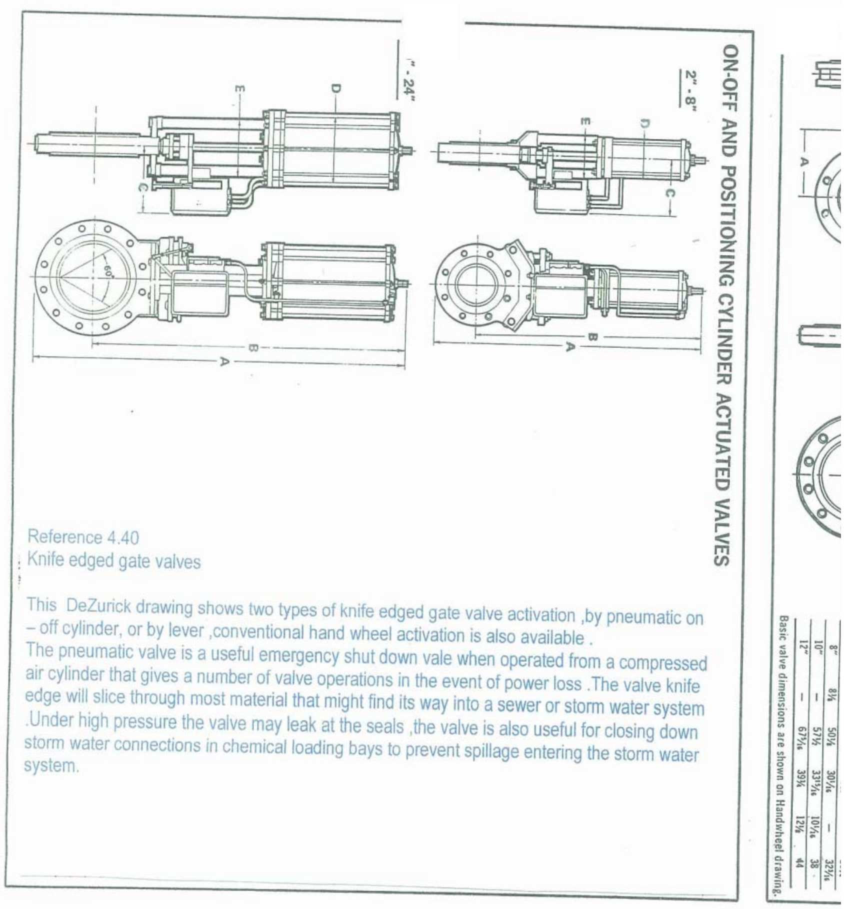
4.44 CLEAN WATER PURGE

The clean water purge (Or cleaner) may be used in conjunction with long undulating rising mains that cannot drain down after use and may contain water and organic material for extended periods, systems as may be found in remote intermittent use clinics that are not open for patients on a 24 hour 7 days a week basis .Such systems may incorporate a tank of clean water and a pumping system that will displace the waste water content of the rising main on closure of business.

4.45 LINK SEAL

Drainage systems to basement areas may involve perforations through retaining walls that are below the water table of the exterior ground level. Conventional wisdom has been to utilize a puddle flange encased into the centre of a concrete wall, the concept being that the increased surface area interface between the concrete and the pipe material provides a much greater travel path for water ingress and a much higher probability that the flow will be reduced to acceptable limits, or possibly stopped completely. Link Seal is the registered trademark of PSI Cell Castle 6525 Goforth Street Houston TX77021 USA The link seal company produce a large range of specialised seals for pipes passing through various type of building fabric, some seals work as a series of links which circumvent the pipe, when the metal bolts joining the links are in place and retightened the outer link case compresses a plastic sack of two part resin that on contact enters the pores of the building fabric and hardens ,expert advice will be provided by this company .

Where pipes connect to concrete water tanks the writer has found the puddle flange concept to be unsatisfactory .Where static pressure in the tank is involved ,the connecting metallic pipe must use a connection the seals the concrete to metal interface ,it in plumbing terminology a compression joint.



Reference 4.40
Knife edged gate valves

This DeZurick drawing shows two types of knife edged gate valve activation ,by pneumatic on – off cylinder, or by lever ,conventional hand wheel activation is also available .
The pneumatic valve is a useful emergency shut down vale when operated from a compressed air cylinder that gives a number of valve operations in the event of power loss .The valve knife edge will slice through most material that might find its way into a sewer or storm water system .Under high pressure the valve may leak at the seals ,the valve is also useful for closing down storm water connections in chemical loading bays to prevent spillage entering the storm water system.

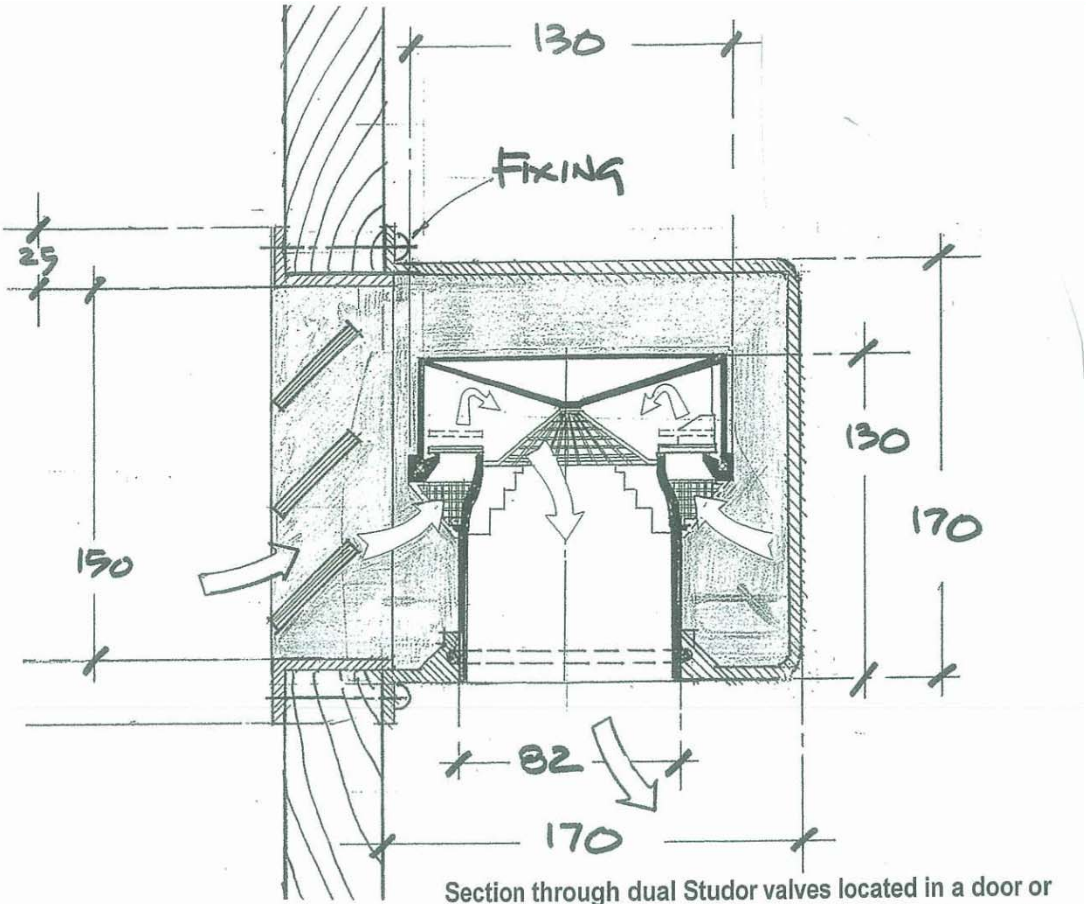
The 100mm Pop up Inspection cover An ORG option

James Hardie Pipelines

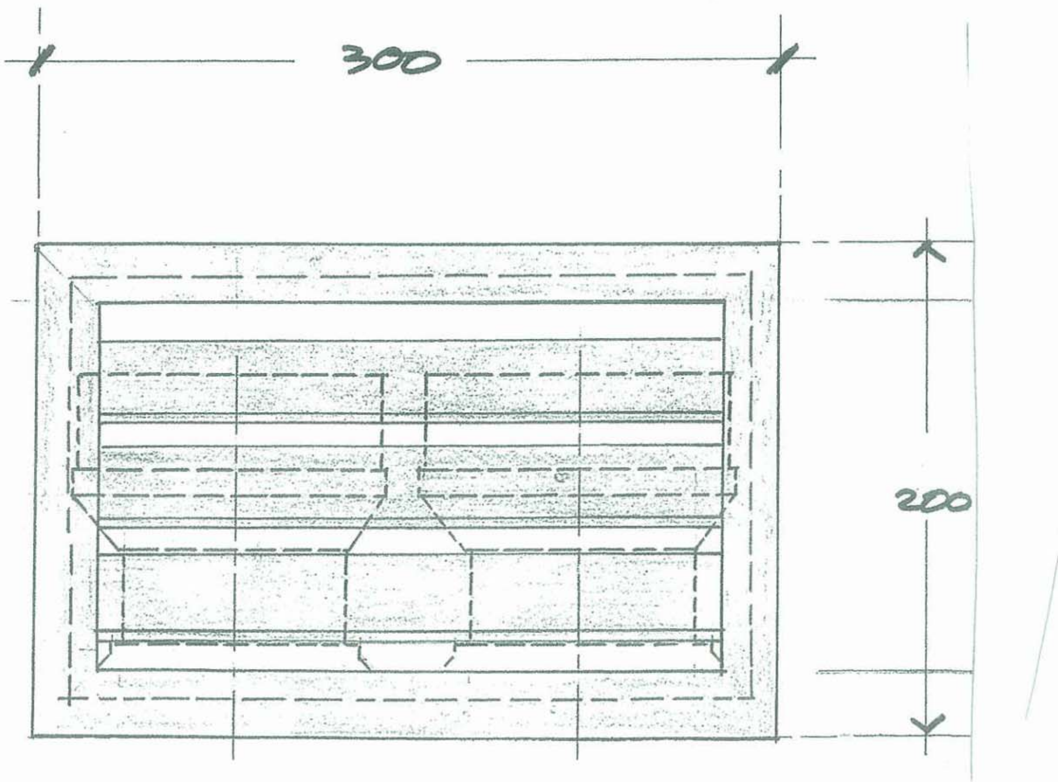
100 mm Pop-up Inspection Cover

Product code D128100D

The new James Hardie Pipelines 100mm Pop-up Inspection Cover provides an alternative to the traditional overflow relief gully in sanitary drainage systems and will provide significant benefits for property owners, plumbers, builders and Water Authorities.
A suppliment to the National Plumbing and Drainage Code AS 3500 Part 2.1 highlights performance requirements with concerns being directed to maintaining the health and safety of the community while minimising the impact on our environment.
In AS 3500 Part 2.1 an option is provided for an alternative to the old fashioned overflow relief gully to minimise problems caused by surcharges or blockages in drainage systems.



Section through dual Studor valves located in a door or partition as a fresh air inlet to a space containing noxious odours from Trade Waste plant or Fume cupboards



Front Elevation of grille

CHAPTER 5 PLUMBING

5.1 A CONTAINED OR CLOSED SYSTEM?

The practical challenge in health care plumbing design is to incorporate sufficient flexibility to allow for future change with ease and also restrict to an appropriate location the release of foul air at roof level.

The long term challenge to the late and much respected Professor John Swaffield was to seek and perfect a closed system of sanitary plumbing.

In the interim a fan assisted system that ensures that the biologically contaminated suspect air from the vents for health care plumbing installations is assisted on its way to UV Irradiation and harmless dilution, might be an improvement. (Refer SARRS data)

It is probably the time for “Design Consultants” to take the initiative in negotiating a move away from the historically based codes that catalogue the historic record of plumbing system change, and urge a move to a more simplified and unified system of venting and air flow criteria that does not separate drainage and plumbing venting because it is a different trade skill involved, particularly where the hydrostatic considerations are the same? And the only obvious difference is the means of access.

5.2 BACKBONE DRAINAGE SYSTEM

In respect to the Health Care flexibility challenge, the backbone system of buried drainage which is inflexible, must recognise the potential for future change and that it should be a system that compliments the need for flexibility, and future change, be achieved by a much more flexible design of the connecting plumbing above ground.

The above ground plumbing design of a hospital should be sufficiently flexible to accommodate future planning changes and the probable demand for more services to compliment the advance of clinical technology.

5.3 THE GLASS FLOOR OR IN-STRATA?

Plumbing designers must deal with a system that resides in the air space of the architectural area directly below the level where the fixtures served are located.

The hidden location of plumbing in respect to architecture and the manner in which the work is presented for tendering and construction is an issue that has been eased by the development of computer aided drafting systems and the ability to transfer layers of information, the development of three dimensional computer drafting systems has also changed the established coordination and work shop drawing process , to an extent that has almost seen the demise of the hand drawn concept design sketches as a means of establishing first thoughts and ideas ,this demise to favour CAD would seem to be driven by project management to facilitate information transfer, rather than a move from the designers who bear the added cost.

The Architects understanding of the hydraulics systems and the initial design process is probably more suited to the glass floor drawing presentation, much the same as drainage drawings presentation.

The glass floor presentation method does not compliment co-ordination where the pipes and the physical presence of plumbing must be represented in company with all other services and obstructions such as structure, sensitive electronic rooms or operating theatres that affect the design. This is seen as an important drawing production cost and drafting technology issue.

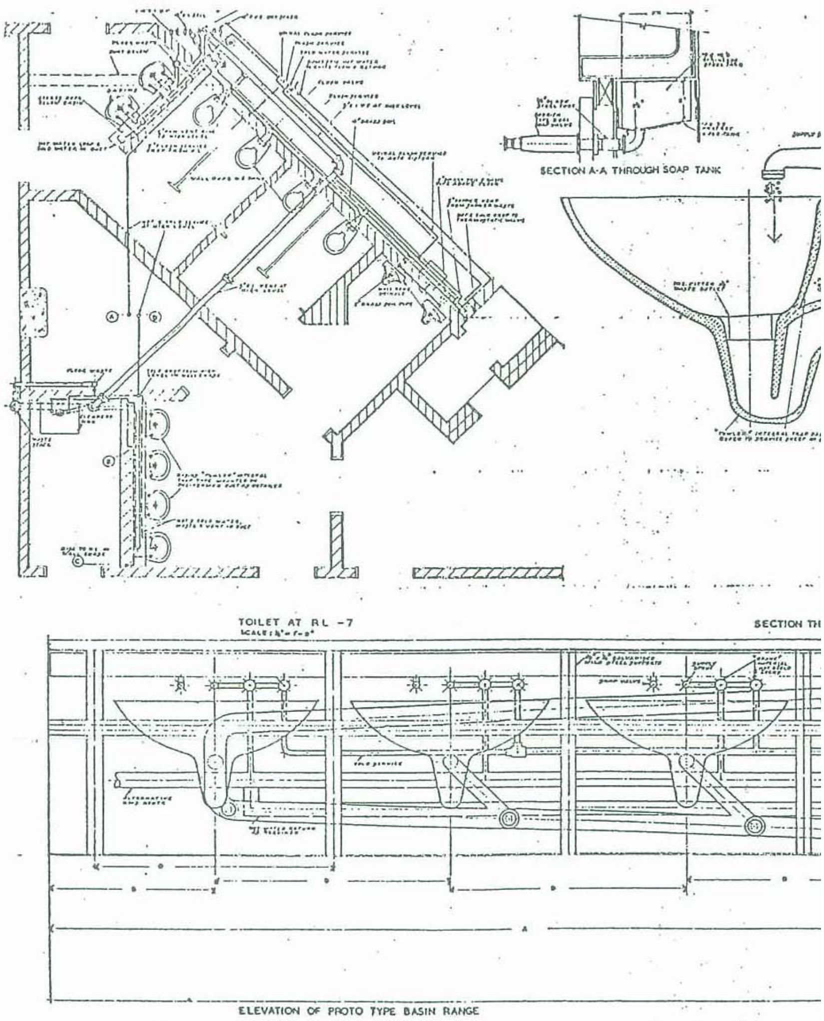
5.4 METHOD BUILDING

Method building, a system that enforced collaboration of disciplines, determined a viable metric grid and building tolerances, in reality we tend to forget that building can be much like a hand made shoe, the tolerances which add up, are not measured with a micrometer.

In the very early (10%) building planning stages 80% of the long term decisions are believed to be made, it is the time for the Hydraulics Design Consultant to establish a repetitive design dogma and secure accessible routes, permanent space locations for plant and vertical traffic. It really is a case of striking while the metal is hot.

Plumbing stacks adjacent to structural columns which are an impediment that insures some immunity to change , and may provide a range and plumbing coverage that is linked to the economics of feasible structural column spacing and beam depth, and that will compliment coordination with other services. A plumbing stack location that will facilitate fast track construction by early installation because the fabric to fix to exists, this will give the construction coordination stage an advantage by adopting a similar path to an established element of structure .

The disadvantage of a column location is that the stack perforations will be through the concrete slab at its reinforced junction with the column which is structurally sensitive, there will probably also be a beam connection, or in the case of a prestressed concrete slab, a column capital. Resolving these issues at columns as a present or future services location with the structural engineer and architect in the scheme design stage tends to focus the hydraulic services design dogma in respect to facilitating access and future needs.



Factory Methods

The Qantas Tower (Now Suncorp) in 1972 by Architects Joseland and Gilling pushed of method building .This rather ancient drawing shows the pre-fabricated basin range system complete with hot water circuit ,cold water .waste and vent and soap system . was factory quality and a reduction of carnage in the 40 levels tower and 10 levels of health care but an example of how industrialised plumbing can work.

5.5 COVERAGE

The distance between stacks is a critical consideration. Based on a notional building with a structural grid and column spacing of 7200 mm (which is a multiple of a 300 mm grid) the beams with a conventional concrete construction are going to be in the order of 600 mm depth. Assuming for fire regulation considerations the hospital has been limited to less than 25 metres high the building has say 7 useable floor levels, each level will have a floor to floor dimension of 3.571metres, a ceiling height of 2.800 m and a gross ceiling space of 771 mm less 200 mm concrete floor 150 mm ceiling and lights leaves 421mm, possibly more over toilets and corridors which may have lower ceilings.

The plumbing pipe will need 200 mm from the slab soffit at the highest point, this leaves 221mm for a 1.66% grade in the pipe which converts to 13.812 metres of run to the extremity in each 7.2 metre bay, with a passing zone depth under beams for a 100 mm pipe at the low point in the duct / toilet / corridor space.

Such a system design will limit venting to connections above the floor slab;
this is considered a desirable feature in health care work. As noted, conceptual planning and preliminary drawings which demonstrate to others the principles of the design can only benefit the total process.

5.6 LINE ACCESS

Man access and OH&S compliance for maintenance to plumbing soil pipes being achieved from high level access doors in high level pipe work suspended below the floor level at which the sanitary fixtures are located is doubtful.

The practical reality of opening an access door in a flooded soil pipe from the top of a step ladder is not considered a viable or acceptable proposition; breaking out the ceramic fixture could be better and less messy option.

A plumbing design which uses 45 degree bends and junctions and provides a charged floor waste with surface removable trap, (Blucher) or rubber lips grate seal which provides rodding access from that point, located to maximise and facilitate rodding, or camera inspection from the line extremity to the stack, or an access door in a branch vent located above the system flood level, is probably better and more considered option.

5.7 PLUMBING SYSTEMS

Plumbing systems in codes have labels that are historical labels defining a change in the concepts of.

1) Separating the pipes that convey human excreta and urine, from the assumed less biologically dangerous sullage water used for cooking and washing both the human body and the clothes that the body wears and the bedding it slumbers in.

2) Changing the sanitary venting configuration to a more considered and more researched method of avoiding hydrostatic problems and recognising the possibility that building use has an impact on the performance of plumbing design.

3) Providing mechanical air valves and trap seals that allow introducing air to replace the exit of water and avoid the loss of water seals in the earlier systems water filled trap seals.

5.8 CENTURY 2000

Bearing in mind the possible de-facto re-introduction of a modified two pipe drainage system to compliment grey water treatment, it would seem possible to frame the Plumbing and Drainage code in a better and easier to comprehend format that reflects current technology, rather than historic change.

The differences between Plumbing and drainage from a technical aspect are blurred and the venting differences of principle are hard to rationalise ,do we need to define two separate systems ?(Plumbing above ground & Drainage) that were originally separated to meet the practical considerations of trade practice , ceramic pipes ,access to remove blockages ,excavation methods have all changed dramatically in recent history ,should the code reflect more on how the total system works (Above and below ground) and deal with the required technical data and limitations , to make it work in a satisfactory manner?

Recognising that in health care it is economically viable and good practical sense to use 100mm P.V.C and allow reduced 1% grades for waste water discharges? Rather than accommodate the prior practical trade differences. Should practical trade differences not be a subject for resolution by the Trade organisations?

In century 2000 our code should broaden its scope from the residential
focus and address all types of buildings as does the BCA also include the reality of environmental issues that affect those buildings? Trade Waste. Black and Grey water Treatment Harvesting rainwater and recycled water systems.

5.9 THE ONE PIPE SYSTEM

The One pipe plumbing system has been over some years modified in America the UK and Australia, generally by the reduction in venting which is dealt with in Australian Standard AS/NZ 3500.2 Sanitary Plumbing and Sanitary Drainage .Section 6 deals with General Design requirements for Plumbing and Section 7 deals with Fully vented systems and modifications to that system for various applications and Section 8 deals with Single stack systems and Single stack modified systems for use in BCA Class 1 to 4 Residential buildings and Class 5 to 9 Commercial buildings ,health care buildings are Class 9a which includes Pathology laboratories .It is assumed that the reader has an adequate understanding of the current Plumbing Code .

5.10 THE SOVENT SYSTEM

A derivative of the Single Stack system invented in Switzerland in 1950 for 3 to 10 storey buildings the system incorporated patented branch connections which overcome some of the hydraulic pneumatic problems of traditional fittings, particularly in respect to the loss of trap seals, this system has been manufactured from cast iron, copper and recently in HDPE .Seen as an invention for precise planning of high rise residential construction, The use in the UK has not been great and the useful application to health care would seem doubtful .

5.11 AIR ADMITTANCE VALVES

The acceptance in Australia of the Air admittance valve may impact upon system designs, however such valves have not been tested for a path of biological travel past the seal of the valve ,bearing this in mind ,and the difficulty in testing such issues , it is not considered prudent at this time, to recommend the use of air admittance valves in Health Care Projects, other than Low level IPMF Vents for smaller projects ,or air inlet vents to chambers and possibly laboratory waste systems where containment of radioactive, radiation or biological contamination could be of significance.

5.12 VENTING

The compliance of venting for plumbing and drainage systems is dealt with in AS/NZS 3500.2

In Health care installations the patients will probably be debilitated by illness and the medication that is given to overcome their health problems to an extent where it must be assumed that their immune system may be compromised and vulnerable to air borne contamination as could be inadvertently released from a sanitary system vent pipe.

The SARRS world pandemic of 2002 / 3 which infected 8000 persons in 37 countries and caused 774 deaths is an example of virus airborne transmission It is considered good practice in health care plumbing and drainage installations to collect vent pipes in two groups .Induct vents and Educt vents ,in order to promote cross ventilation through the pipe system .The induct and educt sanitary vents should terminate as far as practically possible as remote from any air conditioning fresh air or return air intakes ,and in compliance with AS/NZS 3500 All vent shaft termination points and all windows or air exhausts and intakes. Drainage system induct vents (IPMF) should not be used in metropolitan areas or health care buildings, an induct venting path should be provided by a soil stack connection to the sewer riser or boundary trap riser if used.

5.13 PVC

THE ENVIRONMENTAL ASPECTS OF THE USE OF PVC IN BUILDINGS ,A STUDY CARRIED OUT BY CSIRO DIVISION OF CHEMICALS AND POLYMERS DR RUSSELL SMITH DATED SEPTEMBER 1996 ISBN 0 643 05964 4 IS RECOMMENDED .

PVC plumbing has considerable economic advantages over other materials that are approved for use in plumbing and drainage systems.

For a period of time PVC was not recommended for use in hospitals by N.S.W Health Technical Sheet 11 .The negative issues related to PVC were related to the manufacturing process which was not considered environmentally acceptable.

Draft Amendment 1 dated 28 -1- -2010 to Australian Standard 1260:2009 sets out additional requirements for best environmental practice which are related to the manufacture of PVC resins ,dealing with Chlorine .

Vinyl Chloride Monomer (VCM)

Ethylene Dichloride (EDC) & (VCM)

Stabilisers Cadmium and lead stabilizers shall not be used.

A number of Plasticizers are also not to be used in the manufacturing process.

Certification of Standards compliance is required; the draft for review did not deal with the subject of by-product release from burning PVC manufactured to the draft standard.

Note AS1851 and the required task of tagging all Fire collars and inspecting the collar at 6 month intervals. Designers are also alerted to the insidious relief valve, in most instances from domestic hot water systems, these valves can release a torrent of very hot water, particularly if they malfunction, PVC Has a high rate of thermal expansion, expansion joints are essential .PVC is extremely vulnerable to prolonged high temperature flows, and it should be avoided for use where fixtures such as bed pan washers and sterilizers can release near boiling temperature water.

5.14 RUBBER LIPS

In recent history the “Hepworth” rubber lips trap has been approved for use as an option to the conventional water seal trap, the “Grate seal “unit offers the same technology for larger pipe diameters. This type of seal is considered desirable for laundries as a foam barrier, condensate drainage, or floor drains in air handling plant rooms that are also a large plenum space. The less obvious advantage of a removable rubber lips seal is drain access via a floor drain and the initial prevention of surcharge.

5.15 COOLING TOWER SURCHARGE

Refer to drainage and trade waste

5.16 DRAINWAVE

This unique invention by Ducane Research and distributed by LW Gemmell (LWG) is the Drainwave tank system that reminds me of the tipping bucket distributor used on the oblong Aerobic sewerage filter beds used in rural sewerage works in the 1930 and still operate, a critically pivoted tipping bucket that saved the inflow to discharge over the filter bed in a time frame that gave the bacteria an evenly distributed air and water environment. This is a clever streamline version that recognises and should overcome the dry drain problem. Probably not applicable to health care, but a practical recognition of dry drain .A device for the innovation basket, that might be adapted to compliment and improve the pre- biological filter for small black water pre-treatment plants.

5.17 THE CONNECTING COLLAR

A UK stack connection junction made in the form of a double pipe, the inner pipe being the stack and the outer pipe being the wall of the collar, an angled circular entry drains the annular void to the stack and is not affected by the turbulence of WC pan junctions in the critical zone.

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CHAPTER 6 FIXTURES AND FITTINGS

6.1 SELECTION OF FIXTURES

Sanitary fixtures are generally selected and located by the Architect, or Specialist Health Care Consultant, or the Hospitals medical team, or user group.

Recommended reading in respect to sanitary fixture ergonomic design and performance in respect to complimenting the needs of the human body is The Bathroom by Alexander Kira published by Cornell University U.S.A (For Health Care in Australia reference should be made to AS1428.1.2009 Compliance required from May 1st 2011 for Health Care Building Approvals.)

Sanitary fixtures fall into two groups Soil and Waste fixtures, this demarcation is not particularly relevant in Australian design practice, but does become relevant in countries where the two pipe system is a mandatory regulation to facilitate future grey water collection.

Soil fixtures can be classified as WC pans, urinals, bidets, and some hospital fixtures such as flushing sinks, bed pan washers, placenta disposal units, and endoscope washing facilities mortuary waste. Where cleaning processes involve chemicals or high temperatures, the pipe material and trade waste pre-treatment aspects require consideration.

6.2 MEDICAL BASINS

Basins in health care applications have four basic groups.

Basins for medical use ,the brassware will be specialised and preferably wall mounted to minimise the potential fouling surface and cleaning difficulties ,an over slung goose neck spout with wall mounted quarter turn lever action taps that are contra rotating .The basin will be supplied with a Warm (43.5ºC Yellow) and Cold (Blue) service of potable water .The tap seats will be Ceramic (Preferred) or conventional jumper valve ,and the tap bodies will be vertical as a chrome plate and breech with spout combination .Medical basins are not used for face washing therefore the projection of brassware does not represent a hazard. Some Hospitals prefer the Automatic electronic sensor tap (Refer to note)

6.3 AS HB 260-2003

There is a reasonable assumption in health care, that the location and frequency of sanitary fixtures for hand cleansing has a direct relationship to the probability of an acquired infection. Australian Standards Handbook HB260-2003 Hospital acquired Infections Engineering Down the risk is a document that deals with the emergence of methicillin resistant Staphylococcus and other multi resistant pathogens .The spread of infection requires three things

A source of infection

A host

A means of transmission of the micro-organism.

The source of infection is both the patient and the staff, the host may be debilitated and immune system compromised, the transportation for the micro-organism is the air and of significant importance to the hydraulic services engineer and a more significant link is human physical contact .The high risk areas are

Intensive care

Coronary Care

High Dependency / renal dialysis unit /step down units

Emergency medicine departments

Oncology

Paediatrics

The best combat weapons at this point in time are isolation and medical basins .The ability of staff to readily wash their hands through the provision of an adequate number of well-placed clinical hand basins is believed to minimize the transmission of microorganisms.

6.4 PATIENTS BASIN

The basin primarily used by patients will be located in the en-suite ,in older hospitals there may be patient basins located in wards ,the use of basins by staff or patients is not a strictly observed rule ,it is a matter of convenience .Repetitive planning is good practice for sanitary fixture location ,a built in memory forms from constant use of fixtures that are located in a constant repeating pattern which saves staff time ,and this can be a critical factor in health care .The patient basin will have dimensional limitations which accommodate wheel chair use ,it will also have lever action taps ,single point mixers with a lever handle and soft close design(Mattsson) are desirable ,also quick change cartridge of internal moving parts is preferable to O ring seals or similar high wear limited life rubber components. Patient basins may be free standing, not all Vanity configurations are compliant to BCA Sole Occupancy requirements, taps may not be capstan type, and they must be lever handles 50mm clear from the surface.

6.5 STAFF BASIN

Staff basins will be found in Kitchens, Wet Laboratories Pharmacies Workshops Animal Houses Staff Toilet amenities .Stores .Laundries

In kitchens and similar food handling areas the basins must be located to provide an adequate and effective means for frequent hand washing, the basin must be compliant with kitchen design rules and be clear of walls providing no un-cleanable fissures for insect habitation, the taps must be hands free, and the water supplies potable warm and cold with a premixed flow to the basin discharge point.

Wet Laboratories should be provided with basins for hand rinsing, safety features such as an eye wash spray may be a combined or separate free standing feature.

Safety sprays, showers and basins must not be connected to the non-potable laboratory supply; the supplies of warm and cold water must be potable.

Basins in workshops and laundries and heavy and dirty work areas may be subjected to more rigours use and cleaning regimes' and should be constructed of stainless steel

6.6 VISITORS BASIN

It is not unusual for hospitals to provide basins for visitors without a warm water supply, the wisdom of this are doubtful in view of Australian Standards Handbook HB260-2003 Hospital acquired Infections Engineering Down the risk. It would seem probable that visitors could be a contact interface for infection both in the hospital and beyond, it would make more sense for all contact visitors to wash their hands as routine practice after contact in wards.

Visitor's basins and Patient basins should be similar.

6.7 THE FIXTURE SERVICE INTERFACE

The specialised nature of the hydraulic services industry appears to have created fracture lines at the interfaces with other disciplines and also the manufacture of the sanitary fixtures which are created from various materials and processes.

The critical interface between the plumbing and the sanitary fixture product is the fixture support system and its connection to the building fabric and the hydraulic services. This is a no man's land of responsibility

The building fabric is determined by the Architect; the method by which the sanitary fixture is attached to the building fabric material is designed and provided by the product manufacturer, the marriage between the product and the architecture is undertaken by the plumber.

Building construction methods vary considerably, as do fixture traps and hot and cold water connections.

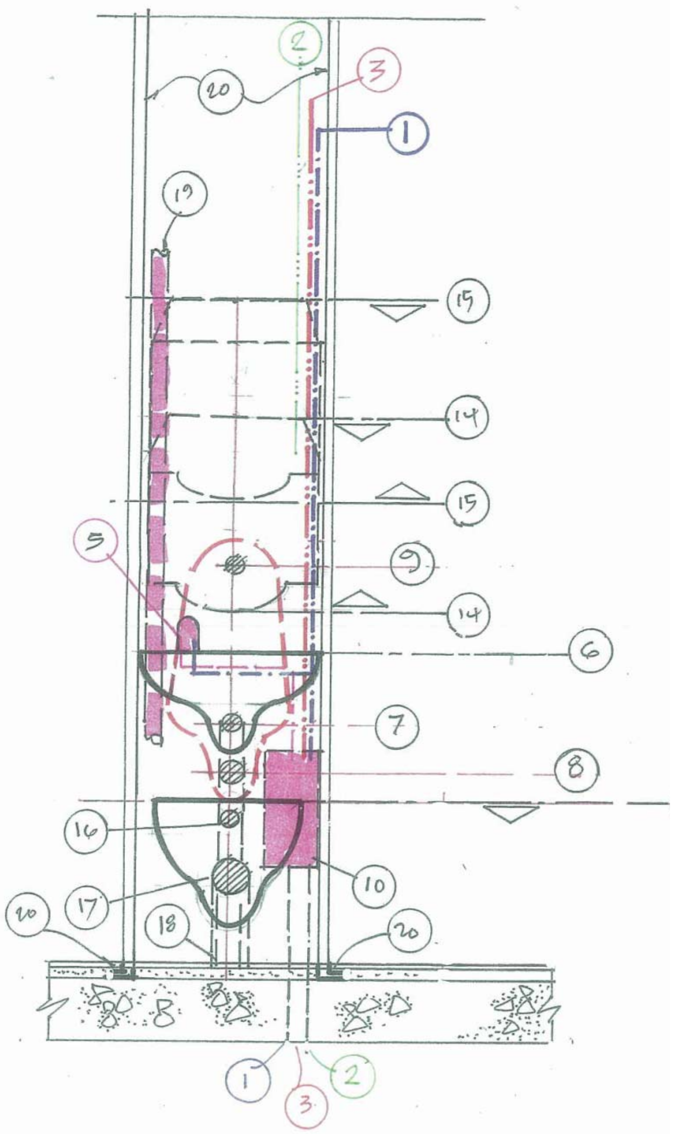
The interface between the supplied sanitary fixture product and the joining and supporting system to the building fabric, and the water and waste service connections, are not currently considered to allow flexibility. Or be resolved in an engineered manner which gives sufficient support to those that miss stake a basin for their favourite chair

It is left to the tradesman's skill and management resources to ensure sufficiently robust noggins or marine ply panels are inserted in stud walls as a secure and structurally stable fixing, or that back to back basins with P traps will not work in a 68mm steel stud wall, or that disabled persons shower grab rail combinations need secure fixing points that do not perforate water proof membranes.

It should after 200 years of building, be a conceivable innovation to manufacture a structurally rigid **Universal FixtureMounting** (UFM) plate from steel plastic or concrete that would coordinate with services and interface with any sanitary fixture and any wall and floor construction system and provide floor perforations, wall mounting and service isolation valves and connection points for a complete range of fixtures that may be required at any future date.

It would be advantageous for fast track building and flexibility to have services provisions and fixings suitable for any wall mounted fixture, including a built in cavity for flushing .TMV. Nurse call .and toilet roll. Even in buildings that are not dedicated to health care, the proposition of changing a urinal for a WC should be beneficial.

.As noted in this document, the use of 65 mm PVC is economically debatable .100 mm could be a universal connection size with an inspection access or reducer, as required.



Sanitary fixture universal fixing concept

No	Description	No	Description
1	Potable Cold water entry	10	Compartment for TMV
2	Harvested rain for flushing entry	14	Adjustable fixings for WC flush
3	Potable hot water entry	15	Adjustable fixings for urinal flush
4	Adjustable top edge level of WC	16	WC Flush connection
5	Warm and Cold water to basin mixer	17	WC Soil connection
6	Top edge adjustable for basin	18	!00 x 50 x40 Connection point
7	Basin 40 mm waste	19	Space for 50 vent pipe
8	Urinal 50 mm soil	20	Structural frame and fixings
9	Urinal flushing		Not shown Path for nurse call cable

6.8 W.C

The historical reference for a toilet pan that originated from naming a cupboard with a water supply.

Hospital WC pans do not require double flap seats ,the seat should be load rated to 150 kg and contrasting colour to the back ground against which it is viewed are predominantly ceramic construction (Prison hospitals use some stainless steel units) with box rim wash down bowl and flush back with concealed plumbing connections and a sealed joint at the rear wall interface, WC pans may be wall hung to facilitate above floor access to plumbing and better cleaning below the pan and also to facilitate a higher seat height to conform with disabled persons standards for wheel chair or commode chair access.

It is important to understand that some patients will need assistance and there should be sufficient space, to Australian Standards, provided to accommodate the patient's carer and a wheel chair

Pedestal pans (Other than flush back) with exposed S or P trap connections are not considered appropriate for health care use. Flushing noise from WC pans should be considered where WC pans are located directly above noise sensitive areas and light weight PVC sanitary plumbing is used.

6.9 BARIATRIC WC

A WC Pan of robust (tested) construction service the special needs of patients suffering from obesity.

610 THE FOLD AWAY WC

The Australian version of the foldaway toilet was designed by K.V. Bainbrige in 1972 for use in the Cardiac Care ward of the Westmead Teaching hospital, the unit is constructed of stainless steel and incorporates a small hand rinse basin in a bedside cabinet, the unit is based on an American product and manufactured in Australia by Dixon and Johnson Pty Ltd. The fold away pan is provided to remove the stress and anxiety of using a bed pan, cardiac patients are particularly vulnerable to stress, they are often attached to medical sensors and intravenous connections which limits movement to normal toilet fixtures, providing a means of self-help to minimise the patients embarrassment and stress is seen as a positive therapeutic investment.

6.11 WESTERN HYGIENE

These notes are endeavouring to expose the reader to the broader scope of hydraulic services design .Whilst Western culture and Health care utilises toilet paper as a personal hygiene method, other cultures utilises water for the same purpose.

To facilitate this cultural difference toilet compartments in Arabia and the Islamic and Coptic Christian world may include a proportion of Eastern squat style compartments, all evacuation toilets will be provided(Similar to Local practice for Urinals) with a floor drain and cold water flexible hose and suitable nozzle fixture in the compartment immediately below the flex pipe and nozzle. This washing facility is provided as standard practice in both Eastern and Western style toilets.

Also in many Islamic Health buildings a Prayer room with foot washing facilities will be provided.

6.12 WC VENTILATION

WC compartment ventilation can be an innovative services interface, ventilation systems that connect to the toilet seat ,or the flushing cistern and draw extract air from the WC pan flushing rim can be used with advantage in removing foul air from the point of origin, rather than removing air in competition with other air circulation forces .Existing systems of this type favour connection via a flushing cistern .However connection via a flushing valve would not seem an insurmountable problem to resolve.

6.13 FLUSHING SINK

The flushing sink is a fixture that requires a flush service and back flow prevention where hot and cold taps are provided for instrument washing

First introduced as a hospital dirty utility fixture in the 1970 the flushing sink has in more recent hospitals replaced the prior favoured slop sink for the disposal of bed pan contents and urine bottles in the dirty utility (Also referred to as the sluice room) Constructed of Grade 316 Stainless steel, the flushing sink may also be a fixture located in operating theatres that specialised in colostomy operations and in adjacent support facility rooms for fiber optic endoscope washing and sterilizing facilities. The flushing sink comprises a square 450mm X 450 mm X 200 deep sink bowl However this basic shape may be modified for particular surgical instrument washing procedures, generally in dirty utilities the sink is included as an integral feature of the stainless steel dirty utility work top, the sink incorporates a 100 mm diameter two part stainless steel trap and flushing rim at the top edge perimeter of the sink. The sink is also provided with Hot and cold water quarter turn wall mounted lever action taps, the breeching pipe may be concealed or exposed to facilitate horizontal lever action taps and moveable center spout with aerator.

Feces samples for laboratory analysis may be taken at this sink.

Mechanical ventilation in close proximity to the flushing sink and below the fixture flood level would seem to be an innovative opportunity to reduce air borne bacteria risk and improve health workers OH&S conditions.

6.14 BED PAN WASHERS

The transmission of acquired infections to hospital patients such as Clostridiumdifficile-associated disease (CDAD) can range from uncomplicated diarrhoea to sepsis and even death. CDAD rates and severity are increasing, possibly due to a new strain. Transmission of CDAD difficile occurs primarily in health care facilities via the fecal-oral route following transient contamination of the hands of health care workers and patients; contamination of the patient care environment also plays an important role.

A source of contamination as described could be inadequate sterilisation of bed pans in bed pan washers, and bed pan sterilisers / disinfectors.

There are available a number of bed pan and urine bottle cleansing systems ranging from the disposable bed pan and macerator disposal unit, to the hinged drop down vertical lid washer such as the RhimaDeko 190 Ward Disinfector which is compliant to AS/NSZ 4187-2003 and EN ISO 15883-3:2002,

The choice of fixtures used is obviously not within the scope of hydraulic services. For design purposes it is essential that the Hospital user group, or Health Care consultant nominates the make and service requirements of the selected plant. The designer may be required to provide any or all of the following connections.

100 mm Soil waste outlet for a 100 Celsius flow.

50 mm outlet from a disposable bed pan macerator unit.

Hot and Cold water with back flow protection and testing facilities.

50mm Flushing service

20 mm **Optional** Steam service and return condensate

Anti-vacuum vents **which do not** interconnect with sanitary vents, **(T**hese units are now dated**)**.

Electrical services may be required for self-contained water heating, pumps and control systems.

6.15 URINE SAMPLE WC

A specialised WC pan appropriate to the female toilet area of urology clinics, the unit incorporates the added feature of a ceramic or stainless steel attachment to secure and remove a sterile sample bottle within the urine flow for removal and laboratory analysis, these toilets are generally installed in a modesty compartment with wash hand basin.

6.16 FIXTURE FLUSHING

Flushing activation buttons must be proud of the adjacent surface and compliant to AS1428.1 2009 As noted previously, the trend to save water in Australia promoted the low flush toilet, choke statistics in hospitals tend to indicate that there may be some correlation between the reduction of transport water and maintenance issues, this phenomena being referred to as Dry drain, no doubt research into the subject will resolve the matter, however the water conservation trend has also stimulated the harvesting of rain water and the treatment of black water by membrane technology ,this flushing water supply in consideration of public awareness is currently considered second grade water, there seems little point in aggravating drainage efficiency and health standards by starving the water transport system of an available source of second grade water.

The US National standard now mandates dual flush of 6/3 litres ASA 1172.2.10.3 In Australia the 2004 Yarra Residential End Use Measurement Study found that in practice the flushing ratios used were 1 to 1 or one full flush to every reduced flush ,thus a 6/3 fixture would effectively have an average 4.5 flush (or approximately one imperial gallon) .from the data available regarding human bodily functions ,flushing habits ,and dry drains it would seem that the optimum water volume for flushing efficiency remains elusive.

Harvested rain water and recycled water in Hospitals is subject to compliance with Legionella irradiation standards. Duty and Standby UV irradiation units are considered essential, however regulations on this point are vague.

Irrigation is considered a secondary use for harvested roof rain water, hospital landscaping in recent history has favoured low maintenance native drought resistant planning, the assumption being that in extended periods of dry weather the roof catchment would not be a reliable source. Harvested rainwater could in some geographical locations be considered a bonus low investment cost water source.

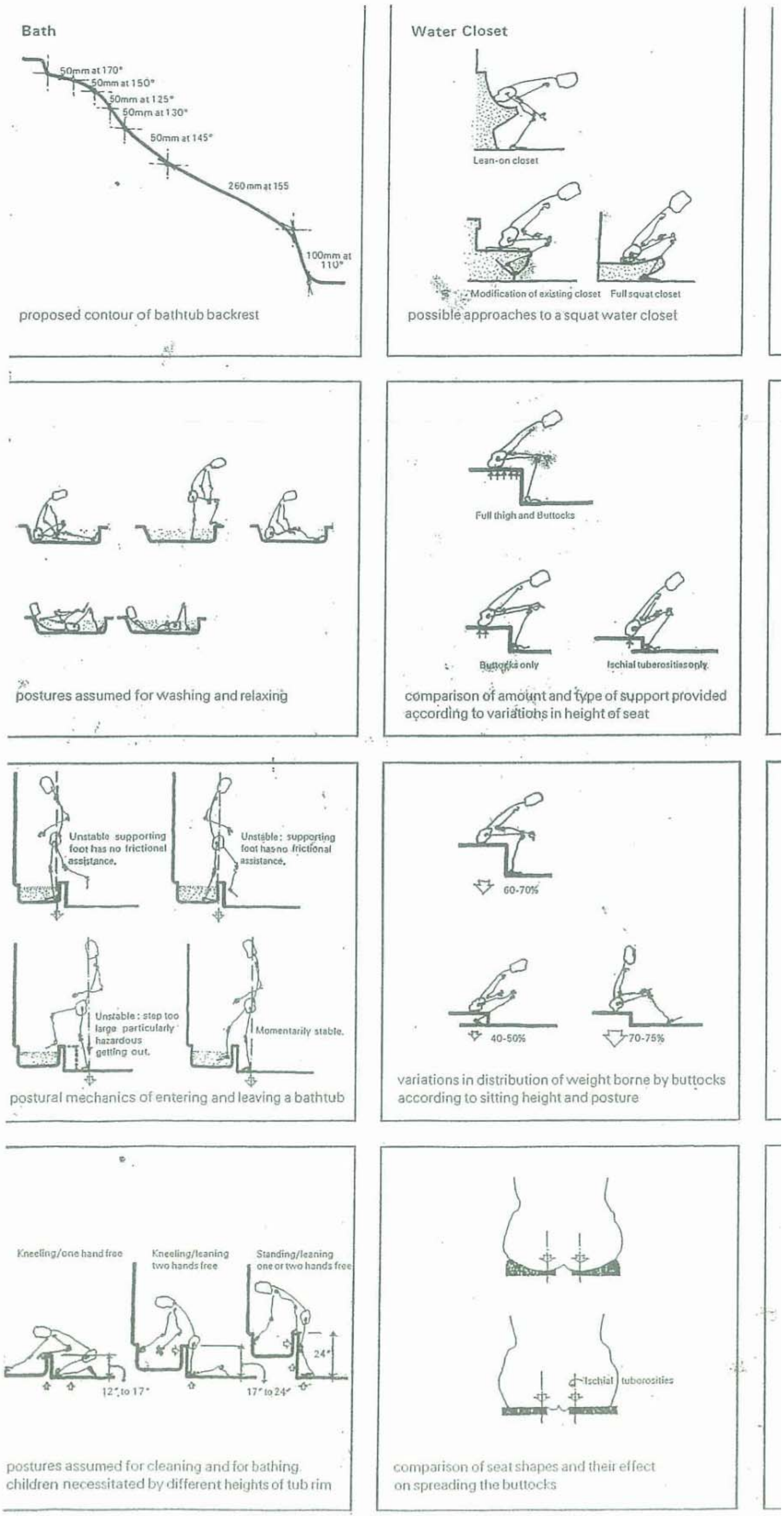
To be cost and environmentally effective the use rate of harvested water should be balanced with the supply potential. The significant cost, which is competing with the bed cost, is in the harvested water storage volume.

An approximation of the potential supply volume of rainwater from a roof catchment is reasonably predictable from metrological records; similarly the consumption of flushing water is predictable within acceptable boundaries,

Where calculations indicate that average rainfall will exceed toilet flushing demand, the less frequent and higher run off storm event run off should be directed to an optional consumption stream such as cooling towers.

It would seem a reasonable proposition to use harvested water at flushing fixtures in flow quantities that have historically proved effective.

Ideal Standard of Britain were the first company to take up development
University 1958-1966 Study fixture recommendations in conjunction with
Inc and Industrial Designer Douglas Scott F.S.I.R.A
The drawings below are only a very small part of the research as Publisl
Criteria for Design



proposed contour of bathtub backrest

possible approaches to a squat water closet

postures assumed for washing and relaxing

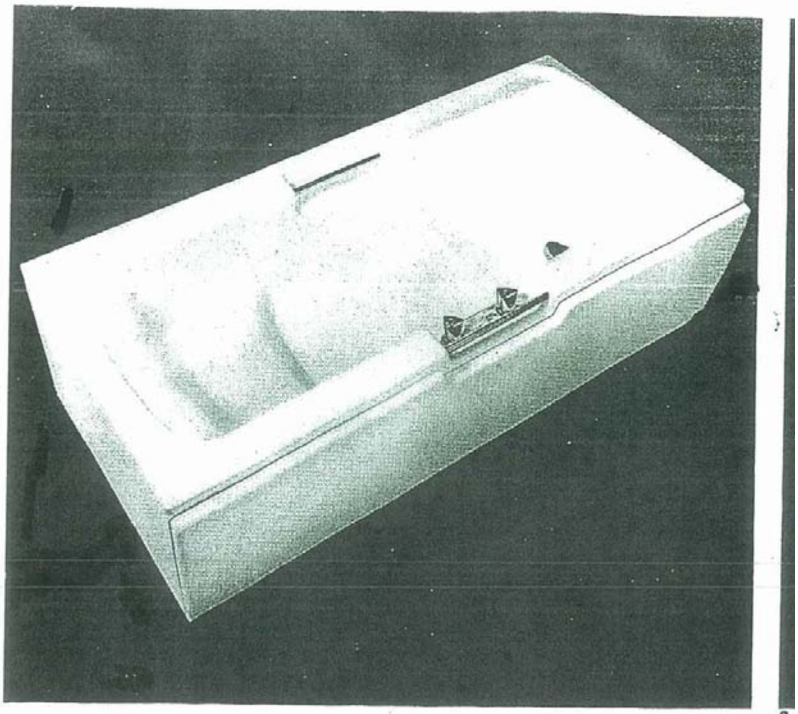
comparison of amount and type of support provided according to variations in height of seat

postural mechanics of entering and leaving a bathtub

variations in distribution of weight borne by buttocks according to sitting height and posture

postures assumed for cleaning and for bathing. children necessitated by different heights of tub rim

comparison of seat shapes and their effect on spreading the buttocks



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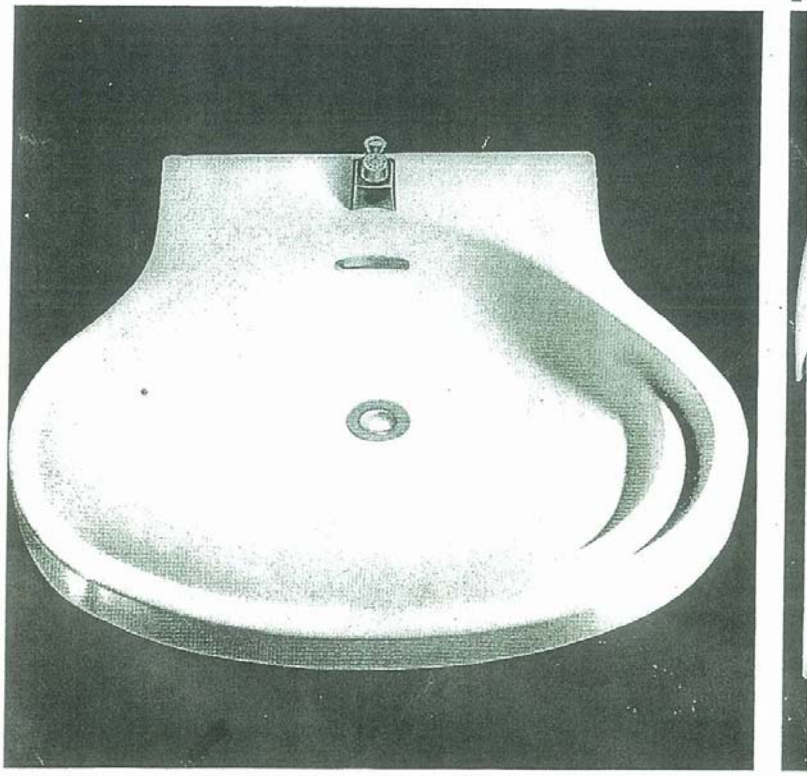
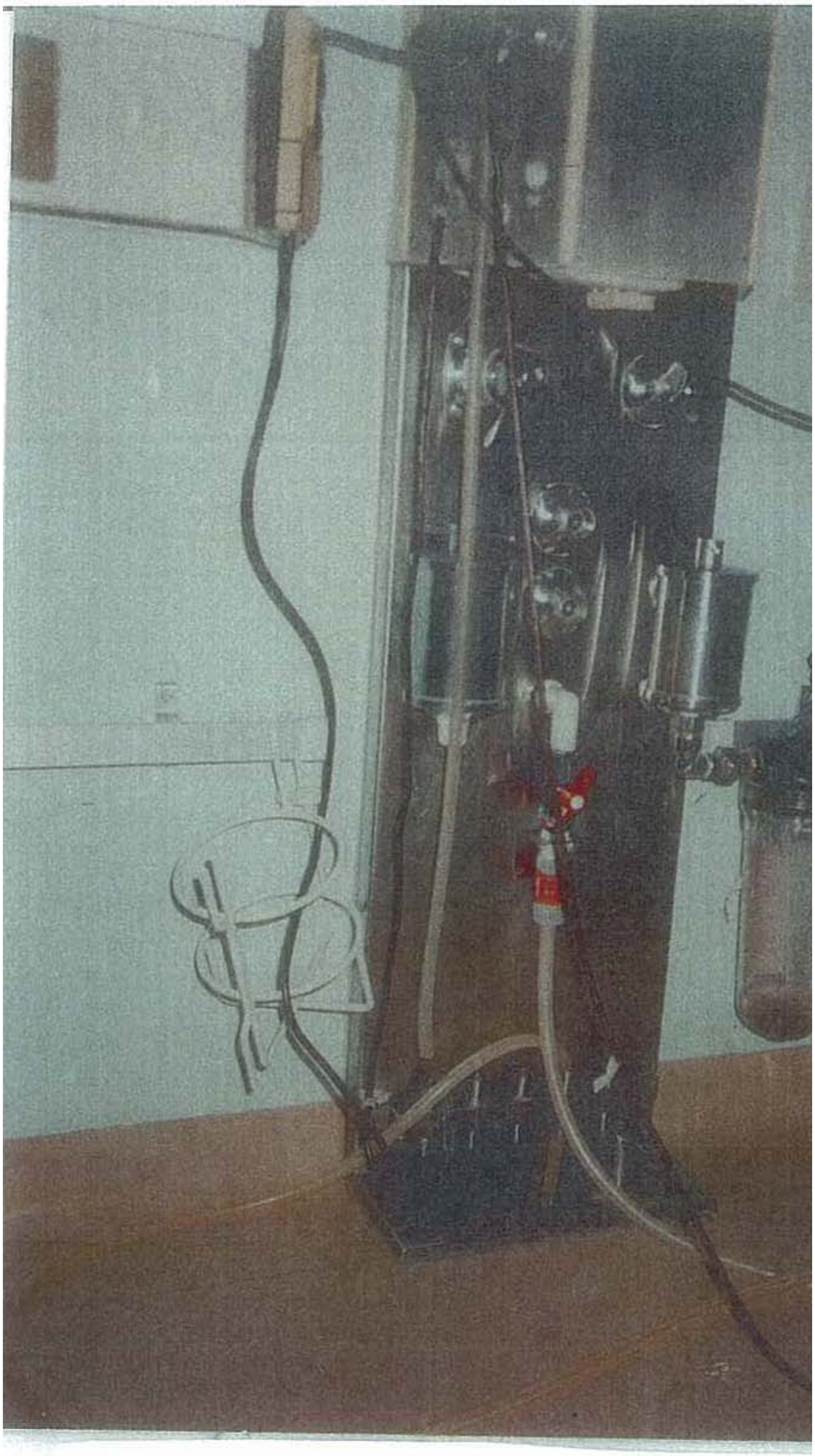


IDEAL STA

A typical hand rinse basin for staff use, as would be found in a hospital corridor alcove o
treatment areas ,the square white panel to the left of the basin is access to the thermost
bottle trap which will trap sharps and allow ease of removal ,also the surgeons style elbc
taps ,these leave the basin clear of projections that impede cleaning ,the taps have left a
are quarter turn ,ceramic seals are suitable for this arrangement because they tolerate tl
tap handles . This basin is cantilever bracketed from the wall to provide good cleaning a
arrangement requires structural consideration when fixed to a stud wall, or directly back
the other side of the wall. Unstable or careless users may use the basin for emergency s
significant structural load

Islamic and Coptic Christian Personal hygienic hose adjacent to WC pan Dubai U.A.R



Between beds or day couches dialysis station

6.17 FLUSHING CHOICE

With regard to WC Pan, Bed pan washers Flushing sinks or flushing or
mortuary floor drains a choice of which of the three terminal flushing devices will be used, must be made.

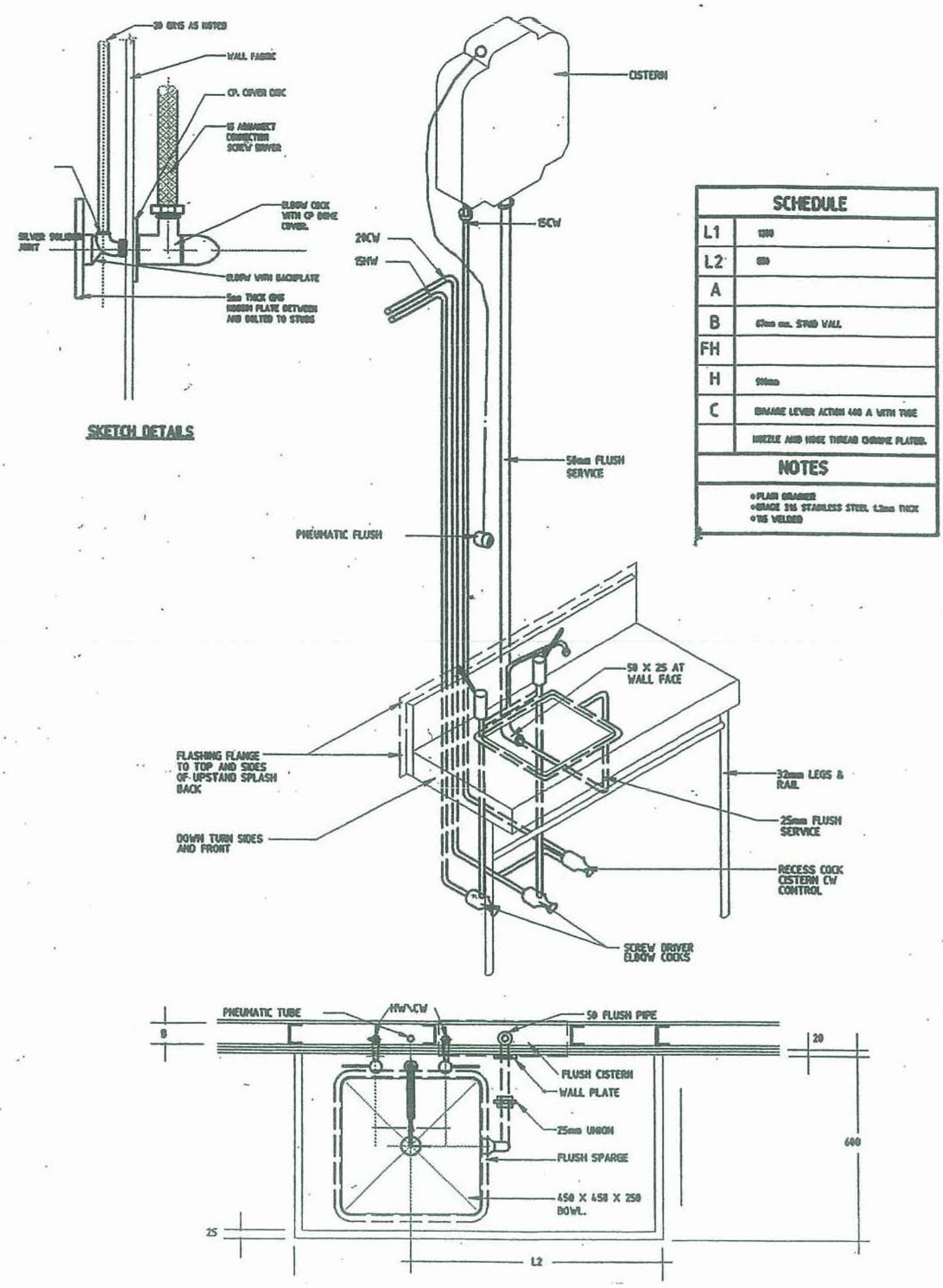
1) Cistern.

2) Conventional Tank fed flushing valve.

3) Mains pressure flushing valve.

All three of the above will require a dedicated pipe system and storage vessel if harvested rain water is to be used. Where the Cistern flush is selected the cistern itself can be a contributor to the harvested rain storage volume .A cistern of 24 litres volume is a practical proposition for construction in most materials and is of acceptable architectural proportions, with a 3 litre flush this gives an 8 flush reserve in each cistern installed, a significant contribution to reducing the harvested rain storage cost.

The conventional flushing valve, which pre-dates the mains pressure units, requires a much larger pipe diameter 40 mm, as against 25 mm for the mains pressure unit. The mains pressure unit served directly from a common cold water service supply can impose severe spike loads in the cold service which are considered detrimental to maintaining similar pressure ranges between hot and cold water services .Where the mains pressure flush valve is installed from a tank storage system using harvested rain, a booster pumping system will be required to serve those levels in the building that do not have adequate static head from the storage tank. As a cost effective system, with the added advantage of reserve storage capacity, the cistern is in most instances the best choice when considering capital cost, running cost and maintenance. (Refer also to NSW Health TS11)



FLUSHING SINK, (CISTERN TYPE)

6.18 FLUSHING VALVES

Flushing valves originated in the USA and are seldom used in the UK being considered an extravagant water consumption use ,the first version of flushing valves were tank supplied ,this type of valve will be encountered in many Australian installations .The basic storage requirement was 10 gallons per valve or 45.4 litres .

The evolution of flushing services appears to have reverted back to the central storage system that uses harvested or recycled water ,the flushing valves may be pressurised system dual flush ,and the pipe sizing smaller.

The change away from the common pipe system using mains pressure flush valves is seen as an improvement, the mains pressure flush valve can introduce very high dynamic pressure changes in a cold water distribution system, changes that create spike pressures of very short duration and that can adversely affect thermostatic mixing valves or other pressure sensitive devices.

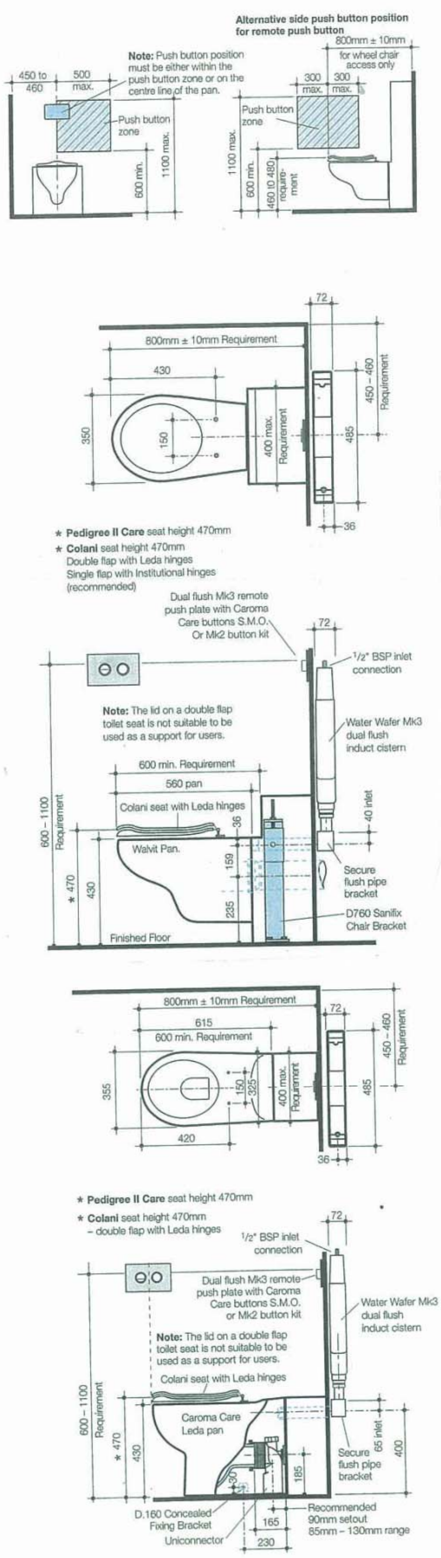
6.19 FLUSHING CISTERNS

Flushing cisterns as originated in the UK were termed W.W.P (Water waste prevention), the hydraulic action was a manually activated siphon, the Burlington Bell constructed of cast iron mounted at high level on ornate cast iron brackets and with a chain pull activation provided a Tsunami of flush water and some interesting sound effects, such flushing arrangements dominated Edwardian and Victorian plumbing. The activated siphon flush cistern could not accommodate that insidious and constant leak via the flushing supply to the pan (That faint shimmer of a ripple that can be seen in the pan water seal) The overflow from cisterns was required to be directed to where it would be apparent, the integral overflow to the WC flush being an anathema to any self-respecting cistern designer.

The Burlington Bell was superseded by a short lever activated siphon piston design, more compact and suitable for low level cistern designs. Such history is of passing interest, it is noted because it underlines a historic concern about wasting water.

In the Hospital environment the cistern is as acceptable as the flushing valve, the in-wall unit is considered cleaner, there is an innovation opportunity the remains to be seized where each cistern could contribute to the storage reservoir of harvest water .However this innovation must come from manufacturers.

Caroma Care Walvit



Caroma Care Leda 2000

Hospital Basin

Vitreous China Hospital Basin

Size 600mm x 515mm (nominal)

A hygienic wall-hung scrub-up surgical basin for hospit industrial 'Clean Area' applications. A generous area at of the basin provides ample room for soap and brush h **Hospital Basin** is available with either glazed or ungla

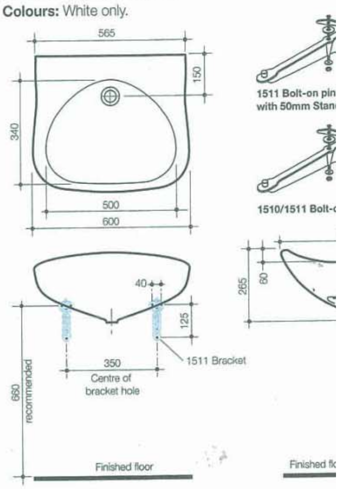
Tap Holes: Available in no taphole, one taphole, two ta three taphole options.

Waste outlet: Waste outlet use 40mm diameter stand assemblies.

Fixing: Two bracket options are available for the Hospi **1510 Bolt on Pin Bracket** – uncoated alloy. **1511 Bol Bracket** – white enamelled with or without **50mm Sta Spacer Kit**.

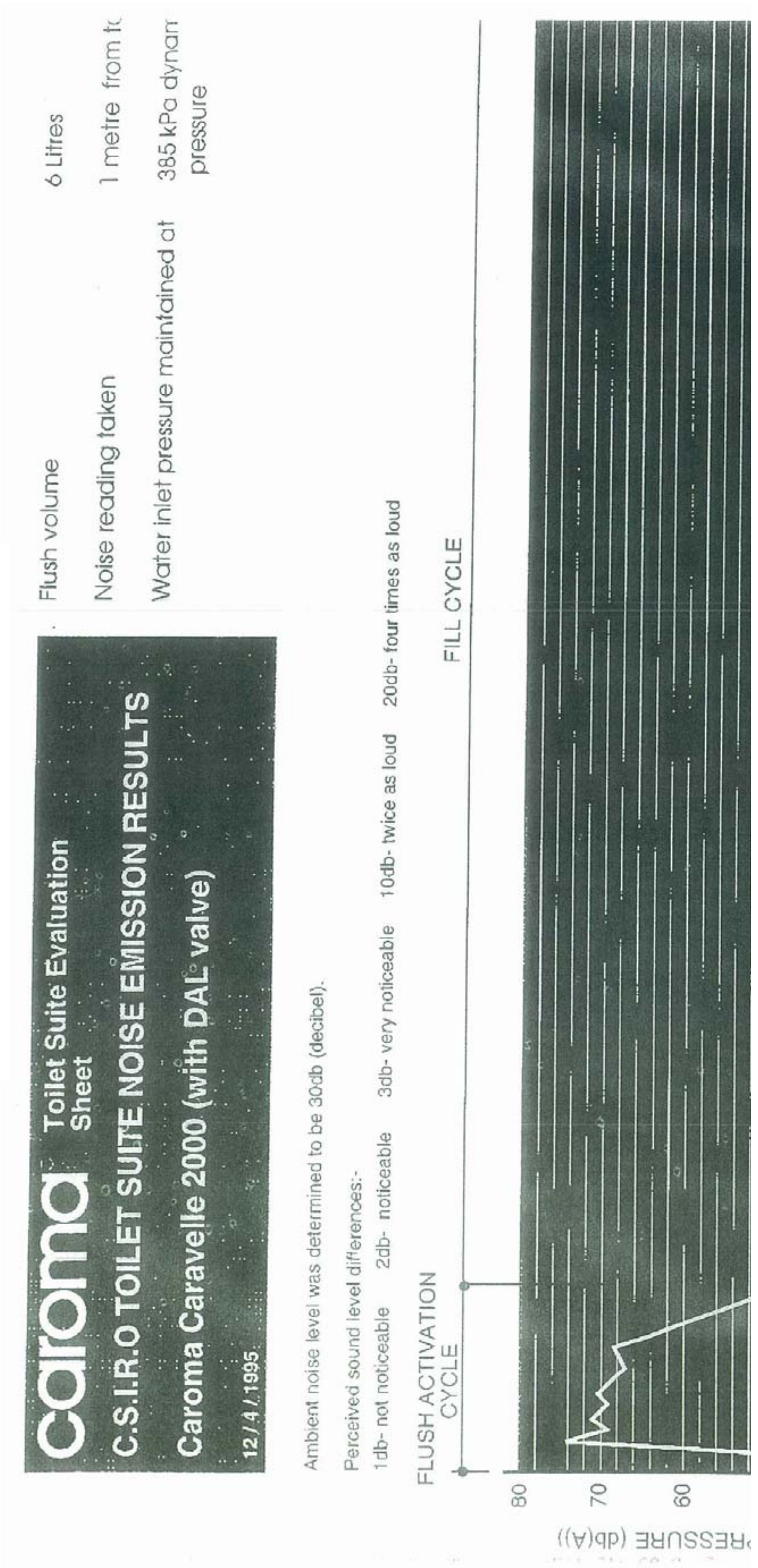
Installation: Refer to *Important Information for Plumbe*

Colours: White only.



Caroma Car Wall Basins

Caroma Industries Limited



6.20 SIPHONED FLUSHING

The automatic flushing cistern with reverse action ball float valve has for all intents and purposes slipped into history, the automatic cistern water waste was curtailed to some existent by system isolation solenoid valves and time switches also modifications to 1970s by-laws and standards calling for central isolation The principle of siphoned flushing might be useful for ensuring a regular flush in seldom used drainage systems.

6.21 URINAL FLUSHING

Urinal flushing is limited in hospitals to male visitors and male staff toilets, the impact on water consumption is not comparable with commercial buildings, movement sensing activation of flushing valves is one means, as is timer controlled flushing, however such systems have a constant electrical demand and sophisticated components that are generally replaced rather than repaired.

6.22 ENDOSCOPE FLUSHING

The endoscope is a surgical inspection device that is inserted into the body to inspect the interior of the bowl and those parts of the human body that are closely associated, it will in use become contaminated and is designed to be leaned and sterilised, the learning process involves first flushing, where potable water services are connected a RPZD is required.

6.23 NEPTUNE

The Neptune waste management system comprises a docking station and a Rover which are magnetically linked, the docking station being located in a disposal area near the operating theatre .The Rover is a mobile unit used in the OR to suction and collect surgical fluid and small debris from the surgical site, optional features include a smoke evacuation unit which collects smoke from cautery or laser surgery.

The docking station is a wall mounted component served by water and drainage and power, when the rover interfaces with the docking station it automatically empties and rinses the collected waste materials from the rovers fluid container ,it automatically releases liquid detergent into the system.

It should be noted that this is a proprietary system (Stryker Instruments 4100 E Milham Avenue Michigan 49001 USA) and is typical of the advancing technology in surgical practice that interfaces with building services and needs to be understood by the hydraulics consultant and the public utility operator, the waste material discharged by such units may not in all cases be an acceptable direct discharge to a drainage system and may require piped transport to incinerationdisposal.

6.24 POST MORTEM

The post mortem table comprising a surface of approximate single bed dimensions with blood drainage channels and an end space for instruments and a sink the surgeon’s taps. Post mortem tables may be height and tilt adjustable, they may be laminar flow air curtain contained for forensic post mortems of decomposed remains; this type of mortuary table will be found where post mortems are associated with police investigations. Mortuary tables may be the focus point of a teaching theatre, and may have video linkage to teaching facilities; the lighting requirements of teaching facilities may influence the choice of bright or satin finish to stainless steel sanitary fixtures.

The mortuary will require Hot water and Cold water Flushing service and Tool air, significant lighting, and possibly locally mounted Hepa, and activated carbon filters for air treatment. All table parts must be demountable and cleanable to sterile specifications.

The key driver is simplicity to sterilise and the ability recovers tissue, or foreign objects that might otherwise be flushed away.

Water services to the fixtures may be flex pipe mounted for adjustable surfaces, or concealed within the stainless steel fabricated structure. Tables may incorporate a perimeter or central drainage herringbone system. Water authorities regard post mortem tables as a backflow risk.

The sink and blood channel drains will be 50-mm diameter stainless steel un-trapped waste discharging to a floor grate or channels with arrestor baskets.

6.25 MORTUARY FLOOR DRAINS

Floors and surfaces of the mortuary will be cleaned from retractable hose reels supplied with high pressure (500 kPa) mixed water, the supply being dedicated from a RPZD or plastic RAG storage tank , this may be equipped with a disinfectant (Liquid Chlorine) dose pump.

The floor surface treatment and drainage design in a mortuary will vary with the concept proposed by the health care consultant, in older installations tiles possibly with demountable plastic or timber decking sections over an impervious floor may be used, with special tanks for high chlorine dose soaking of the floor section and protective rubber footwear, being a sterilising feature.

Composite or vinyl seamless floors may be used with coved easy clean floor to wall junctions. Floor drains and channels require removable basket strainers and automatic waste valve closure (magnetic refer SPS) should be a feature, also vinyl seal clamps if this flooring material is used.

Floor drains with integral flushing rims to flush blood .and stainless steel channel drains with tapering wedge(non- clog) bars that minimise agglomeration of organic material, these may be fabricated with hollow section square stainless steel tube to facilitate a grid blood cleaning flushing system.

Flush valves can be activated by a cleaning attendant from a central control point.

Floor grades of 1 to 1.25% are used. (As a guide tennis courts use similar grades)

Industrial waste disposal systems are not generally approved for use in mortuary and associated post mortem activities, such devices may be approved for placenta disposal in maternity units

6.26 URINALS

Urinals in hospitals are in most cases limited to staff toilets and visitors or public toilets ,whilst water saving may be applied with the use of movement activated flushing and harvested rain water the resulting impact on overall water savings from urinals will be modest ,the use of waterless urinals in health care installations is not seen as justifiable .

Modern urinal installations favour wall hung systems that offer improved floor cleaning properties, and the feasibility of a moving partition toilet designs to readjust male /female staff population ratios.

Plumbing design considerations extend to floor drains within 450 mm, hose taps possibly tee key operated to minimise vandalism and the careful consideration of sight lines from entry doors that includes the reflected image of mirrors.

6 .27 BIDETS OR LITTLE HORSE

The bidet a peanut shaped bowl WC fixture without a cistern originated in France and will be found in Western Europe and former French colonies, the original bidet was equipped with a warmed ceramic rim and an ascending mixed water spray, with various attachments generally considered appropriate for female use.

In hospital use the bidet in its current design format with an over the rim directional spray, that does not constitute the submerged inlet of older designs, will be considered useful in female wards, or in wards where surgery is performed in areas of the body that will require gentle cleansing as part of the recovery program .

The Little Horse name is derived from the position of using the bidet by sitting on it facing the wall.

6 .28 SHOWERS

Shower in health care are a significant departure from residential design and have ,like the tip up toilet , the most important and subtle contribution to patient care, in that they stimulate a feeling of self-reliance and self-care , a mentally positive attitude can only be helpful to recovery.

It is important that the patient can enter the shower in a wheel chair, or if viable, as a pedestrian without the hazard of shower containment kerbs to step over, or hard transparent screens to negotiate.

The shower temperature must be pre-regulated to a 42.5 degree Centigrade upper limit, the spray temperature and location taps, must be easy to use for persons with debilitated hands and height adjustable from the sitting position in a wheel chair and in a location that will allow the user to test for comfort the deluge temperature prior to entering the spray range.

The spray must be a telephone style with plastic flex and preferably with a soft spray that does not cause overspray or water vapour that can be inhaled and the spray must be robust and be impact resistant if dropped on floor tiles. The shower spray mounted on a 32 mm stainless steel grab rail is desirable with height adjustment of the shower spray negotiable from an extended rod accessible to a wheel chair patient.

The health care shower must have strategically located grab rails and a nurse call button. The floor drain for a heath care shower must not present a hazard to foot traffic and it must be served by a minimum 65 mm waste drain.

(Refer to Therapy pools for group shower activation)

6.29 BATHS

The standard assisted bathroom bath in hospitals occupies a peninsular location with space at each long side to assist the patient, or allow a patient hoist in position to lower the patient into the bath .There may also be taps for a short hose over the bath telephone shower set.

Flow control on baths may increase filling time, if available 20 mm taps are an advantage.

The bath must be served by a 40 mm waste outlet which joins a 65 mm outlet floor drain with a sealing rim appropriate for the floor finish used.

6.30 BIRTHING BATHS

Birthing Suite baths are fibre reinforced designed specifically for entering the bath with safety, and to compliment the posture required for ease of giving birth with medical assistance. Taps must not be hazards as protrusions and grab rails are required for patient reassurance.

6.31 ARJO BATHS

Arjio bath is a specialty bath fixture manufactured in Sweden the designs vary from egg shaped baths that swivel around a sitting patient (Adventist Hospital Hydro Therapy Unit) to aquarium like shallow baths for burns victims or to allow medical therapy staff to direct hydro-therapy exercises that are assisted by heated water.

6.32 BABY BATHS

The baby bath is a specialised maternity ward fixture usually constructed of stainless steel with a sloping base into the water ,baby bath warm water temperature is critical and the writers experience a source of contention from the people at the work face doing the work who allege that the warm water is too cool, this may be the effect of the stainless steel absorbing the initial input of heat ,also the large water surface to volume ratio that would promote rapid cooling .Looking to an innovative baby bath proposition of a jacketed bath with thermal insulation to maintain the correct temperature of the bath water would not seem to be a difficult problem to solve

The taps for a baby bath should include a telephone spray head and flex pipe as an optional water source, a full way (Spherical ball) valved waste outlet is also a desirable feature for any bath installation.

6.33 TAPS

Taps and brassware for hospitals should be a negotiated agreement between the Architect who has an aesthetic interest, the Health planning consultant, who has an economic and functional interest and the Hydraulics Consultant who has a compliance with authorities and best practice interest.

From the Hydraulic Consultants view (The focus of this guide) the taps for patients basins should have local isolation valves ,mini cocks or similar and be suitable for disabled persons use ,single long lever mixer taps with soft close and long life expectancy of the moving parts Mattsson are recommended.

Baths require a quick filling time and 20 mm taps are justified if they can be sourced.

WC Pan. Flush valves are the preferred option, tank supplied to allow the use of harvested rain from high level tanks and to provide a storage reserve.

Cisterns may be appropriate for public areas, vandal proofing is an unfortunate requirement.

Thermostatic mixer valves are an option to provide warm water to debilitated persons; all patients are included under this description.

6.34 CAGE WASHING

Cage washing and sterilisation will be a feature of an animal house ,where the animals are pathogen free for medical testing purposes the problem of infection is a relevant consideration to the hydraulic services designer .

The cage washing machine may be quite a large and specialised stainless steel tubular frame on wheels to facilitate loading into the washing bay / or machine .The frame will incorporate cadge racks, the cadges being inserted upside down, the frame will also be the pipe work system feeding numerous high temperature water jets located to clean and sanitise the cadge surfaces.

Waste water from the cage washing system will be high temperature and the cooling system before discharge to sewer should incorporate a heat pump recovery system to preheat the next cage wash cycle, cage wash waste must be compliant to Trade Waste requirements.

Note Cage animal feeding systems for pathogen free animals will be Ultra-pure water.

6.35 SENSOR TAPS

The movement activated sensor tap has met with a mixed reception from the health care industry .Primarily designed for medical basins.

The practical problems experienced have been.

Cost .This is a high-tech device that requires an energy supply to activate the sensor electronics and the magnetic flux in the solenoid valve.

Energy .Whilst the energy load is minute ,it is on line 24 hours 7 days a day a week ,the useful life of the electronic components are reduced by the constant active state of the device.

False signals operating the valve, doors, passing traffic, the sensitivity of the activation is critical.

Maintenance .Two trades are required; replacement rather than repair is required for minimum off line time.

Time to receive mixed water at the basin discharge point. It is possible in the permitted 10 metres dead leg pipe to supply up to three close proximity basins, the time frame that the warm water takes to travel the 10 metres of 20 mm diameter pipe can be unacceptable, plus it is a great waste of water and energy .It is desirable to run a much smaller pipe 7.5 mm from the mixer to a small manifold at the sensor tap, this reduces the loss of water to 33% and also the waiting time from 15 seconds to 5.

Research in 2000 by the UK Thames Water Research has shown that over 240 taps the average water use per visit was as follows

Manual -0.9 litres Sensor -1.8 litres Increase 100% (Hot water seldom reaches the tap refer also to ‘The case for small bore pipes”)

6.36 KITCHEN SINKS AND WASTE DISPOSAL

Refer also to trade waste in respect to waste disposal units .The kitchen sink is very much a specialised industry unit together with dishwashing machines and ice machines used for drug or specimen storage .The brass ware for kitchen sinks should incorporate local fixture isolation valves

6.37 SAFETY SHOWERS

Deluge or emergency showers for specified areas of work are mandatory and must be serviced from the potable water supply with a service that has minimal intermediate isolation valves.

It is noted that other than contamination bay showers; the laboratory deluge shower is seldom used for its design purpose.

Water temperature at deluge showers can, in **some cold climatic regions**, represent a problem, and whilst .Laboratory Codes tend to confuse this question; it has been the writer’s experience that in Sydney cold water at 15ºC discharging over people that are fully clothed, it is doubtful to cause hypothermia and considered as a common sense issue ,to be satisfactory. The supply of tempered water at over one litre /second flow could represent a high cost installation, the initial deluge would not be tempered and the routine testing arduous, the advantage of tempered water to dilute acid or biological material is also very doubtful. Such questions are not often raised and when they are it's usually the result of an overzealous peer review.

The emergency shower and eye wash are an essential Occupational Health and Safety provision.

Deluge and eye wash showers are required to serve Laboratories with Chemical or Biological use, and that serve Industrial areas such as contamination bays and Chlorine delivery areas are provided with compliant deluge and eye wash and hose down facilities from a potable cold water supply of adequate size(Minimum 25mm). 32 is more appropriate to flow.

A flow switch incorporated in the flow supply service to emergency fixtures may be linked to the BMS as a means of directing immediate assistance to the emergency .In addition where bunding and containment storage is a feature or are required an automatic Fox diversion valve may be required to divert contaminated flows from entering rain water drainage systems.

The question of drainage for deluge showers located within laboratories can be a design and operational issue, it is mandatory that such showers are tested as a recorded routine.

The deluge shower will discharge a prodigious amount of water that will in most internal locations exceed the capacity of the standard 100 x 65 floor waste drain ,to facilitate testing a mobile bucket with shower spray curtain is available .

The cleanup task and damage from emergency shower use can be minimised if a floor drain is provided in close proximity as a means of draining a basin or other fixture that is within range and that will be used as part of normal operations.

Emergency equipment and condensate from air handling units, both have long periods of little use, the receiving waste water trap should incorporate a “Grateseal” or similar rubber lips dry seal to prevent air contamination from the plumbing or drainage system.

The question of contamination from the result of the run off, and the cleaning process resulting from the emergency shower deluge should be considered.

Codes and regulations are specific in regard to the drainage and containment of de-contamination bays, but less informative in respect to deluge showers that serve laboratory areas.

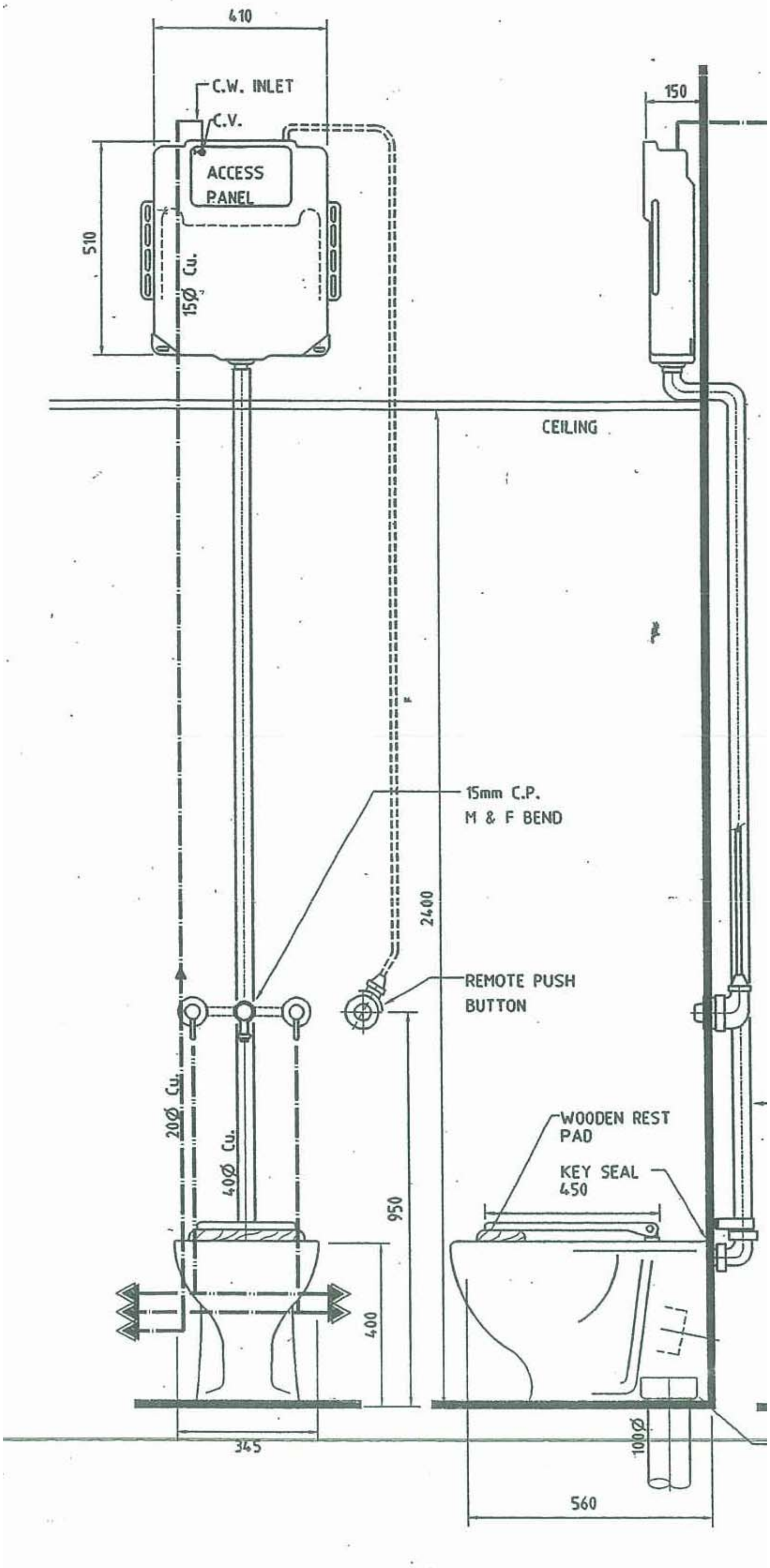
Where no drainage is provided below or in close proximity to a deluge shower, the user group and client must be advised that there may be a significant clean up job if a deluge shower is used. Consideration of the nature of the contamination is relevant, an aggressive chemical spill on unprotected flesh might be considered, less danger as a diluted substance, than a capsule of cyanide, a very strong poison, or a biological experiment spill releasing dangerous pathogens.

The biologically dangerous spills are not generally considered to be in the deluge shower emergency category; this work having stringent containment procedures, also the benefit of a water deluge is doubtful and may even exacerbate containment of living cultures.

The target group for emergency action by water dilution is the aggressive burning chemicals, there diffusion into the building fabric in a diluted form and a later clean up would seem to be a reasonable and practical approach, an adjacent floor drain that is water charged and joins the trade waste system would also appear to be beneficial.

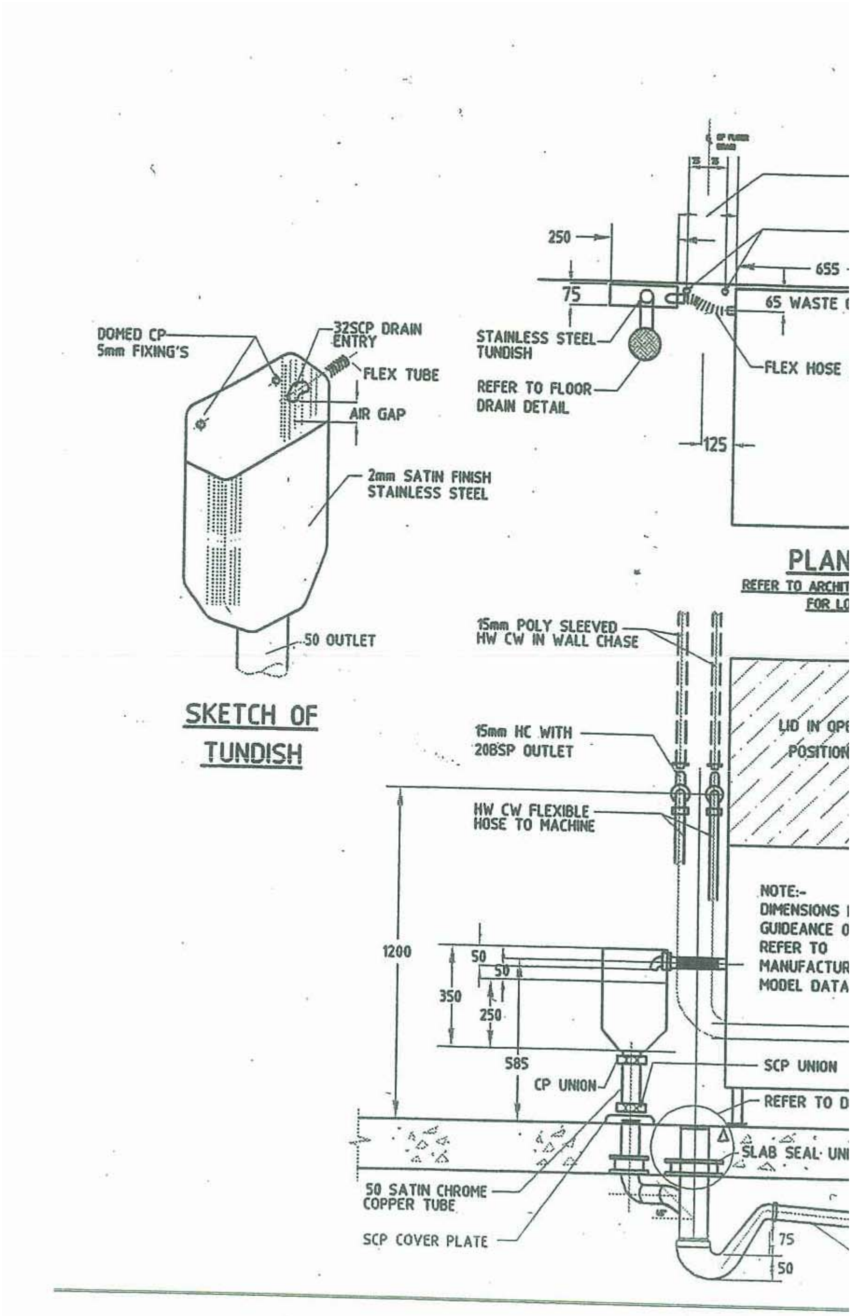
The proposition of a specialised waste collection system is reasonable for a high risk contamination bay, but it would seem to be impractical to capture the deluge discharge from a laboratory floor by means of standard surface drains and also maintain a water seal.

A special provision of dedicated drainage for internal deluge showers and eye wash sprays is considered to be an expensive and impractical proposition.



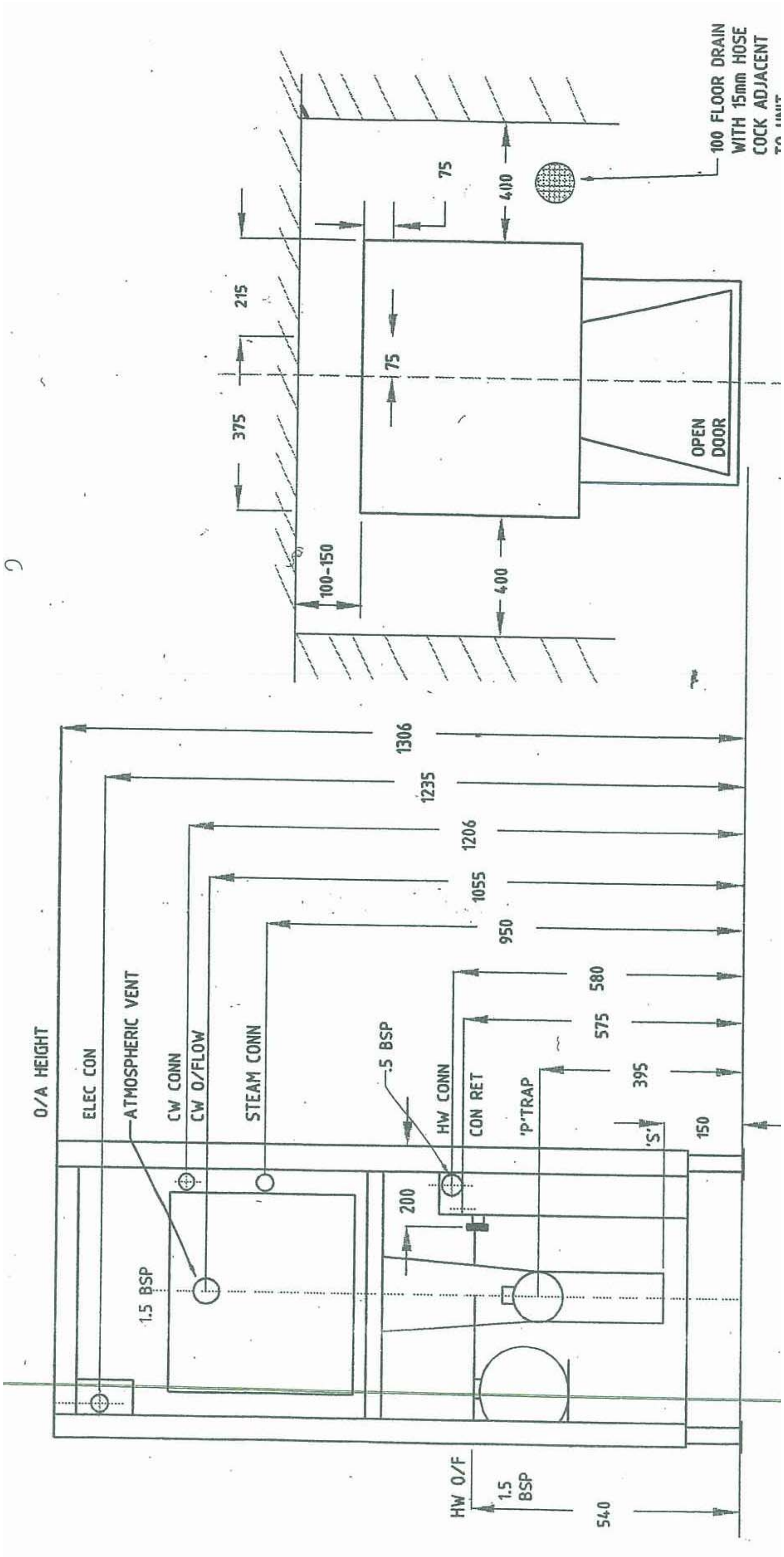
TYPICAL SLOPHOPPER DETAIL

SCALE 1 : 10

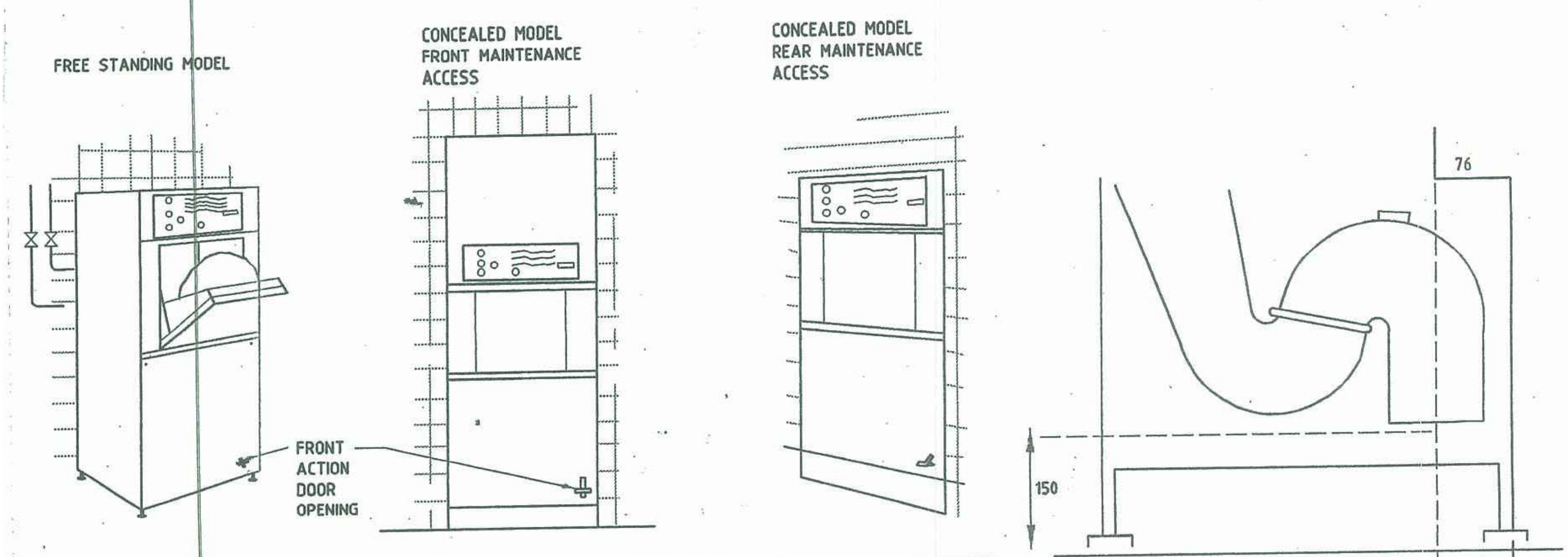


WASHER DISINFECTOR DETAIL DRAWINGS

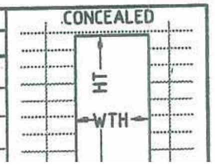
NOT TO SCALE


100 FLOOR DRAIN
WITH 15mm HOSE
COCK ADJACENT
75
400
215
75
375
OPEN
DOOR
100-150
400
1306
1235
1206
1055
950
580
575
395
150
O/A HEIGHT
ELEC CON
ATMOSPHERIC VENT
CW CONN
CW O/FLOW
STEAM CONN
.5 BSP
HW CONN
CON RET
'P'TRAP
'S'
200
1.5 BSP
HW O/F
1.5
BSP
540

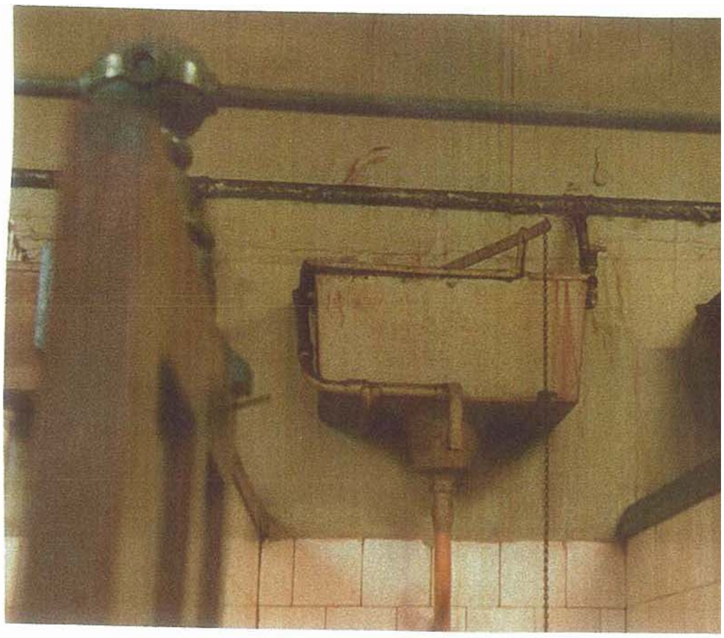
THE BED PAN FLUSHER/SANITIZER CAN BE EITHER ELECTRICALLY OR STEAM HEATED, FREE STANDING OR CONCEALED.



WATER HEATING	PLACEMENT	ACCESS REQUIRED	DIMENSIONS		
			HEIGHT	WIDTH	DEPTH
ELECTRIC	FREE STANDING	BOTH SIDES	1306	590	533
ELECTRIC	CONCEALED	REAR ACCESS	1213	590	600
ELECTRIC	CONCEALED	FRONT ACCESS	1600	590	600



OUTLET TRAP



This Information included for historic interest only.
Both the Burlington bell Water waste prevention cistern and the four way island Urinal with and floor grating was photographed in the Queen Victoria Building at Town Hall prior to the they were preserved.

NEPTUNE

Waste Management System

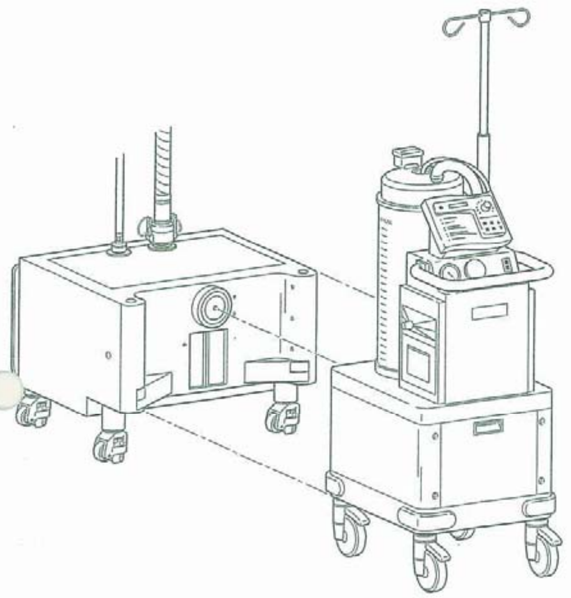
SITE PREPARATION and INSTALLA

Introduction

The **Rover** is a mobile unit used in the operating room to suction and collect surgical fluid and small debris from the surgical site. Optional features include a smoke evacuation unit which collects smoke from cautery or laser surgery, and a power IV pole.

The **Docking Station** is a wall mounted component of the system and is plumbed with water inlet and drain lines. The Rover interfaces with the docking station which then automatically empties and rinses the collected waste materials from the Rover's fluid collection container. A detergent dispenser is available as an ·tional feature. It automatically releases liquid detergent into the system.

Proper utilities must be available in the installation site. The user facility is responsible for preparation of the installation site and installation of the system.



⚠ **WARNING:** Keep hands away from the Docking Station doors. The docking mechanism could be inadvertently triggered to extend from the Docking Station and cause personal injury.

stryker®
INSTRUMENTS
4100 E. Milham Avenue
Kalamazoo, Michigan 49001
(USA)
1-800-253-3210
269-323-7700

US Patent: D446,791
5,997,733
6,180,000
6,222,283
6,331,246
Other patents pending.

Disposal Area an

Docking Station - The
disposal area near the c
used.

Electrical:
120V, 60 Hz, 15 amp

Plumbing:
- Hot or cold tap wa
  Inlet accepts garde
  NOTE: Hot water
- Water usage is ap
  REF 700-4. Water
  rinse cycle with the
  REF 700-5.
- Plumbed with a 1.(
  permanent service

Rover

Electrical:
REF 700-1 requires a
with protective earth

REF 700-3 requires a
with protective earth

No plumbing connect

Operating Rooms m
grade electrical outlet

Installation Layou

The sides of the Docking
of clearance to allow acc
There should be a minim
the unit for the Rover. A
the right side of the Dete
700-5.

Uncrating and Installation Procedures

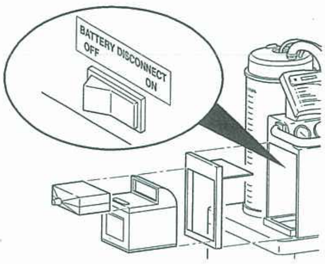
The Rover Unit
No special uncrating procedures are required for the Rover.

Battery Disconnect Switch
You must activate the internal battery located inside the Rover.
To access:

1. Grasp and pull the frame from the compartment on the side of the Rover as shown.
2. The disconnect switch is located in the top center of the compartment. Place the switch in the ON position.
3. Re-install frame.

   NOTE: Neptune's fluid volume display shows this message: **Shipping Mode/Dock To Use/Waiting To Dock**. The display will not provide any other status information until this message is cleared. The message clears automatically during the Docking Station installation procedure when the Rover is docked and the initial docking cycle is completed.

4. Follow instructions for use of Neptune System.



The Docking Station

CAUTION: The Docking Station weighs 90 lbs [41 Kg]. More than one person will be required to uncrate and safely lift the unit off the shipping pallet.

Detergent Dispensing Docking Station only:
WARNING: Read the important safety information on the Detergent bottle.

CAUTION: Use only Stryker approved Detergent REF 700-5-1 and 700-5-4. Other detergents may be chemically incompatible and therefore damage the system.

Container Contents

- Docking Station
- 5 ft. [1.52 m] water inlet hose
- 6 ft. [1.83 m] waste outlet hose
- Detergent inlet tube (supplied with Detergent Dispensing Docking Station REF 700-5 only.)

You will need to supply:

- Wall mount screws
- Anti-siphon device for inlet water supply compliant with state and local water supply requirements.

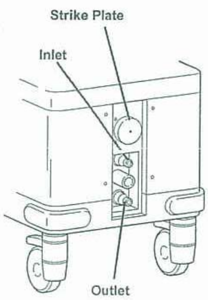
Docking Station Installation

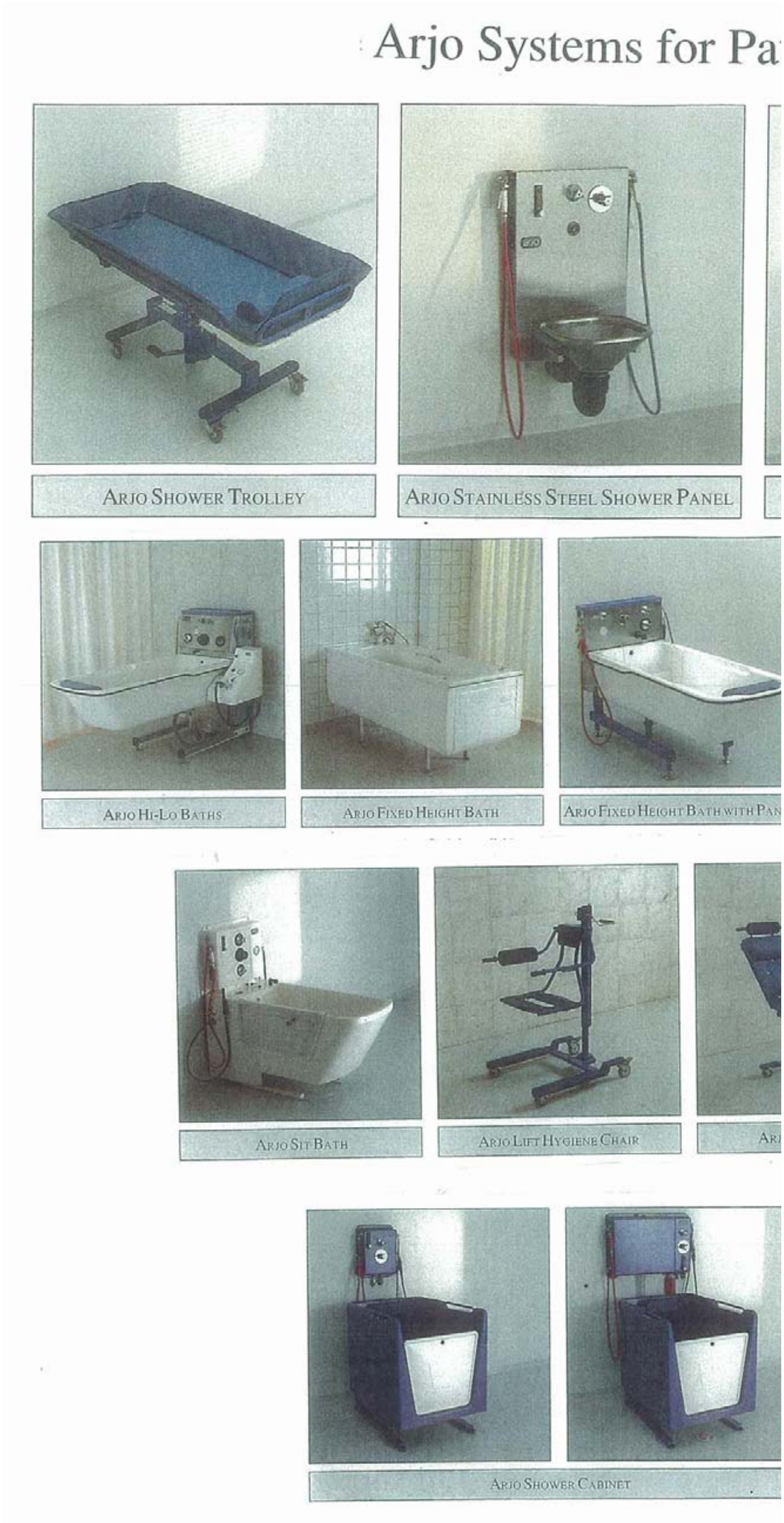
1. Loosely attach docking station to wall by placing wall mount screws through brackets. Do not tighten screws yet.
2. Connect inlet hose to tap water.
   NOTE: The docking station is equipped with an internal anti-siphon device which may not satisfy your local plumbing codes. Near the shut-off valve on the inlet water supply, use an anti-siphon device which meets the requirements of your local plumbing codes.

2

3. Attach the waste h
   permanently moun
   drain. Refer to yo
   ments. (See illustr

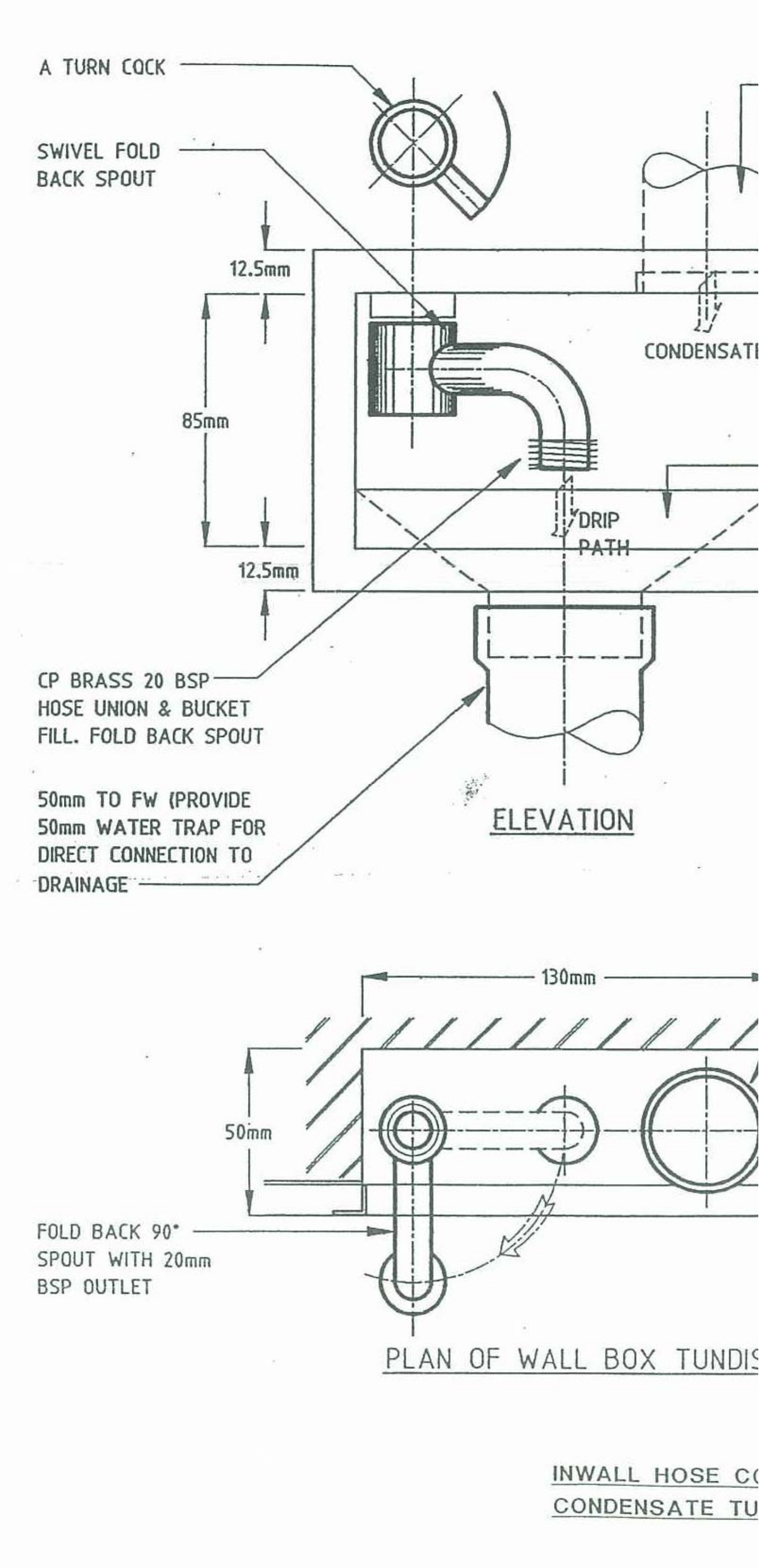
4. **IMPORTANT! Lev
   and outlet couplin
   the caster height.**
   NOTE: Increase ca
   dial counterclockwis
   Decrease caster he
   clockwise.
   To achieve proper
   a) Adjust height of
   caster so that the m
   level and flush with
   b) Look at the magi
   required, adjust the
   casters so magnet a
   example, to remove
   the height of the fro
   casters.
   c) Turn on the Dock
   d) Fill the Rover wit
   Rover in the Dockin
   fully and simultaneo
   couplings during doc
   proper alignment. M
   before each docking
5. After proper engage
   screws and confirm
   NOTE: Shimming m
   of Docking Station.
6. If installing a Deterg
   5, secure the deterg
   tion). Remove the c
   the seal. Replace th
   detergent inlet tube
7. Fill Rover with water
   Rover and completin
8. Visually inspect all fitt
   exist.

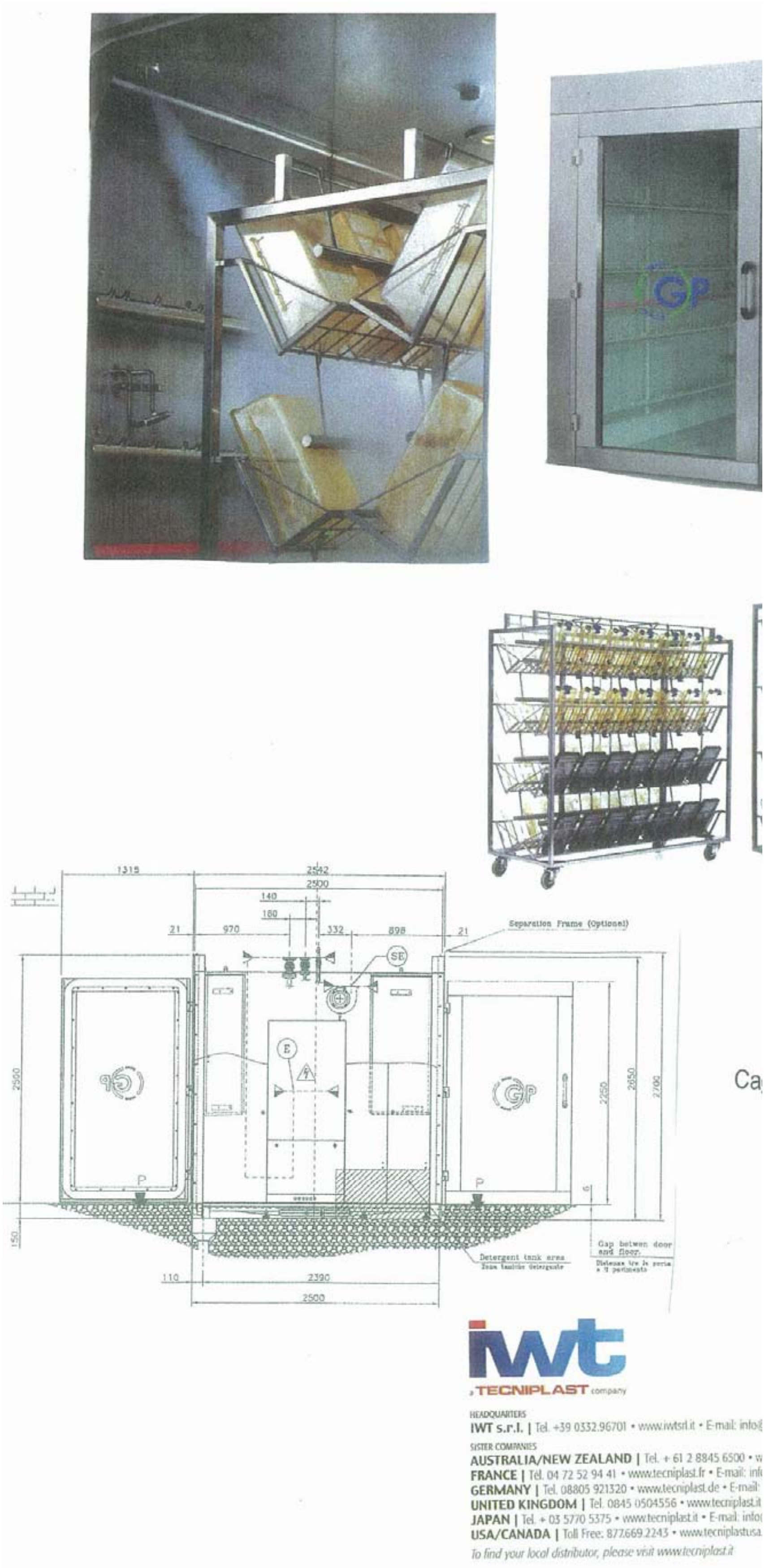



Arjo Systems for Pa
Arjo Shower Trolley
Arjo Stainless Steel Shower Panel
Arjo Hi-Lo Baths
Arjo Fixed Height Bath
Arjo Fixed Height Bath with Pan
Arjo Sit Bath
Arjo Lift Hygiene Chair
Arjo Shower Cabinet

This information is Included for historic interest only.
The Walker Crossweller (Rada) Unitap introduced low flow fixed mixed water tempera the UK in the late 1950s, there were three versions, the Standard pillar tap (Not showr later basin mounted unit and the upper version is the original pillar type valve converte lever action flow control and an instant connecting fitting. As with all very low flow taps length is severely limited, if not the waiting time for warm flow is not acceptable. The n valve is the sensor activated valve which delivers pre-mixed water in response to mov received a mixed reception in Health Care , The constantly activated and sensitive ele negative issue ,also over sense-tive sensors responding to non user movement ,and fi water.

Deko-190
ward-disinfector


A TURN COCK
SWIVEL FOLD BACK SPOUT
12.5mm
85mm
12.5mm
CONDENSATI
DRIP PATH
CP BRASS 20 BSP HOSE UNION & BUCKET FILL. FOLD BACK SPOUT
50mm TO FW (PROVIDE 50mm WATER TRAP FOR DIRECT CONNECTION TO DRAINAGE
ELEVATION
130mm
50mm
FOLD BACK 90° SPOUT WITH 20mm BSP OUTLET
PLAN OF WALL BOX TUNDIS
INWALL HOSE C(
CONDENSATE TU



CHAPTER 7TRADE WASTE

7.1 WHAT IS TRADE WASTE?

Waste water can be defined broadly as any waste water that is normally generated by human habitation that includes cleaning, cooking, ablutions and the washing of clothes and bed linen.

Health Care Trade waste generation will be found as a by-product of the following departments.

131 I Radioactive therapy treatment (Dealt with herein)

Animal house facilities waste.

Cooling tower drain down and bleed

Plaster arrestors for the capture of plaster in casting rooms or dental units

Grease waste from kitchens

Laminar separation of Hydro-carbons from paring or vehicle maintenance

Arrestor traps of all types

Chemical dilution of laboratory waste (See notes)

Dangerous viral pathogen eradication plant

Deluge shower waste from contaminated wash bay.

Cooling and heat recovery from Very hot waste water. (Refer cage wash)

Wet developing processes from medical imaging (Silver recovery)

Placenta Disposal units (Registration as a trade waste appliance)

Food waste disposal units (Kitchens)

NOTE: - TRADE WASTE IS A WELL-COVERED SCOPE OF HYDRAULIC SERVICES DESIGN BY SYDNEY WATER, AND ACTEW (ACT)

RECOMMENDED REFERENCE LIQUID TRADE WASTE INSTALLATIONS BY JOHN TESORIERO ISBN 0-958700-32-X

This Guide has not amplified the excellent information that is available, other than notes related to heat recovery from grease traps, mortuaries and radioactive waste disposal.

Where commercial enterprises lease tenancies in hospital complexes the charges for water and trade waste treatment should be a separable entity which may require measurement for billing.

7 .2 PHYSICAL CONTAINMENT LABORATORIES PC 1-2-3

The standard of construction for containment laboratories of various classifications and as outlined in the following referenced data is extensive and comprehensive dealing with all services, construction and management. The volume of material is extensive and requires to be current .For precise information about the certification of facilities or about any other matter related to the regulation of gene technology, please contact:

The Office of the Gene Technology Regulator

MDP 54

Commonwealth Department of Health and Aged Care

PO Box 100

WODEN ACT 2606

Ph: 1800 181 030

Fax: (02) 6271 4202

Email: ogtr@health.gov.au

Web: www.ogtr.gov.au

Copies of the Gene Technology Act 2000, the Gene Technology (Consequential Amendments) Act 2000 and the Gene Technology (Licence Charges) Act 2000 may be obtained from the OGTR or may be downloaded from the following websites:

www.aph.gov.au (Parliament House website)

www.health.gov.au/tga/genetech.htm (IOGTR website)

7.3 RADIONUCLIDES IN MEDICINE

REFER TO THE INTERNATIONAL ATOMIC ENERGY AGENCY TEC DOC DATED NOVEMBER 2000.

“Radioactive materials have been found to be very effective in a variety of medical applications and as a consequence a wide range of radioactive waste is produced, the amount and types of wastes is dependent upon the medical application and the radionuclide’s involved.”

Possibly the most common radioactive waste that will be included in the Hydraulic consultants work scope is treatment therapy with isotope 131Iodine for cancer care therapy of the thyroid gland.

For this waste application the soil and waste pipes will be connected to a toilet dedicated for use by the patients being treated, the patient’s waste water is to be conveyed by the plumbing pipes to a waste water delay tank by the shortest practical route following a path that is accessible for inspection and the pipe shall be conspicuously marked with Australian Standard Radio Activity Hazard signs at intervals of not less than 1000 mm centers.

The pipes from such toilet facilities should be metallic (cast Iron) with high mass, the pipes shall be provided with warning signage as noted and at all access doors and cleaning points that would be potential exposure points.

The half-life delay tank will be constructed of translucent plastic, the tank room roof, floor and walls shall be constructed of concrete of sufficient thickness to provide safe shielding of the radiation contained within the tank and room.

Shielding dimensions and the half-life tank volume will be based on the isotope used and its half-life; this will be determined by a specialist consultant. (*Gammasonics Pty Ltd)*

Delay tanks in practice are generally installed as duty, stand-by and emergency standby. However three tanks are recommended, the third being provided as a failsafe back up unit. Delay tanks must be located in a bund with 110% capacity of the largest delay tank .Pipes shall not perforate the walls of the bund .The trade waste authority may limit the rate of disposal EG 8 cubic metres over 1 hour ,and the time of the discharge may be critical . All operational functions of the plant shall be recorded by a logger. Pumps and electrical gear must be explosion proof compliant. Tanks must be flushed after emptying

Where tank surcharge can release the tank contents prematurely a shutdown solenoid valve interlocked with the flushing system water supply to the radioactive toilet facilities should be a design feature.

It is noted that the public perception of radio activity for medical use, is not totally aligned to the actual danger of the substance; however the possibility of long term failures and the trend for public utilities to recycle black water as treated water for irrigation, as an environmentally pro-active means of sewerage disposal, is a combination that requires stringent control measures for public health and the acceptance of black water recycling.

The International Atomic Energy Agency (IAEA) IAEA-TEC DOC -1183 November 2000 Pages 44 / 45 Clause 6-4-3 and Fig 13 Delay tank drawing show two 5000 litre tanks for a two bed ward treating patients with 131-I for thyroid carcinoma to delay waste 6 to 8 half-lives (The half-life of 131- I is given as 8.0 days for Clinical Therapy) ,this will ensure that about 1% of the initial activity remains in the tank at the time of release .Delay tanks are stated as common practice in India for radioiodine therapy but tanks (2000) were not at that date used in the UK or the USA .Delay tanks are installed at Westmead Hospital 1973 . Liverpool Hospital 2011 and RPA .The delay tank content is tested and discharged by a positive displacement helical screw interference fit stator rotor pump to the sewer subsequent to the satisfactory completion of radio activity testing and sign off procedures.

The primary concern regarding radio activity is the exposure to personnel working in the public utilities sewer. Bone and Renal Scanning will result in radio activity from human waste; the levels can be estimated and are generally less than 1mSv per year as a source of exposure to workers in the sewer, which is less than the annual background exposure from natural sources of 2-3 mSv. In all instances of radioactive waste disposal to the sewer it essential that detailed information is provided to the Public Utility who will ascertain the treatment required, with very low dose discharges, dilution mixing at a high flow drainage confluence may be adequate.

There are 54 listed Radionuclide's listed in the IAEA publication table 1 page three as being used in Medicine and Biological research for therapy and diagnostic purposes .By far the greatest application of radionuclide's in medicine is the studies performed on human biological samples " in vivo" which means a dynamic function within the human body using gamma camera imaging.

Unsealed Isotopes used in medicine that have solid, liquid and gaseous waste products are listed for the following applications.

Radio Labelling

Clinical measurement.

Biological Research

Organic Synthesis *The construction of synthetic organic material as pioneered by Robert Burns Woodward 1965 Nobel Chemistry Prize winner*

Positron emission tomography (PET) *Among other uses,the Short lived isotopes injected into the blood stream for three dimensions scanning to reveal the extent of cacogenic activity*

Medical diagnosis

Clinical Therapy

Medical and Biological research

Lung ventilation studies

Monoclonal antibodies. *A complex cell generation process used to treat cancer and other ailments*

Nuclide generators. *A long half-life isotope used to produce short lived (60 min) daughters, decay products.*

Palliative Treatment.*From the Latin PalliareTo Cloak The relief of suffering that may be experienced by patients undertaking cure treatments*

7.4 ISOTOPE USE AND HALF LIFE

Typical Example of the technical name of isotope which will be used in the new 2011 Liverpool Hospital Clinical Science Building (CSB.)

**Based on increase in provision of Nuclear Medicine and PET services by 34% in 2016/17.

Example: - Liverpool Hospital

Type and technical name of isotope were in use prior to 2011

Radio-nuclide	Isotope	Half-life	No of patients per year	Hospital stay
C-14	Carbon-14	5730.0 Yrs	105.86**	No
Co-57	Cobalt-57	271.8 Days	–	QC only
Cr-51	Chromium-51	27.7 Days	10.0*	No
Ga-67	Gallium-67	3.26 Days	85.76**	No
F-18	Fluorine-18	1.83 Hrs	3538.94**	No
I-123	Iodine-123	13.2 Hrs	10.0*	No
I-131	Iodine-131 diagnostic	8.1 Days	108.54**	No
I-131	Iodine -131 therapy	8.1 Days	62.98**	No
I-131	Iodine -131 ablation	8.1 Days	3rooms X 36.18**	3-5days
P-32	Phosphorus-32	14.3 Days	10.0*	No
In-111	Indium-111	2.8 Days	26.8**	No
Se-75	Selenium-75	119.8 Days	10.0*	No
Sm-153	Samarium-153	46.3 Hrs	10.0*	No
Tc-99m	Technetium-99m	6.0 Hrs	4305.42**	No
Tl-201	Thallium-201	73.1 Hrs	10.0*	No
Sr-89	Strontium-89	50.5 Days	10.0*	No
Y-90	Yttrium-90	64.1 Hrs	10.0*	No
Ra-223	Radium-223	11.4 Days	10.0*	No
O-15	Oxygen -15	2.03 Mins	50*	No
N-13	Nitrogen-13	9.96 Mins	50*	No
C-11	Carbon -11	20.40 Mins	100*	No
Cu-64	Cooper-64	12.7 Hrs	100*	No
I-124	Iodine -124	4.18 Days	50*	No
Rb-82	Rubidium-82	1.27 Mins	50*	No

Half live of the isotopes.

Please refer to the table.

Approximate number of patients, which treated, and their average hospital residence or treatment duration.

Please refer to the table.

Chemical data sheet of isotopes if available**.**

Data sheets can be obtained from manufactures or from stabilised institutions, e.g. http://www.safety.queensu.ca/radiation/data_sheets/Tc-99M.pdf

7.5 LARGE LABORATORY BUILDINGS

REFER TO AS2982-2010-LABORATORY DESIGN AND CONSTRUCTION, IN PARTICULAR SECTION 3 3.3 SERVICES ISOLATION 3.4 EMERGENCY CUT OFF. 3.9 HYDRAULIC SERVICES.

Other than I 131 Radioactive therapy ,the trade waste drainage from very large laboratory buildings that specialise in all manner of chemical and biological work is a challenge to the Hydraulic services designer ,there being very little textbook advice the deals with this cocktail of chemistry .

7.6 AVERAGING PITS FOR LABS WHERE THE DISCHARGE IS NOT KNOWN, OR WILL VARY.

The sizing of the averaging pit is based on 5 litres per lab sink and 300mm of bench runnel drain which allows for approximately 1 hour retention

For lab equipment other than sinks allow 1 hour detention

Pit inlet and outlet at 90 degrees

Pit outlet 150 mm centre line from base of pit

Inlet 150 mm cascade

Epoxy paint acid resistant internal painting

Sample cap and outlet rodding eye combined

Automatic PH Control with PH probe to activate motorized valve

Neutralizer storage tank with motorized valve.

Stirrer mixing device in neutralizing tank

Settlement tank after neutralizing tank Baffles and PH Probe controlled pump release

7.7 WESTMEAD TEACHING HOSPITAL 1973

The Institute of Medical Research at Westmead Hospital was a challenge, room after room of laboratories and a fast track building system that could not identify the work to be undertaken in each lab. The roof of the building 07 was in place prior to laboratory design.

The building is three levels with plant room pods sitting above fire stairs and core facilities such as toilets and lifts .The design criteria for this hospital was based on a strict modular discipline of 900 mm -1800 mm- 3600 mm – 7200 mm, the labs were set out on the 7200 double column and beam grid, the space between the columns is a services duct.

Plumbing trade waste services comprise a Boro silicate glass trade waste stack and PVC vent at each column duct the hydraulic services comprising

Non potable hot water ,cold water ,deionised water (An early option to RO water) and gas services including medical and lab gases were reticulated horizontally in a three legged ring main at the center point of the three zones two outside zones with windows and one inside zone without windows and two corridor

Each 3600 x3600 lab module was provided with a multi service core hole in each corner .For Departmental budget purposes the services to lab sinks were fixed at a cost ,services required by the department that could not be services from the core pattern provided were an added cost penalty to the fixed fixture cost budget .

In the entire building only one deviation was requested and this was to service an electron microscope installation. We lose sight of the fact that laboratories are a sophisticated work shop, the experiments are set up, they are modified, they are discarded, and the basic bench work and services are universal tools to service the needs of the experimenters'.

The trade waste from this building was a dedicated drain the services all trade waste in this building and all others in the complex, including the back wash discharge from the therapy pool.

The trade waste tank was below ground in a remote location ,more than the mandatory six meters for any air intake grilles ,it was constructed of epoxy lined concrete with a baffle race to stimulate mixing ,the pH and temperature of the mix are measured at the entry point and dosed accordingly with acid or alkaline. The flow rate leaving the pre-treatment is measured by a V notch weir; however there are now more accurate flow measurement systems with telemetry communications for remote readings and alarms.

The tank volume is based on the total capacity of all sinks served, and the flow rate based on the diversified inflow to the laboratory water service system. Access into the below ground tank area requires consideration of confined spaces legislation, means of safe exit and adequate ventilation to remove both chemical fumes and to protect maintenance personnel from any inherent biological hazard.

The system has been in place for 30 years.

The Boro silicate stacks and drains are all in visible locations, the hydraulic performance of the waste water is observable.

The pressurised services ring mains followed the profile of the concrete slab soffit ,this resulted in a very flexible system that was anchored at the branch connections ,but able to absorb expansion and contraction between these anchor points .Valves were minimised ,the concept was to utilise a freeze plug system for modified pipe work Because this system was a Fast Track design ,loads on the hydraulic services were broad brush, the pipe size of ring mains was resolved on the best buy philosophy ,this was a 50 mm pipe serving as a ring main.

7.8 ANIMAL HOUSES

A research hospital may require an animal house to accommodate animals of various types (Rodents, dogs, pigs chimps) The animals may be bred on site or raised at an off-site specialised Specific Pathogen Free facility and transported in sterile containment.

The waste material from animal rooms varies with the size of the creature, rodents may be contained in modular cages held within a mobile cage rack which incorporates the watering system, and flexible hose connection points for sterilising and cleaning, the animals cleaning routine transfers the animals to a clean cage module and the mobile rack is taken to the cleaning process via the dirty side of the animal house. The cleaning process removes animal bedding and waste products including uneaten food which is usually a manufactured tablet of the diet required ; in some instances records of food consumption may be required. Bedding removal may be undertaken by a central vacuum system and transported to a central incinerator, or transported off site for disposal.

The cages and rack are nominally free of bedding and is connected to the cage cleaning device which will scour and sterilize the rack and cages contained within it.

The waste water from the cage washing machine will be at 85 ºC + and should be directed to a cooling chamber which recovers the heat for pre heating the hot water supply to the cage washing machine, a direct water to water heat exchange for heat recovery should incorporate a periodic solids flushing arrangement to remove any particulate material.

Cage washing and sterilizing for larger animals may involve total immersion of the cage in a stainless steel tank which contains in very hot water, or Chlorine dosed water, or similar biocide agent It should be noted that some grades of stainless steel are vulnerable to chloride attack, cage wash tank manufacturers must be advised of proposed chlorine concentrations to be used.

Care must be exercised in the disposal of high concentration chlorine; also an OH&S deluge shower eye wash may be required in close proximity.

HW and CW Fill points for cage immersion tanks shall allow quick filling. Drainage shall be valved with a full way rubber lined diaphragm valve, a floor drain as described must be provided to capture spillage and the tank shall be provided with a heat exchange circuit and overflow.

The rooms where the animals are kept generally comprise racks, access isles between racks should be fitted with floor drainage comprising a two stage basket arrestor first stage and automatic closing second stage strainer.

The floor fabric will in most cases be a continuous fabric such as vinyl, the floor outlet must be provided with a clamping ring and wedge wire style grating that does not allow waste material to become jammed between the bars.

Floor drain seals should also be charged by a dedicated pipe charging system which introduces a biocide into the trap water seal on a routine basis by activation of a remote soft close solenoid valve. The transmission of outside air or from the waste into the room via the floor waste or vacuum system should be considered, the air in the room will be UV irradiated and Hepa filtered to high levels of purity, it is possible that the room is air pressurised to ensure air is pushed out of the sterile areas rather than the opposite.

Minimum pressure 25 metres Non potable hot and cold hose cocks with breech and central mixed hose outlet shall be provided for a white 20 mm hose suitable for use with hot water, hose length must not be excessive , the hose shall terminate with an approved brass and heat resistant handle flow adjustment nozzle . Drainage as described must be provided in close proximity to hose points.

The drinking water supply for laboratory Specific pathogen free animals may be RO treated ultra-pure water , such systems are provided with polypropylene or polyethylene reticulation which has stainless steel wetted area joining threads or compression joints, and isolation valves including the terminal water feeder which may be Lixit or similar.

Where stainless steel is used it is not acceptable to join a stainless steel male thread to a plastic female thread.

Where the hydraulics designer undertakes central vacuum system planning,
such systems should not be used to draw bedding material and similar in an up-flow vertical riser, on stopping the system any material in the vertical rise will drop back on to the suction inlet connection. A simpler cleaning proposition is probably the mobile cart vac system with treated reject air.

7.9 KITCHEN WASTE

Hospital kitchen waste is appreciably hotter than most other waste systems because of the requirement to undertake high temperature dish and utensil washing.

Where solids may enter the trade waste system via a waste disposal unit in significant volumes, authorities have varied the regulations regarding the disposal of solid waste food to the drainage system, some require the waste to enter the kitchen grease trap, presumably to contain any grease content and where this is the case the grease trap with waste disposal connected is subject to a different size scale.

7.10 GREASE TRAPS

Line	Trap Volume	Litres/day	Hospital beds	Notes
			Maximum	
1	1000	1000	69	
2	1500	3200	199	
3	2000	6400	399	
4	3000	9600	599	
5	4000	12800	799	
6	5000	16000	1000	
7	5000 +			Dissolved Air Floatation DAF system
8	**Traps with Waste disposal connected**			
9	1000	1100	55	
10	1500	3200	159	
11	2000	6400	319	
12	3000	9600	479	
13	4000	12800	639	
14	5000	16000	800	A 20% allowance for solids material
15	5000 +			Dissolved Air Floatation

The probability of high volumes of partially degredated solids being removed in the grease trap cleaning process would not seem to be the most efficient way to recycle this valuable organic matter.

Waste disposal generally in a hot climate does present Health Problems Wet Solid organic waste material should be temporarily stored in chilled rooms to reduce insect activity prior to the routine removal of the waste.

In the UAE, which is an arid country lacking fertile top soil, any opportunity to recover waste organic material for compost as a rich source of beneficial material is seized.

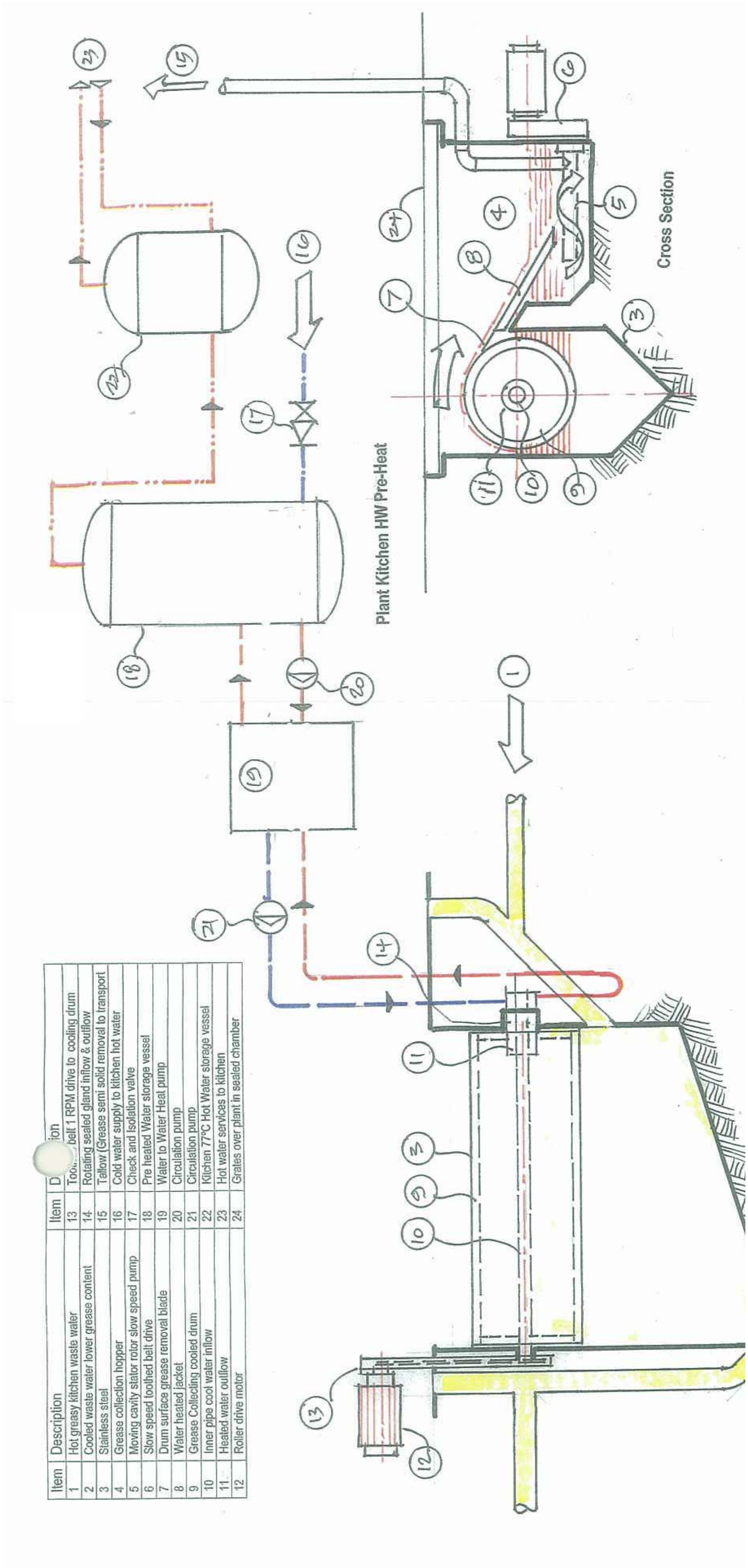
The hospital kitchen will include a number of central food pulverisers and macerating hoppers that are connected to a negative suction head that will transport the waste material efficiently via a stainless steel tube system to a refrigerated storage hopper for daily removal by the composting agency.

Any waste considered dangerous is incinerated.

Australia is a continent with considerable arid content, but we persist in wasting a resource that has value and could with the will and management be self funding.

A similar proposition for waste heat recovery applies to the Grease Arrestor which is in effect an inefficient cooling device, as the cooling effect in the large volume of water in the trap takes place and the specific gravity of the liquid content changes, the oil and grease content agglomerates and then rises to the surface as a crust, or layer which further inhibits thermal release from the surface

Bearing in mind the lack of thermal loss through the buried walls of the vessel, and the lack of air movement over the surface of the water content, there would seem little engineering design that promotes temperature drop or heat recovery.



Item	Description	Item	D[illegible]ion
1	Hot greasy kitchen waste water	13	Too[illegible] belt 1 RPM drive to cooling drum
2	Cooled waste water lower grease content	14	Rotating sealed gland inflow & outflow
3	Stainless steel	15	Tallow (Grease semi solid removal to transport
4	Grease collection hopper	16	Cold water supply to kitchen hot water
5	Moving cavity stator rotor slow speed pump	17	Check and Isolation valve
6	Slow speed toothed belt drive	18	Pre heated Water storage vessel
7	Drum surface grease removal blade	19	Water to Water Heat pump
8	Water heated jacket	20	Circulation pump
9	Grease Collecting cooled drum	21	Circulation pump
10	Inner pipe cool water inflow	22	Kitchen 77°C Hot Water storage vessel
11	Heated water outflow	23	Hot water services to kitchen
12	Roller drive motor	24	Grates over plant in sealed chamber

7.11 LAUNDRIES

A large central hospital laundry is a Trade Waste discharge that will require heat removal from waste water, Screening of strings and fragmented fabric, chemical adjustment of pH and possibly phosphate removal from laundry waste water.

Laundries for hospitals are specialised and may involve the following features;-

Ozone water treatment to destroy bacteria,

Waste heat recovery,

Water recovery last rinse cycle being reused for the initial cycle within the program of the machine

It is common practice to soften laundry water to save detergent Soft water areas such as Sydney will not benefit from water softening ,

Laundries have high peal loads and reheating which can benefit from a stored water system.

The hot water temperature is 82 degrees C

There are five classifications of laundry and hot water demand

Institutional 16.7 litres per kg

Commercial 16.7 litres per kg

Linen supply 20.9 litres per kg

Industrial 20.9 litres per kg

Diaper 20.9 litres per kg

The total mass of wash x the above scale gives the hot water required.

The designer must consider peaks, for example a 270 kg machine may have a 1.3 l/sec average requirement but the peak could be 22 l/s.

With multiple machine systems it may not be practical to fill all machines at the momentary peak rate, large storage tanks and VSD Pumps can rationalise this production problem.

Laundries are ideally suited for heat recovery, most use commercial laundry standard a Luddell tube in tube heat exchange with flow reverse valve for lint and strings removal to a discharge over a shaker screen.

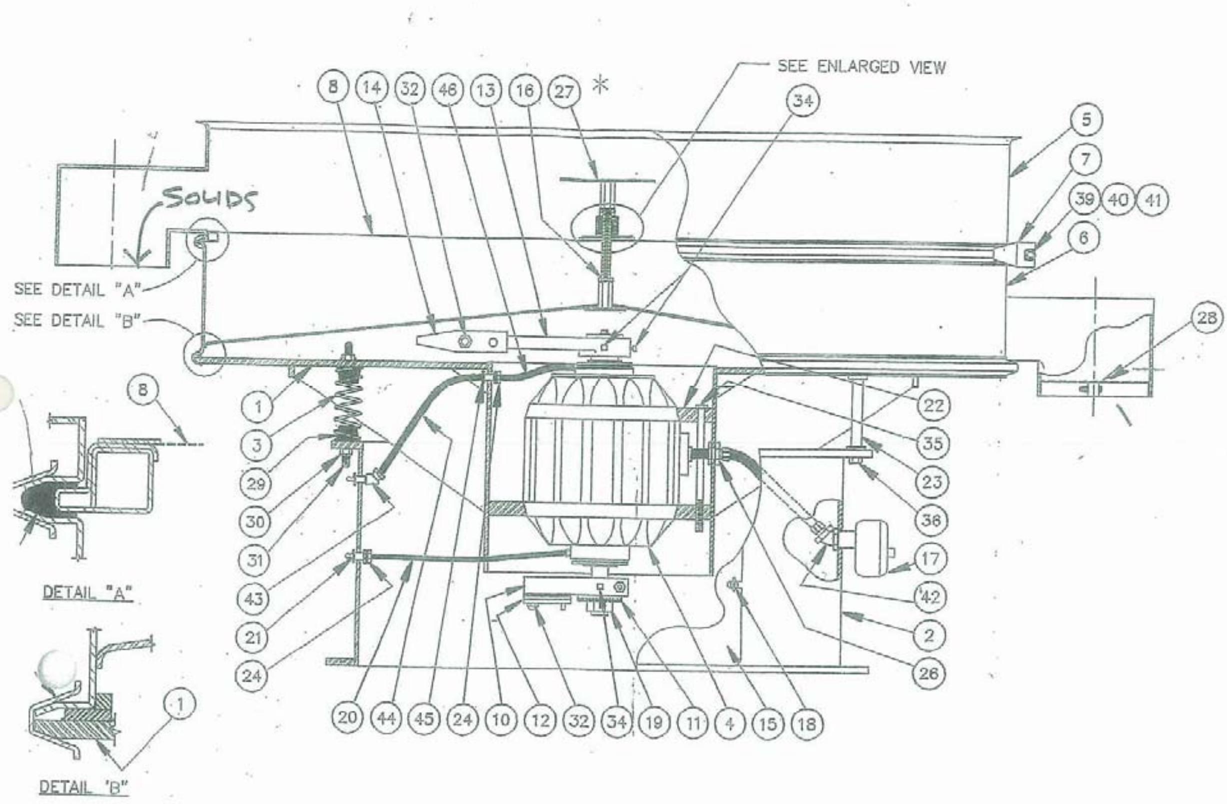
Waste water is released at approximately 57 degrees C givers a 42 degree heat exchange temperature difference. With a Δt 57 – 42 = 15°C each KL of water is going to save 17.44kK

Laundries have good potential for a solar contribution. Significant storage is required to balance the available solar gain contribution to the hot water load.

Laundries also have potential for rain water recovery, it is important to ensure a catchment area that is reasonably free from external pollution from organic matter such as leaves and industrial pollution, First flush and micro mesh straining water treatment is desirable.

Laundries require waste treatment to remove heat and phosphates and can attract trade waste costs.

Large commercial laundries may use steam or hot oil ironing machines for
large items such as sheets this design work is not generally included in the scope of hydraulics, interfaces can be below ground structure to house machinery, safe bunds for oil capture and coordination of services.



Laundry Shaker Screen

In large commercial laundries which could include a Hospital laundry, the shaker screen is used to remove strings and fabric that has become detached from the washing during the washing process .The shaker screen is circular on plan of varying diameters (1500mm average) according to load, after waste heat exchange collection, the wash water discharges over a perforated screen (8) the water passes through the screen and the strings and similar debris remain on the upper side of the screen. The eccentric motor (4) driven weight (14) vibrates the screen on spring supports (3) and the captures material moves on vibrations of 1450 pulse per minute (From a (4) 1450RPM motor) from the space above the screen (5) to the upper outlet for disposal as waste

7.12 CAPTURING WASTE WATER HEAT

Laundries have a significant consumption of hot water ,as do hospitals, particularly for patient showering ,the capture of low grade heat from patient showers in a similar manner to commercial laundries could be achieved by means of a simplistic tube in tube heat exchanger in the waste water system of the shower, this proposition has not been attempted in Australia (It is done in Sweden by SWEP) but cold water temperatures there are lower which enhances the proposition ,the problem of returning the low grade heat recovered back into the central system had to this date not been resolved .

This is achieved by:-

The low grade heat must be captured as close to the shower being used as possible, and returned to the system by tempering the cold water shower supply, the user will automatically adjust down the hot input to comfort.

The cold water at 15°C will ,if similar performance to the Luddell laundry heat exchanger is achieved ,render an approximate 10 °C Δt from the 40° C waste water which would raise the cold water to 25°C for each shower saving of 744 w/shower assuming an 850 bed hospital showers 75% of the bed count daily 744 W x 637= 473 kW/day or172,983 kW/PA which at 10c a kW = $17298 say $15000-00 PA allowing some local pipe work loss.

Bearing in mind "Greenstar" gives no credit points for the saved energy of Polymer pipes compared with copper tube, it is doubtful that designers will have sufficient incentive to promote waste water heat capture; however the same might not be said of Nurses Quarters or Hotel like accommodation for patient visitors.

7.13 BOILER BLOW DOWN

To determine the size of a cooling pit suitable to receive the discharge of 100 litres of hot water at 55°C when the required temperature of the waste outflow is taken at 38°C and the temperature of the cooling pit water is 18°C

$$P = H-M / M-C$$

Where

H= Temperature of hot water inflow

M= Temperature of mixed water

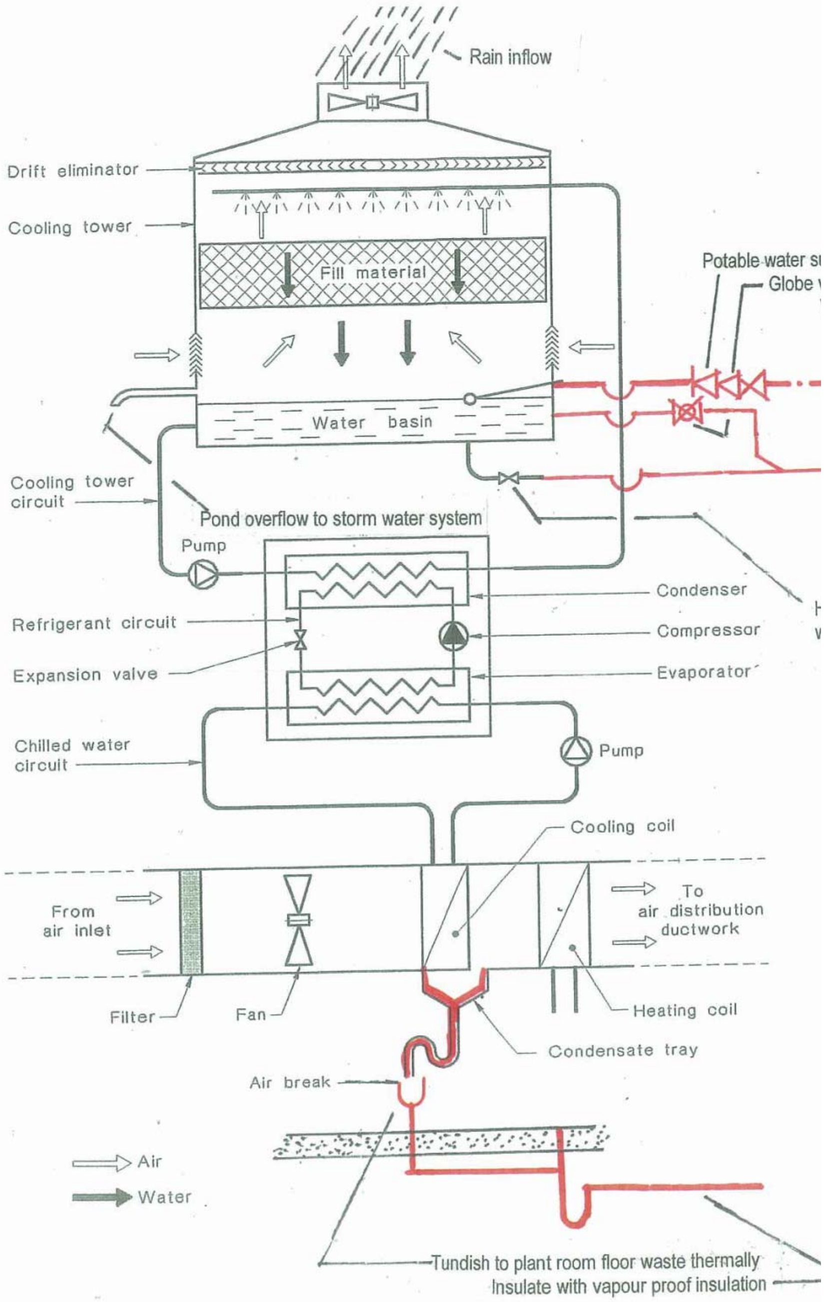
C = Temperature of cooling pit contents

P = Proportion of cold water required

Example 55°C - 38°C / 38°C - 18°C = 17 / 20 = 0.85 = Proportion of cold (18°C) to reduce the temperature of the 100 litres to 38C

Therefore 100 litres x 0.85 = 85 litres & 85 + 100 = 185 litres (The cooling pit volume)

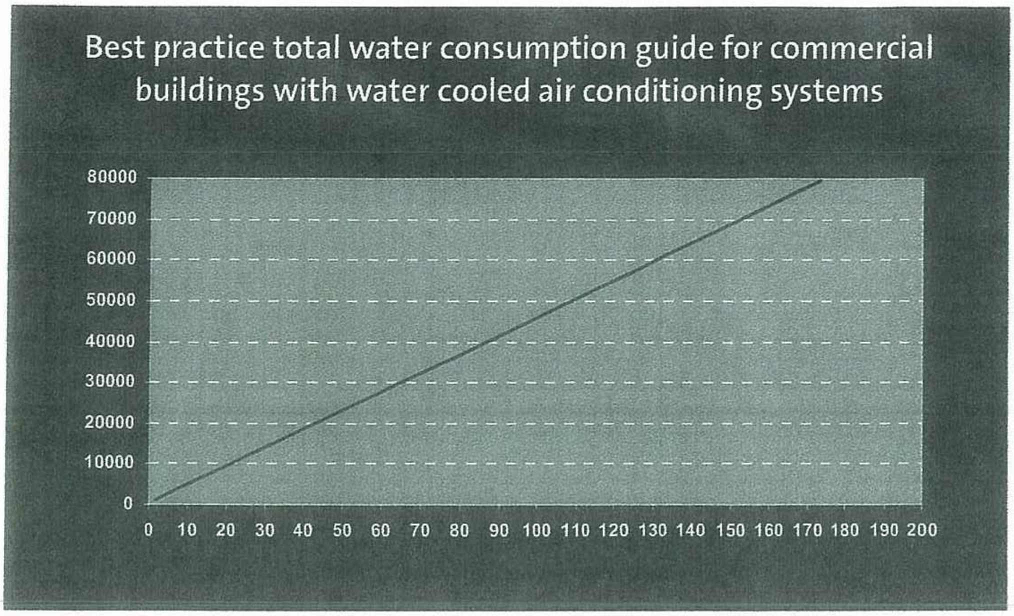
The cooling pit depth will be determined by the entering drain invert and surface RL .The cascade below the entering drain is 150mm to the top water level of the cooling pit ,the outlet pipe comes from the bottom of the pit 150 mm to centre line ,some pits have removable baffles ,or two pits with surface access ,the baffle forces the entering hot water into the colder water zone of the pit contents .The cooling effect of the pit contents from 38°C to 18°C (Ambient ground temperature which may vary with location) is achieved by evaporative lose from the surface water of the pit ,hence larger water surface areas are more efficient .



Cooling Towers

The above cooling tower and refrigeration circuit diagram illustrates how the evaporative loss and low grad from phase change of water evaporating as vapour in the cooling tower air stream, is then transferred by th exchange stage using phase change of liquid gas expanded to vapour by the chiller compressor and refrig finally the third direct heat exchange stage at the cooling coil in the air handling unit.
Trade waste comes from the constant drain water from the cooling tower pond (Shown in red), this has a c created by the evaporation process, there is also a probability of rain entering the cooling tower at the air e joins storm water. The condensate from the air cooling coil (Also red) is considered trade waste and may b air filtration debris or bacteria in a return air situation.

Heart exchange can take place with hot gas down stream of the refrigerant expansion valve ,however three problems with warranties with many chiller manufacturers.



Benchmark for water use

Sydney Water conducted audits in a number of commercial buildings in Sydney. It was found that some well managed buildings consume considerably less water than others. How building owners managed their cooling water systems played a significant role in determining overall water efficiency.

Current best practice in Sydney is 0.8 kilolitres (kL) per square meter per annum. That is 22kL per day for a 10,000m2 office. Use this graph to see if your office building is water efficient.

When you reduce your overall water consumption, you not only save the cost of the water coming in but you also save on water going out through the sewerage system. Sewer usage charges apply to businesses discharging greater than 1.37kL/day. They are calculated based on your sewer usage discharge factor (SUDF), a measure of the ratio of water going out to water coming in.

In 2003, water costs were set at $0.98/kL and sewer costs at $1.12/kL based on a SUDF of 100%. If your SUDF is 95%, your sewer cost becomes: 0.95 x $1.12/kL = $1.064 kL for every kL of water used above 1.37/kL/day.

Sydney Water Data
Cooling Towers Best practice

CHAPTER 8 RAINWATER COLLECTION AND HARVESTING

8.1 AN OVERVIEW OF HARVESTING

Rainwater systems for health care installations differ little from the systems for other building types and in most instances the differences are a matter of common sense.

There are major differences geographically in respect to rainfall intensities, and storm cycles and in this regard reference must be made to Metrological records of the area concerned.

In Health care installations it would be unwise to locate rainwater outlets or horizontal rainwater drainage over a critical area such as an operating theatre, or critical support service area such as a switch room or communications facility or concentrated electronics such as computer support systems with diagnostic computers.

Lateral pipes of any drainage require consideration in respect to permissible noise emission levels; the BCA is probably the relevant guide in respect to acoustic matters.

8.2 RAINWATER DOWN PIPES EN12056-3

The writer has found little formal regulatory authority's data that is published in a simplistic easy and direct format that relates to the performance of rainwater down pipes.

The exception to this is;-

European Standard EN12056-3

Gravity Drainage Systems Inside Buildings

Part 3 Roof drainage layout and Calculations June 2000.

internal diameter di	Capacity in litres/second Q RWP (0.20)	Capacity in litres/second Q RWP (0.33)	Notes
50	0.7	1.7	
65	1.5	3.4	A filling degree of 0.33 is recommended
75	2.2	5	It is noted that the capacity of a vertical rainwater pipe is
90	3.5	8.1	Determined by the type of inlet from the roof
100	4.6	10.7	In Australia refer to SPS Outlet test data
120	7.6	17.4	Flows Based on EN 12056-3-2000 Page 6 Table 8 modified for

150	13.7	31.6	Australian Commercial pipe sizes and the Wyly-Eaton equation
200	29.5	68	
240	48	110.6	
280	72.4	166.9	
300	87.1	200.6	Pipe diameters below 75 mm are not recommended

8.3 VERTICAL FACE RAINWATER RUN OFF

The following data comes from the UK Building Research Station .Research Series 54 Driving Rain Maps and the onslaught of rain on buildings by R.E Lacy B, Sc (Eng) F.R Met Soc presented to the Symposium on moisture in buildings at Helsinki 16-19 August 1965.

This paper is about driving rain on buildings ,wind driven rain on vertical faces ,and the effects at ground level which is of interest to hydraulic and civil engineers . Whilst the experimental work reviewed in this paper was undertaken in Europe where rainfall characteristics vary considerably from those in Australia ,the object of reading the paper and including the essence of its conclusions into this document was to arrive at a reasonable proportion of the wind driven rain that should be included in catchment calculations. Without doubt determining wind driven rain is not an exact science, a standalone building facing the ocean and the prevailing wind is going to be a different proposition from an inner city high rise surrounded by buildings of similar elevation and wind patterns that will lift light debris to high altitudes. The designer needs to view the site and consider the surrounding buildings or land contours and consider the geometry of the vertical wall face, if it forms a funnel like trap to the driving rain, then a prudent allowance should be made.

Where a new building rises above the roof catchment of an existing building there is a legal responsibility to the existing owner to protect the existing roof from driving rain that would be intercepted by the new work and would increase the catchment area of the lower roof ,A horizontal gutter to capture vertical face run off is usually permitted to encroach past the property line ,the logic being that if the existing building were to be extended upwards into the air space then the gutter could be removed.

In circumstances where there is no valid standard or established reference upon which to base a design it is recommended that the designer includes the calculations and assumptions that have been made as the basis of the design on the drawings, and specifications.

The hydraulics designer must also establish the existent and limits of his responsibility in respect to driving rain, the Helsinki report stated that in almost every country of the world problems were experienced with water that found its way into or through the walls of buildings by wind driven rain, the waterproofing of the buildings outer shell and roof is not the responsibility of the hydraulic services designer.

The report states that if the raindrops in a storm were all of one size, falling with a terminal velocity v in a uniform wind of velocity u, the intensity of driving rain on the vertical rv could be computed from the rainfall on the horizontal rh by the simple relation

rv = rhx u /v

However in practice there are a wide range of drop sizes, a further complication is that the wind is deflected by the vertical wall and this deflected wind affects the driven rain pattern,

Page 7 of the report Fig 2 Driving rain caught by a vertical wall expressed as a % and its variation with wind speed (by AC Nell 1946)

The chart has.

A vertical scale ranging from zero to 40%

A horizontal scale of wind speed zero to 10 metres/second.

Readings are 1%@ 5 m/s 9% @ 8 m/s 21% @ 7 m/s 31% @ 8 m/s 35% @ 9 m/s 38% @ 10m/s

Bearing in mind that a square plan building is only going to expose 50% of its vertical face to driving rain, it would be prudent to allow 50% of the exposed face as catchment and run off based on the selected storm frequency intensity / for a 5 minute storm duration.

In buildings that discharge rainwater to street gutters and that have two, or more street frontages the impact of driving rain could overload the gutters serving the rain driven face, this can be a feature of footpath canopies, where possible such systems should incorporate a surcharge flood path to divert the added flow to the lee side of the building.

8.4 RAINWATER HARVESTING

Rainwater harvesting is a recent Western world environmental trend associated with climate change.

In Australia the desire is to conserve water reserves in our dry continent and it is of interest that archaeological evidence shows the capture of rainwater was a significant undertaking 4000 years ago and the concept of rainwater harvesting may date back 6000 years in China .

As with many environmental initiatives that would mean government instrumentalities faced high infrastructure costs, the action plan tends to become a matter of legislation and rhetoric that places the burden of cost and the practical and moral responsibility for conservation with the individual property owner, or property developer. Solar and Rain Harvesting are typical examples of this.

Whilst this approach does generate a commendable pro-active public spirit towards conservation and is also much faster than the ponderous progress of the alternative which involves expert reviews and other time consuming implications, there are some considerations that do seem to be overlooked.

8.5 WHERE IS HARVESTED WATER USED

The probability is that the harvested water in a health care installation will be used for flushing WC pans and Flushing sinks, hose down of garbage areas and similar hard surfaces, it may also be used for cooling towers or irrigation.

Irrigation in modern landscape designs tends to be minimal ,a service only
to establish the initial growth of indigenous drought resistant plant life ,there is some logic in this because the rain source is probably not going to be available when needed most to support drought sensitive plants.

Supplying the cooling towers, this rain is going to be given back to the atmosphere as evaporative loss, it will return to the earth as rain. There is a low probability of Legionella contamination from birds and foot traffic.

The harvested rain used for flushing and hose down, is in most coastal cities, going to take the fast lane to the ocean.

The impact of depriving the natural water courses of rain water varies considerably with the location, topography and geology.

In the Sydney sandstone areas where there is numerous bush land creeks with intermittent flows already prejudiced to some extent by hard road surfaces and concentrated run off and manmade flood paths, the added loss is going to affect the bush habitat.

In areas where the sub strata are porous there may be an aquifer and its geological stability may be affected and recharging may be mandatory by local Council rulings.

These larger issues cannot legitimately be considered the responsibility of the Hydraulic services designer?

8.6 COST OF HARVESTING

The capital cost to the total budget is a major consideration of any health care project, it has been said that a modern hospital has annual running costs that are approximate equal to the initial construction cost.

Whilst it is desirable to reduce recurrent costs, at the end of the day, health care is the primary objective and if rainwater harvesting is going to cost beds, the opposition will be strenuous.

The capital construction costs will vary with the design and the nature of the architecture to facilitate cost effective harvesting opportunities. The recurrent cost will be effected by pumping costs ,filtration ,and UV Irradiation ,which is for reasons not explained to the writer , current standard practice requires ,disregarding the fact that roof catchment rainwater is near distilled water, and has few opportunities to come in contact with Legionella , in its use for WC flushing there is little probability of causing inhaled vapour.

8.7 HARVESTED RAIN WATER STORAGE

Is the most expensive added cost component , storage is essential simply because it does not rain all the time, and when it does rain it can be at a rate of flow that is probably more than the installation can use.

8.8 WATER STORAGE AT ROOF LEVEL

is desirable because the tank cover can actually form the waterproof roof fabric and collection system, there are counter arguments that imply the weight of water increases the cost of the structure, however if the roof is to be a flat concrete slab, the weight of water distributed as a weight per square metre will have a marginal structural impact if the water depth is limited, the depth should be sufficient for cleaning ,the option of a shallow tank that virtually forms a roof pond may be a viable for “On Site Detention” system ,but the longer storage time of harvested water would allow photo synthesis and the growth of algae.

The storage at roof level also reduces the need for pressurising all of the downstream harvested rainwater reticulation system; some pressurisation will be required for filtration.

8.9 WATER STORAGE AT LOW LEVEL

Harvested rain water storage at low level in the building is common place ,possibly because of the low use potential for windowless spaces influences this ,also the practicality of adding some concrete to that being used for external retaining walls may be a factor .

The shared use of tank walls as external retaining walls introduces the problem of undetectable leakage and polluting infiltration of contaminated ground water.

Consideration must be given to the overflow from below ground tanks, It must not be possible to over charge the tank with an inflow that cannot be removed by pumping systems, if this possibility exists the inflow must have an automatic valve that functions in much the same manner as a ball float valve in a cistern, if the rain water tank is full the inflow must cease and its path at high level where storm water drainage is available to accept the diverted flow.

A pneumatically operated Knife edged gate valve will shear through any minor debris in the untreated rainwater, or alternatively a close wave stainless steel screen strainer and Bermad remote pilot activated ball float valve.

The pilot activated ball float valve proposition is a simple mechanical devise but requires upstream pressure to operate, the knife edged gate system requires an independent but very small air compressor and reserve cylinder to ensure a number of actions are feasible without power .All such systems should have an automatic test program to ensure the system functions as required and has not deteriorated by long periods of inactivity.

8.10 TANK CLEANING

The requirement for two compartments for cleaning harvested rain water tanks is not considered essential; the harvested rain supply will need a 100% potable water back up for drought conditions, this supply will be called upon when tank cleaning is undertaken. Where provided two compartments can provide a buffer of raw water allowing an economical filtration system between the two compartments, and no drop in line pressure due to dirty filter media.

The tank will require cleaning, much the same as a potable water storage tank, the cleaning process for potable water storage tanks allows the inspection of the tank construction and replacement of membranes as required, or the removal of corrosion, or replacement of corroded stays and supporting components.

8.11 DEBRIS TO BE REMOVED

The material removed from a potable water storage tank when cleaning, will be the accumulation of suspended solids carried into the tank with the water supply, bird droppings, wind borne leaves, or contributed by corroding components in the pipe work system. A floating draw off pipe will extract water free of floating material and sediment.

In a rainwater harvesting tank the rain water is essentially distilled water, it can have a chemical reaction with metal tank construction, and if the rain has passed through an industrial atmosphere it may contain carbonic acids making it aggressive and corrosive, rain may also carry suspended solids if it has passed through extensive dust clouds, even volcanic ash, however the altitude of ash is generally higher than the formation of rain.

8.12 HARVESTED RAINWATER TANK MAKE UP

Dependent on the ratio of catchment area to consumption load, it is most probable that rain water storage volume will not be available as a viable source of supply to meet the total full time flushing requirements of the project.

A stand by supply will be required from the potable water service; the make-up potable water can be supplied to the harvested rainwater tank in two ways.

1) By a RAG make up ball float valve that is activated to open when the harvested water tank level reaches a pre-determined low level of operation. This has the disadvantage of utilising pump energy if the harvested water tank output is pumped (Which is probable) and the mains supply is not pumped.

2) A direct potable water supply connected via a RPZD unit to prevent cross connection, this proposition can be discredited if the mains supply is pumped which tends to reduce the added energy cost of pumping. Care must be taken checking the compatibility of the different pump heads involved.

It should be noted that the potable water supply make up will in most instances carry a proportion of chlorine added in the original treatment process, a low volume proportional addition of this source of chlorine supply to the storage tank is considered desirable for residual sanitisation.

If the tank make up is a ball float valve, the residual chlorine will be added, if the make-up is direct RPZD chlorine levels in the tank should occasionally be dosed.

As noted to avoid the tank outlet drawing from the floatable zone of the tank or from the settled solids zone of the tank, a floating draw off is recommended.

Arguments' have been raised that roof storage tanks can be exposed to solar gain and zones of blood heat water could stratify ,also the possibility that birds could carry Legionella to roof tops ,as could occasional foot traffic which provides the combination of ingredients for Legionella colonisation .

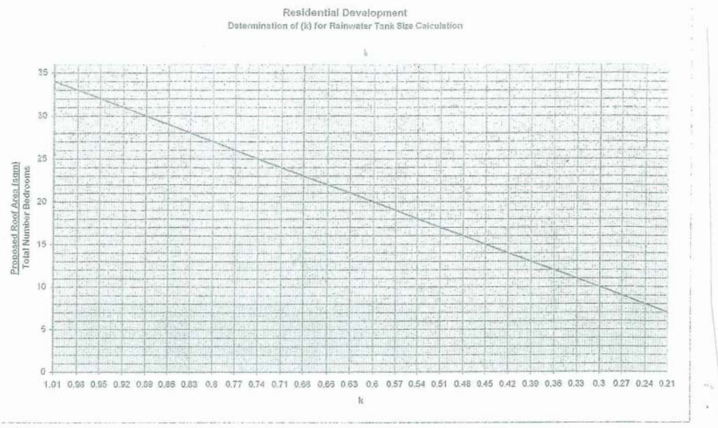
The downstream distribution system of a harvested water tank should be subjected to micro mesh straining with automatic back wash and Ultra Violet irradiation to kill any dangerous bacteria, or chemical treatment if preferred .Chlorine or Ozone.

Note:-

Legionella infection is transmitted to humans by inhaling the bacteria into the respiratory system Legionella bacteria which are resident in water vapour.

In practice .water vapour and human inhalation from flushing mechanisms, would seem to be unlikely, however this is not the case with cooling towers.

8.13 SIZING THE RAIN HARVESTING TANK



Example:

Determine the required minimum rainwater tank size for a proposed 4-bedroom home having a total roof area of 120 sqm.

roof area / total bedrooms = 120 sqm / 4 = 30
from the graph, k = 0.89

C = 100 litres/day x 4 bedrooms = 400 litres/day

so, the minimum required rainwater tank(s) storage capacity is therefore:

Q = 400 litres/day x 14 days x 0.89 = 4,984 litres

Rainwater Tank Capacity (Q) for other development is: Q=C x L x k

Where:
Q= rainwater tank(s) volume in litres
C= minimum 25 litres per day per number of car parking spaces
L= the mean dry period between rain events is adopted as 14 days

A further calculation is designed to determine the minimum roof area (**R**) to be connected to a rainwater tank(s)

R = 8.5 x P

Where:
R = minimum roof area permanently connected to the rainwater tank(s)
P = total number of car parking spaces

Sutherland Councils Rainwater tank Data

8 13.1 AUTHORS NOTE

Sizing the rainwater harvesting tank is the core issue of the *harvested water design, such* work is arguably more appropriate to Civil Engineering than Hydraulics *(refer* Scope Creep) However after significant debate with engineers of considerable ability *and* who's pragmatic opinions the writer respects, it was considered incumbent upon the author to accept the responsibility that this collection of Hydraulic *data implies.*

Bearing this in mind, the reader is alerted *that the jury is still out considering* the complex issues of harvesting and the current state of *valid "easy to understand* technical input*"* on the *subject.*

8.13.2 GREENSTAR

The tank size may be determined as a Greenstar initiative, the tanks determined in this manner can be very large, a major structural feature, a budget issue of more structural content than hydraulic.

Many spread sheet systems exist and are widely used (EG BASIX) for determining the volume of rainwater harvesting tanks and it is hoped that Local Authorities will eventually accept the responsibility for guidance in respect to the environmental impact of redirecting rain water and its use and quality within buildings.

8.13.3 SUTHERLAND SHIRE COUNCIL

In this respect Sutherland Shire Council have understood the realities of budget restraint and providing the home builder with simple rules in their Stormwater Specifications Development Control Plan that do not compromise the need to conserve water.

Sutherland Shire.Council 2.4 Rainwater Harvesting.

a) Rainwater Tank Capacity (Q)

For residential development not subject to BASIX is Q = C x L x k

Where Q = rainwater tank volume in litres

C = 100 Litres a day x the number of bedrooms in the dwelling

L = The mean dry period between rain events adopted as 14 days

K = Co-efficient derived from the proposed roof area and the total number of bedrooms ,this is determined by the graph ,Regardless of the ratio of the roof area and total bedrooms the maximum value of k is 0.01 and the minimum is 0.21

Example

Determine the required minimum rainwater tank size for a proposed 4 bedroom house having a total roof area of 120 square metres.

Roof area / total bedrooms = 120 m²/ 4 = 30

From the Graph k = 0.89

C = 100 l/day *x 14 days = 400 litres*

Q = 400 l/day x 14 days x 0.89 = 4984 litres

8.14 A PLAUSIBLE OPTION.

As an alternative to BASIX A more simplistic design dogma was researched.

In 2005 there was no National Rainwater Harvesting regulation in the USA.

In Australia 13% of the population (2.6 Million) persons use rainwater as the primary water supply source. An Australian National Standard for sizing storage relative to roof catchment and outflow demand was not found; ironically prior to 1990 Rainwater collection for domestic use was virtually illegal.

8.15 THE TEXAS MANUAL ON RAINWATER HARVESTING

The Texas Manual on Rainwater Harvesting Texas Water Development Board Third Edition 2005 in cooperation with Chris Brown Consulting Jan Gerston Consulting Stephen Colley Architecture DrHari Krishna PE Contract Manager.

This is a 58 Page document Comprising 7 Chapters and 4 Appendix

Whilst the complete Manual is well written and worth reading, there is obviously subject matter and geographical differences, however Texas and Australia do have climate similarities.

The Water balance method using Median monthly rainfall statistics and Monthly Demand and Supply is explored

This method starts with an initial storage volume in the tank. This is not explained but it is presumed to be the buffer capacity to use when rainfall is not adequate, however in application it is a one off which seems not to have much bearing on the system.

The supply is determined by median rainfall and catchment.(An alternative using Average catchment is considered less conservative)

The demand dictates the required storage capacity.

Median monthly rainfall system

Assumptions

850 bed Notional Hospital

Demand based on records 200 m³ / day flushing service 700 m³ day Domestic service Design criteria for water supply (1m³/bed 1000 bed eventual expanded maximum)

1.125 m³ /m² per year rain (Sydney average over 76 years).

8.16 SAMPLE TEXAS WATER BALANCE CALCULATION METHOD

FOR SYDNEY USING MEDIAN RAINFALL DATA

Month	Demand Day	Demand Month	Median rainfall	Roof area m²	Rainfall Capture m³/ month	End of month storage
January	200 m³/day	6000 m³	102	80	8160	2160
February	200 m³/day	6000 m³	114	80	9120	5280
March	200 m³/day	6000 m³	136	80	10880	10160

April	200 m³/day	6000 m³	124	80	9920	14080
May	200 m³/day	6000 m³	122	80	9760	17840
June	200 m³/day	6000 m³	132	80	10560	22400
July	200 m³/day	6000 m³	101	80	8080	24480
August	200 m³/day	6000 m³	77	80	6160	24640
September	200 m³/day	6000 m³	69	80	5520	24160
October	200 m³/day	6000 m³	79	80	6320	24480
November	200 m³/day	6000 m³	81	80	6480	24000
December	200 m³/day	6000 m³	78	80	6240	24420

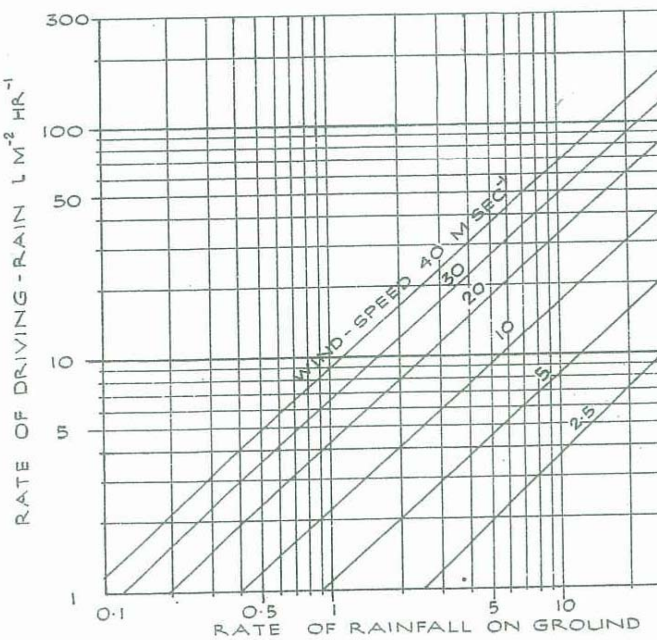
Balanced on the demand of 200 kl/day and a theoretical capture of 100% rainfall ,the storage for the loads noted would require a tank 25,000 m³ volume .The saving would be 20 to 25% of the domestic water service charge.

If the tank were 2.5 metres deep the area would be 100 metres square, if constructed of 150 mm thick reinforced concrete it would require 1650 m³ of concrete.

The cost of such a tank may be offset by integration with structural elements serving other functions, which is an opportunity for Structural Hydraulics innovation. The large area of the holding / storage tank would lend itself to a pipe collection system design of numerous direct untreated flow rainwater down pipe discharge, thus saving drainage and excavations.

Driving Rain

As an example of driving rain .The jogging shoe is on an up sta
entering under the sliding doors of this high rise Gold Coast apa



The relation between rate of rainfall, wind-sp
rate of driving rain.

8.17 MEDIAN

The Bureau of Meteorology Department of Arts Sport The Environment Tourism and Territories Climatic Survey Sydney December 1991

The variability of climatic elements is as important as their average values .A useful indication of this provided by percentiles or deciles which may be described as follows.

The observations of rainfall are arranged in ascending order .The nth percentile is the value below which n percent of the ranked observations fall .Deciles 1 to 9 are equivalent to the 10 20 …..90th percentiles .Hence in one year in ten, the rainfall is less than the 10th percentile (Decile 1)

Or greater than the 90th percentile (Decile nine) The 50th percentile or median represents the rainfall that is exceeded on half the years and not reached in the other half of years .In the Sydney region the arithmetic mean rainfall is generally higher than the median due to the effect of very wet years The median is considered to give a better representation of the average conditions A general discussion of deciles concepts can be found in Lee and Gaffney (1986)

The rainfall variability can be quantitatively represented by the spread of the 10th to 90th percentile range as a fraction of the median value (50th percentile)

I.e. Variability = $\dfrac{(90^{th}\text{ percentile- }10^{th}\text{percentile)}}{50^{th}\text{ percentile}}$

Low variability corresponds to an index value less than 0.5 Variability is high when the index exceeds 1.25

8.18 TEXAS SYSTEM AUDIT

The sample of the Texas system produced a very large storage tank which is conserving the oversupply to augment the deficit in supply; in the sample this happens in September, where the inflow for the month is short by 480 m^3, the least monthly input for the year in respect to median inflows. Rainfall patterns and intensities vary considerably, in Sydney dry spells that last 8 to 14 days can occur ,our 25000m^3 tank volume is going to last for 4 dry days at best ,the records used show that a 3 to 7 day dry spell has happened 727 times over the 31 years of records for Observatory Hill (1995-1936).

The variables in the Texas example and most others are as follows:-

Ref	Variable	Notes
1	Catchment area	Practicalities may limit collection systems
2	Rainfall per month	Without this variation we could do without the tank
3	Consumption per month	We have control over this by the selection of the flushing system
4	Storage	We have control over this relative to economic viability
5	Cost	The core issue of all capital expenditure which we control

Of the five variable components of the storage equation ,ref 3 Consumption is the most relevant to the hydraulics design .The sample data entered into the Texas system format originated from record of water consumption at a hospital using 9 litres a flush low pressure gravity fed flush valves , since 2005 4.5 – 3 litre flush

cisterns and similar flushing valves have been available ,notwithstanding
the comments regarding dry drains and the significance of very low flushing volumes ,such a reduction would obviously effect the consumption rate by as much as 50% .

Based on an 850 bed count and the 200,000 litre consumption over 24 hours, the sample consumption pro-rata to beds was 245l/bed/day, or 9.8 l/bed/hour average ,for supply the data could be extrapolated as 2.3l/s average consumption x 3 = 6.9 l/s estimated peak.

8.19 FLUSHING LOAD ESTIMATION

The primary load for the harvested rainwater system will be flushing toilets and flushing sinks. Urinals, in hospitals urinals are limited to central staff amenities and visitor's toilets .most male patients will be using the WC flush of the en-suite, or the urine bottle and bed pan washer flush.

Bearing in mind that the higher flush rate is taken to avoid dry drain phenomena and that a high proportion of the hospital population are debilitated and also that a high proportion of the visiting numbers will be outpatients that may be stressed, the toilet usage could be considered to be higher than in other buildings.

8.20 RETRO FIT FLUSHING WITH HARVESTED CONDENSATE WATER

Condensate that occurs when air conditioning cooling coils lower the dew point of air is in effect rain. We tend to regard it as waste water and dispose of it via a tundish and floor waste arrangement, it could logically be transported by the rain water system, much the same as ground water, but for reasons not known to the writer, it is considered as a trade waste.

The collection of condensate from air handling units for use as recycled rain water for flushing and similar is not a common design feature, retro fitting has problems and these problems are outlined in the following.

The retro fitting of AHU Condensate collection to supply flushing systems in existing buildings can be a high budget proposition.

The condensate must first be collected and then reticulated to the flushing system storage tank; treatment of the flushing water (UV or Chemical) then becomes required.

Air Handling Units (AHU) can render harvested water to values in the order of $50,000 (2009), if a viable means of reticulating the harvested water to the flush storage tank can be found. There are some detail design issues to resolve with the AHU condensate. The condensate tray will be located directly below the initial intake air cooling coil ,whilst pre-filtered this air flow will contain a certain amount of air borne dust and particulate matter ,some of which will lodge in the initial cooling coil ,the coil requires routine hose down cleaning and hose taps are provided for this task.

The air cooling coil, which is the source of condensate, is hosed down as a cleaning routine and the dust and debris is captured in the drain tray and the particulate matter finds its way to the waste water system.

Were the condensate water to be harvested and used for flushing the particulate matter would have to be removed or by-passed.

A retro fit method of achieving AHU harvesting is to have a coil drainage tray with two drains ,the lower drain of the tray is connected via a Fox valve type of mechanism that is activated to open when the cleaning hose tap is used ,this automatically diverts coil debris to the waste system via type the floor waste , the second but higher drain is connected to a shallow sump which has an overflow to the floor drain ,and a suction connection from a 20 mm moving cavity stator rotor pump (Mono) ,the pump is controlled by a small float switch.

The pump delivery joins any nearby branch service of the existing flushing system ,when the pump is activated the flow will marginally pressurise the flush system and the water level in the flush tank will rise into the freeboard space ,this space having been appropriately adjusted.

One other issue must be catered for in this system .The floor drains must be air sealed with Grateseal rubber lips units to contain foul air should the floor drain contents dry out, an alternative is a float activated low voltage direct current solenoid valve make up circuit.

8.21 ON SITE DETENTION OSD

The author does not consider OSD to be a genuine part of the hydraulic designers scope ,however commercial pressures do on occasion influence the work we do ,the important issue is to be aware of the extent of expert advice that your professional indemnity insurance covers **.**

Most Municipal Council's publish a Development control plan for new constructions and site works ,many of these publications in NSW are based on Water Sensitive Urban Design (WSUD) basic procedures for source control of storm water Australian Water Association November 2004 (This should be checked as the current issue) The Sutherland Shire Council deals with most aspects of infiltration ,rainwater harvesting and OSD for residential properties as might be appropriate for medical staff residential quarters that are in some cases located in off site in close proximity precincts.

8.22 FLAME TRAPS FOR HELICOPTER LANDING PADS

It is not considered good practice to connect surface water catchment to rainwater harvesting systems because of the surface contamination problems, roof located helicopter landing areas should also be excluded from the harvested rain collection system.

The rainwater collection from a helicopter landing area should be a dedicated system with all rainwater outlets serving the same catchment level.

The surface grade of a landing area is much the same as a tennis court 1.25%, at roof level the rainwater outlet intervals should be sufficiently frequent to minimise the water depth required above the outlet grate to achieve the required flow rate, the flow rate must include the flow generated by fire fighting in an emergency.

Pipe work fittings and rain water outlets must all be fire rated cast iron and stainless steel is preferred.

The flame trap must be located to prevent the spread of fire in the storm water drainage system by ignited fuel, most helicopters use kerosene as fuel; however the fuel must be checked prior to the design.

The flame trap is in effect a water seal trap that prevents the passage of fire and has sufficient water depth and fire side volume to contain the maximum fuel capacity of the helicopter, current maximum fuel payload is 1500 litres (This must be checked and confirmed for the design record) .

The specific gravity of kerosene is less than water; the difference in the specific gravities will determine the kerosene storage depth of the trap.

The flame trap will not be charged with rain water in dry weather conditions ,it is essential that a trap charging make up water supply is provided ,this should comprise a time switch control for daily action ,for a predetermined time frame ,sufficient to charge the trap to seal level and allow a margin for evaporative loss (2.5mm/day minimum) The solenoid valve shall be pre-ceded by a strainer ,shall be soft close 12 v DC with a battery supply and trickle charger with a power supply and water supply failure alarm to the BMS / Fire control room.

REFERENCE SHOULD BE MADE TO NFPA 418 STANDARDS FOR HELIPORTS 2001 EDITION

8.23 SIPHON SYSTEMS

HDP Siphon systems are considered to be a cost effective field of proprietary brand supply and construct endeavor that would service the needs of Health Care Buildings in much the same manner as it does other buildings. Siphon systems are believed to achieve more competitive system costs because the technology moves from hydrostatics to hydraulics ,the motivating energy that conveys the water is bigger ,the pipes perform better and carry increased flows at greater velocities and lower grades .as with any pipe system noise must be considered and the anchorage of hydraulic reactions.

8.24 VSD PUMPING STORM WATER

Pumping storm water is not a recommended practice, particularly where there is not an adequate overland flood path.

The following VSD system approach has been used for existing buildings which had limited space available and few other options existed .It is noted that in this instance the client was made fully aware of the risk involved, the storm intensity and frequency that would overcome the pump system, the need for stand-by power and the insurance burden.

A variable speed pumping system has been used for pumping storm water from low lying flood prone buildings where the existing structures prevented the incorporation of a detention holding tank to contain the peak flow until the storm intensity reduced.

The system incorporated a small centrifugal pumps for the low intensity storms ,and larger VSD pumps to take care of the once in 100 year storm, the advantage being the larger pumps can be activated at low speed range pumping levels reasonably frequently to keep the system in operational status at minimum impact to the receiving drain. The control system for the VSD pump motor comprised a digital level switch which will increase the pump speed to maximum as the water level rises, in this way the pump was prevented from hunting or drawing high power loads for small storms, or overloading downstream systems when this was not required.

8. 25 PUMPING BASEMENTS AND DRIVES

In many buildings including health care ,the basement areas will be allocated to parking cars ,the access path for vehicles may require a dive or ramp that exposures catchment to rainfall and is very often at a level that is below the storm water drainage system .Pumping is in practical terms the only option to remove such run off . AS/NZS 3500:3:2003 Section 9 provides for such areas of less than 2000 m² area (Clause 9.2) by means of a pumped wet well.

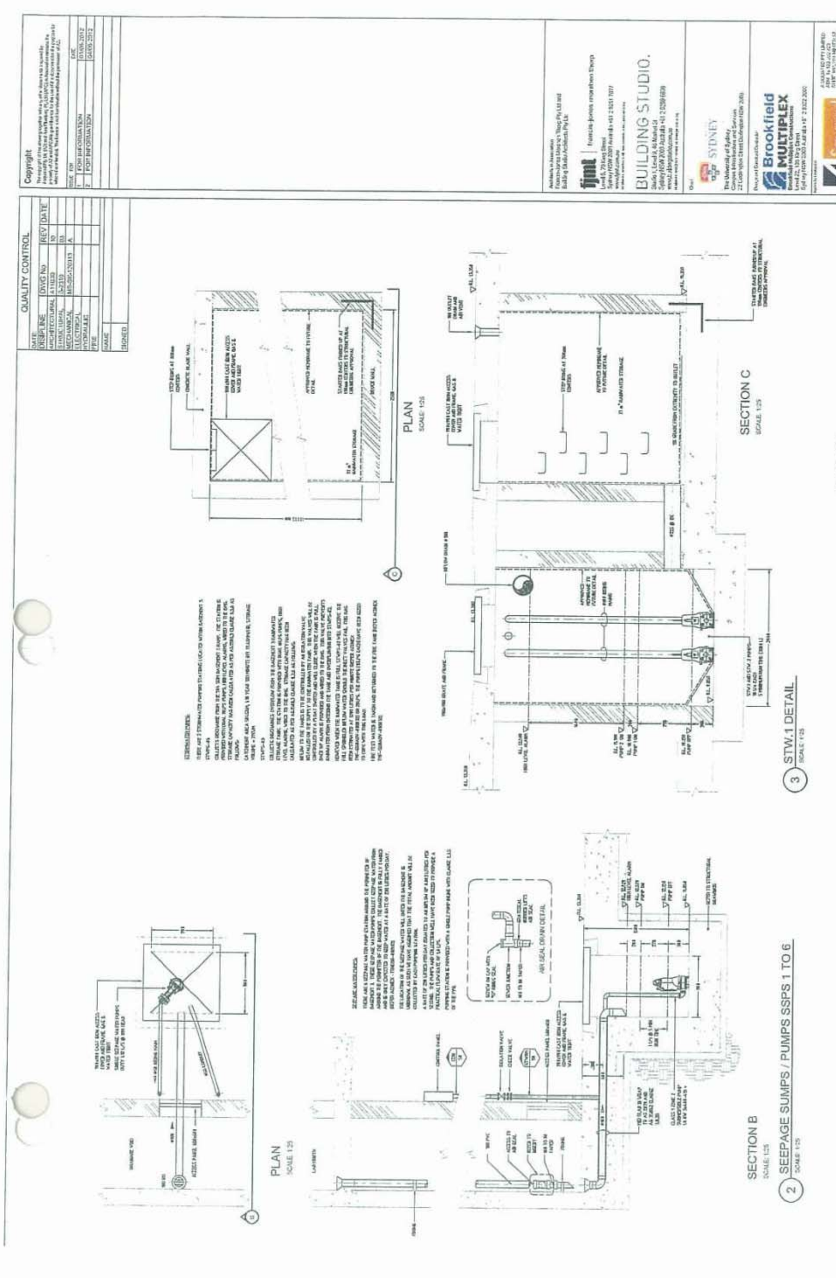
Clause 9.3.6 Combined effective storage: - A combination of pump capacity and the wet well storage between high and low levels .The combined effective storage being the volume to be pumped in 30 minutes plus the wet well storage shall not be less than ARI = 10 years and duration 120 minutes, the minimum wet well storage expressed in m³ shall be 1% of the catchment area in m² but not less than 3m³ and a minimum pump capacity of 10 L/s. In Sydney the 1:10 ARI for 10 years is 50 mm/hour which would deliver 27.77 l/s which over 30 minutes would accumulate 27.77 x 60 x 30 = 49999 litres or 49 m³ ,this less the pumping rate of minimum 10 L/s x 30 min

x 60sec = 18000 litres bringing the wet well volume down to 32000 litres .
Bearing in mind the risk and damage that can result from basement flooding a triple 10 L/s each pumping set with provisions for standby power, would give a greater margin of safety.

Most Council which permits pumping will require two pumps the capacity of each being based on the 1% AEP storm event with duration of 6 minutes, one pump is acting as reserve capacity. Alternative power supplies should be considered where flooding risk will effect critical services or cause significant damage.

RAINWATER QUALITY

Pollutant	Treatment target
Suspended solids (SS)	80% retention of the average annual load
Total Phosphorous (TP)	40% retention of the average annual load
Total Nitrogen	40% retention of the average annual load
Faecal coliforms	90% retention of the average annual load
Litter and inorganic matter	Total retention of litter and organic matter greater than 50mm storm events up to 1 in 3 months ARI
Oil and Grease	Total retention of oil and grease for storm events up to 1 in 3 months ARI



Reference 4.20

Drawing basement level 3 Detail sheet 3

This drawing deals with the common place situation of a basement car also applies to rail dives into tunnels) where the catchment over the ramp can rainwater drainage system by gravity and the only option left to the hyd pumping AS/NZS 3500.3 Deals with this in clause 9.3 by a combination pump capacity.

The combined effective storage comprising the volume of water pumpe wet well storage .The storage shall be not less than the run off of the AI a duration of 120 minutes .The minimum wet well storage shall be 1% c m² but must be not less than 3 m³ and the pump capacity not less than

CHAPTER 9 HOT WARM AND COLD WATER SERVICES

9.1 THE NATURE OF WATER

Water is nature's solvent; it will embrace and absorb a profusion of organic substances and chemicals and provide a habitat for a universe of biological microorganism's, or be the nourishment delivery system for plant and insect life ranging from trees that live a thousand years to fungus that will survive in darkness.

Water has the capacity to phase change and capture or release energy in very small or very large quantities, water is virtually non-compressible and it has an infinite relationship with gravity the atmosphere and kinetic energy.

9.2 HOSPITAL WATER SUPPLY

The most probable supply of water for the hospital located in a major city metropolitan area is a Public Utilities Water Main. The water main may be located below ground in a footpath or road services zone.

In the UAE (And part supply of some Australian Cities) The water supply may be a desalinated source which has high production costs ,the U.A.E ambient water temperature will be higher than most Australian supplies ,where the water supply is solely reliant on complex membrane technology plant it is desirable to store at least 24 hours consumption .

In the UAE the supply must be direct to the storage tank, filtration and pumps are located downstream of storage tanks, where concrete water storage tanks are constructed there must be a nontoxic lining / paint seal, the means of maintenance and no below ground external party walls. It should be noted that whilst rainfall in the UAE is low as would be expected in an arid zone ,it does however rain on occasions in significant intensities,

NSW Health Technical Sheet 11 (TS11) at the time of writing the first edition, TS11 did not provide, guidelines as to determining water supply reliability, a statement from the local authority giving the potential of the system to network alternate supplies to the site connection, also the history of breakdowns and the availability of a Grade 2 Supply, are issues which the design should make reference to and consider.

Whilst cold water storage is considered an essential feature of a disaster hospital, for other types of hospital storage must be considered relative as added system complexity and capital and recurrent cost effect, these facts must be balanced against the hospitals projected life expectancy, the age and history of the supply water mains reliability used as a means of evaluating the risk probability of the localwater mains networks failure to maintain supply.

If the history of the network has not included a major supply or shut down problem, and if the mains are relatively new and well maintained, delivering pressures in the order of 25 metres at the required peak flow rate for the project under consideration, the need for a storage tank is questionable.

The modern hospital hydraulics design (In common with most other buildings) should consider rain harvesting for use as a non-potable water supply and a means of subsidising the potable water supply load with a low pressure system that would in the case of cross connection be pressure overwhelmed.

Where wet cooling towers and toilet flushing systems are dedicated ,storage tank systems become more relevant .The proposition of low level storage tank where the total weight will have least structural impact and which can harvest high peak rain falls is considered a valid proposition. However if the structure can tolerate the load without added cost, a metallic or composition tank at high level with its cover combined with the roof fabric, can minimise pumping costs, in some instances it is cost effective not to serve the floors immediately below the storage tank thus limiting the system to a low to medium pressure range suitable for servicing cistern flush toilets.

When considering storage the initial task for the Hydraulics designer is to establish.

The potential reliability of the available water source.

The location of the supply in the network, can a Grade 2 supply be provided?

The capacity of the supply to satisfy the consumption load for the hospital as proposed (Records of water consumption indicate very high loads for mental care units)

The probable load increase to service future expansion, this being based on land availability, planning restraints, and the demographic curve of the population catchment served by the hospital.

The quality, volume and pressure of the available supply.

9.3 WATER USE

Hospitals may have any, or all the following water supply systems and needs

Potable water for Domestic and associated consumption.

Cooling systems associated with critical use diagnostic computer technology

Water for flushing

Ultra-pure water for dialysis .Clean Steam. Pathogen free animal feeding

Hydro therapy pool and baths

Sterilizing

Cooling and heating systems (COOLING TOWERS AND SIMILAR) Sea water may be viable

Steam services

Laundry

Irrigation (Indigenous drought resistant plants are preferred)

Fire Services (THE RECURRENT DEMAND FOR FIRE IS LIMITED TO TESTING WHICH SHOULD BE RECYCLED)

9.4 WATER CONSUMPTION

Domestic Water consumption records for The Westmead Teaching Hospital which comprises 850 beds and about 3000 persons staff /visitors consumes an average 700 to 1000 litres/bed/day .Liverpool Hospital consumes approximately the same ratio to bed consumption .

Conventional Industry practice is to allow 3 times the average flow rate as the peak demand; however where storage tanks are part of the design the peak load effect on mains may be buffered to the average consumption load.

Sydney Water 2011 advise 249-l/day average use ,assuming a 2.5 staff to bed ratio the water consumption x total population (Patients + Staff) = 740775 litres day water use ,which fits reasonably well with the buildings Building Management System units measured as total water consumption.

The consistent Westmead flushing amount measured is 200,000 litres or 27% of the total water consumption per day for flushing WC pans. Dirty utility flushing sinks and Bed pan washers

Assuming the (1973) gravity flushing valve system delivers 9 litres per flush then per day for the measured 200,000 litres, the valves are activated 22,222 times by an assumed population of 2975 patients and staff, which amounts to 67.2 litres per person or at 9 litres per flushing action 7. Flush actions per person/ per day.

(The calculation has used gravity flush valves at 9 l/flush + male patients will be using en-suite WC flushing .For a 6 litre flush an approximate estimate of 20% of total water consumption for health care flushing would seem reasonable)

Note 1: - UAE Watersupplies are required to join a ground or below ground water storage tank with 24 hours storage, 1000 l/bed/day is accepted design practice.

Note 2 UK Watermains generally run at lower pressures than Australia and low level storage peak load buffer tanks may be required.

In the UK water from tanks is considered vulnerable to pollution and as such is not considered potable, or fit for use as drinking water, for large buildings with storage tanks a separate pressurised mains supply delivers drinking water to dedicated drinking water taps located in toilets or at water fountains. Activated carbon filtration may be used to remove Chlorine taste.

In UK domestic dwellings the water main will enter the dwelling and first supply the kitchen sink tap ,this tap will be of a bi-flow design, a pipe within a pipe until 5 mm from the spout exit point, the main will then rise to supply a roof mounted water storage tank 454 litres approximate volume ,this tank serves all other hot and cold water draw off points .Travellers will be aware of the shower electric heater and flow switch operated booster pump which is used to overcome low pressure problems.

Recent trends in load assessment include on site loggers connected to an internet address and Water System Networking where the building has an energy Dashboard that measures energy and water usage and is accessible from the Internet via Google Power Meter or apps widgets. For information refer Jan/Feb 2011 Plumbing Systems & Design American Society of Plumbing Engineers.

As noted the domestic demand for large 800/1000 bed teaching hospitals has been measured at a nominal 1000 litres / bed/day. The schedule below gives accurate readings for consumption.

Bearing in mind the probability of future private hospitals being developed that have autonomously managed commercial, residential and wellness areas, there are following the schedule other building types data which may be of interest.

Schedule below is based on the Sydney South West Area Health Services Energy and Water Management Annual Report 2008 to 2009 Prepared by Steven Cowen Area Energy Manager.

9.5 SCHEDULE OF WATER CONSUMED. LARGE AND MEDIUM HOSPITALS SOUTH WEST SYDNEY

Hospital	Occupied bed days O.B.D	Beds O.B.D 365	Water m^3 year	Water m^3 day	Water Bed Day	Flushing Water 27% of	Flushing Water 14% of	Average Inflow Litres/second	Peak inflow Average

					Litres	total day	total day		x 3
RPA	272447	747	285149	781 m³	1045	282 litres	146 litres	9.039 l	27 l/s
Concord	210602	577	183159	501	869	234	121	5.79	17.37
Liverpool	269746	740	210689	577	780	210	108	6.67	20.1
Campbelltown	115979	317	*59764*	163	1002	270	140	1.886	5.65
Bankstown	136072	372	*74336*	203	547	147	76	2.34	7.02
Balmain	25013	68	9499	26	382	103	53	0.3	0.9
Bowral	23378	64	14492	39	609	164	85	0.45	1.35
Camden	20818	57	9619	26	456	123	63	0.3	0.9
Canterbury	57195	156	46874	128	820	221	114	1.48	4.44
Fairfield	58287	159	50531	138	867	234	121	1.59	4.77
Queen Victoria	31000	85	15200	41	482	130	67	0.474	1.423
Column	1	2	3	4	5	6	7	8	9

NOTE COLUMN 2 O.B.D (OCCUPIED BED DAYS) IS OBD/365DAYS

9.6 SCHEDULE OF WATER AND GAS CONSUMED PER OCCUPIED BED/DAY AND FLOOR AREA USED

Large and Medium Hospitals South West Sydney

Hospital	Occupied bed days O.B.D	Beds O.B.D 365	Natural Gas Used Mj/Day	Water m³ day	Water Bed Day Litres	Gas Bed Day Mj	Floor Area used M²	Floor Area used M² per bed	Estimated Domestic hot water storage litres with 2 hours reheat
RPA	272447	747	159068	781 m³	1045	212.94	241043	322	26145
Concord	210602	577	318955	501	869	552.78	87040	150.84	20195
Liverpool	269746	740	172936	577	780	233.69	113232	153.01	25900
Campbelltown	115979	317	70854	163	1002	223.5	24559	77.47	11095
Bankstown	136072	372	59450	203	547	159.81	45722	122.9	13020
Balmain	25013	68	6591	26	382	96.9	NDP	NDP	2380
Bowral	23378	64	5304	39	609	82.88	NDP	NDP	2240
Camden	20818	57	10735	26	456	188.33	NDP	NDP	1995
Canterbury	57195	156	25205	128	820	161.57			5460
Fairfield	58287	159	24132	138	867	151.77			5565
Queen Victoria	31000	85	3352	41	482	39.44			2975

Column	1	2	3	4	5	6	7	8	9

NOTE:- COLUMN 9 BASED ON 35L/BED 2 HOURS REHEAT ΔT (15-65°C)

9.7 NAPOOS (NON ADMITTED OCCASIONS OF SERVICE)

Where Health Care facilities provide service that does not involve admission and presumably bed accommodation the activity of the facility is measured by NAPOOS.

9.8 COMMUNITY HEALTH CENTRES

In the population area of service rendered by Sydney South West area Health Services there are 81 Community Health Centres the Year 2008-9 recorded the following statistics in respect to water and gas and more importantly service rendered.

The object of reviewing water and gas consumption for existing Health Care Installations is to establish by Pro-rata comparisons a useful design guide for future installations, or for the modification or expansion of existing installations.

In the case of conventional Hospital care, the bed population becomes a good indicator of water and gas loads, Floor area /bed ratios of the larger hospitals appear to hover around 150 square metres of facility space per bed, however in the larger hospitals where research and teaching are included in the range of activities the ratio appears (on minimum data) to double.

For Community Health and similar such operations the very existence of the facility has been driven by the health needs of the population catchment as understood by the health planners.

The provisions for drainage ,domestic hot and cold water and gas ,these services will be determined by the provision of sanitary fixtures to service the anticipated human load in accordance with the Building Code of Australia , the code works on population to facility ratios ,it does not need to address the transient nature of the short visit patients and the increased human load imposed upon the service to the fixtures ,it is also relevant to the sanitary fixture provisions and the hydraulics design that a proportion of patients will be stressed ,or debilitated ,some will be children or nursing mothers .

9.9 COMMUNITY HEALTH (81)

Gas MJ Consumption	Water Consumption	Occasions of service	Gas per occasion	Water per occasion
13963	2494 kl	611742	22.82 kj	4 litres

9.10 DENTAL HEALTH CENTRES (16)

Gas MJ Consumption	Water Consumption	Occasions of service	Gas per occasion	Water per occasion
3408052	13951	239624	14.22 MJ	58.22 litres

9.11 DRUG HEALTH SERVICE (20)

Gas MJ Consumption	Water Consumption	Occasions of service	Gas per occasion	Water per occasion
3501	101	269206	13 kj	0.375 litres

9.12 MENTAL HEALTH (30)

Gas MJ Consumption	Water Consumption	Occasions of service	Gas per occasion	Water per occasion
3233483	19899	232587	13.90 MJ	85.55 litres

9.13 INSTITUTE OF FORENSIC MEDICINE (1)

Gas MJ Consumption	Water Consumption	Admissions	Gas per admission	Water per admission
2035504	5418	3289	618 MJ	1647 litres

9.14 WATER CONSUMPTION RECORDS FOR OTHER THAN HEALTH CARE

Sydney Water 2011 One person 249 Three 374 Four 564 Five 643 Six persons 716 litres/day for the group

9.15 SAMPLE BUILDINGS MEASURED

Anchor House Sydney NSW

Office Building Population 375 persons

Consumption per person average over 5 working days 47.5 litres person/ day.

Lend Lease House Sydney

Office Building population 470 person

Consumption per person average over 5 working days 47.82 litres person/day.

Caltex House Sydney NSW

Office Building Population 1150 Persons

Consumption per person average over 5 working days 43.03 litres

Blues Point Tower Sydney NSW

150 Home units Population 264 average per day 190.68 litres unit 385.9 litres

Quarter Deck Sydney NSW

45 Home Units Population 77 average per. day/ person over 7 days 175 litres. unit 295 litres

Ithaca Gardens Sydney NSW

40 Home units Population 87 average per. day / person over 7 days 149 litres unit 331 litres.

9.16 WATER CONSUMPTION IN HOSPITAL LAUNDRIES

Laundries water consumption is dealt with in clause 7.11

9.17 WATER STORAGE

Water storage is a subject addressed by the NSW Health Guide line TS 11 (Technical sheet)

This Guide line is up-dated from time to time; the hospital services designer in NSW should check the most recent publication.

9.18 STORAGE TANK CONSTRUCTION

Non corroding materials are preferred. E.G. Stainless Steel Grade 316 Approved plastics.

Storage tanks may be constructed of various materials, acceptance / approval of which may vary geographically. Tanks in Australia must consider Earthquake resistance and compliance with the Seismic provisions code.

TANK OPTIONS

Cast in situ concrete tanks with a suitable nontoxic lining.

Pre-cast concrete tanks with a suitable nontoxiclining, consider also the proximity of other below ground tanks which could constitute a pollution source.

Large diameter rubber ring jointed pipe located above or near the perimeter wall of the at roof level .material suitable to resist solar gain and corrosion may be any approved water product.

Internally or externally bolted, combination stainless steel and plastic, cast iron, or mild steel sectional tanks   with internal painted surfaces.

External bolted sectional tanks require permanent clearance on all surfaces including the base for construction. Sectional tanks require internal struts and bracing, these should be grade 316 stainless steel.

All large volume tanks should be Earthquake restrained, the tank weight is not considered to offer sufficient structural support in earthquake conditions.

Combination stainless steel ,and thermo plastic bolted plate tanks

.Smaller volume plastic tanks.

Copper tanks. And Stainless Steel tanks generally round in plan up to 5000 litres to facilitate transport.

Cast Iron sectional tanks produced in Australia (Gordon Marr and the UK Mather and Platt) such tanks have been superseded by other materials and commercial considerations .however these tanks were used for many years and will be encountered in existing health care projects. External bolted construction is considered superior to internal bolted construction.

Historically even timber has been used for both tanks and pipes

.The choice will be a matter of local supply availability, water quality, and local skills available.

9.19 STORAGE TANK DESIGN

Storage tanks have basic public heath engineering requirements.

As noted in some countries on site tank stored water is reasonably considered vulnerable to contamination and is not considered acceptable as potable, the potable water being reticulated by a totally closed and pressurised system with storage in cylinders, as a dedicated drinking water system with taps in toilets and drinking water bubblers in public places, the water also may be filtered with activated carbon to improve taste and then chilled to 12 degrees Centigrade.

Atmospheric tanks below ground constructed of concrete can be vulnerable to ground water contamination if built in direct contact with the surrounding ground, in the UAR such an arrangement is not considered acceptable. In Australia it would be considered doubtful practice, and may jeopardise professional indemnity insurance should a defect give rise to litigation. Connections to large structural concrete tanks need consideration ,the conventional Puddle flange is not a good option if any significant water depth is involved

In most instances where tanks are used the building will be reliant on the viability of the storage to operate .All potable water storage tanks should incorporate an alarm system to identify lower than normal water levels and load profile changes that indicate a loss or reduction below normal of the incoming , and stored water supply.

Tank alarms require careful consideration, it should be understood that the low water alarm may only function once in 20 years, duty personnel at Building Management Systems may not respond, human error is the weak link of most warning systems.

As a training aid the random activation of alarm testing functions should be incorporated to test emergency procedures and ensure that an immediate response is actioned and recorded.

Exposed tanks at roof level must be protected from climate extremes, solar gain which will heat the water to facilitate Legionella and low temperature freezing where wind chill factors may amplify low temperatures.

Tanks should have insect and rodent proofed openings (Hinged Cover flaps)
such as overflows, in the UK a small flow overflow is discharged as a warning pipe to a location which will be noticed and reported as a nuisance.

Tanks must have covers to prevent contamination, and access to undertake inspections and maintenance after which the content must be chlorine treated and flushed away. Care must be taken where copper tanks and reticulation may be exposed to high chlorine levels

Potable water supply tanks must be duplicated by a compartment's to allow 50% drain down for cleaning and maintenance whilst the building remains on line.

Tanks must have silt drains, and overflows as a safe guard against supply malfunction.

Water supplies to tanks must provide an approved air gap registered to Code requirements, some exceptions to this may be acceptable for non-potable water supplies, however in Health Care installations this would be considered unconventional.

Tanks must be compliant with access and confined spaces Occupational Health and Safety legislation, in particular adequate means of ventilating when internal protective coatings are being replaced or repaired.

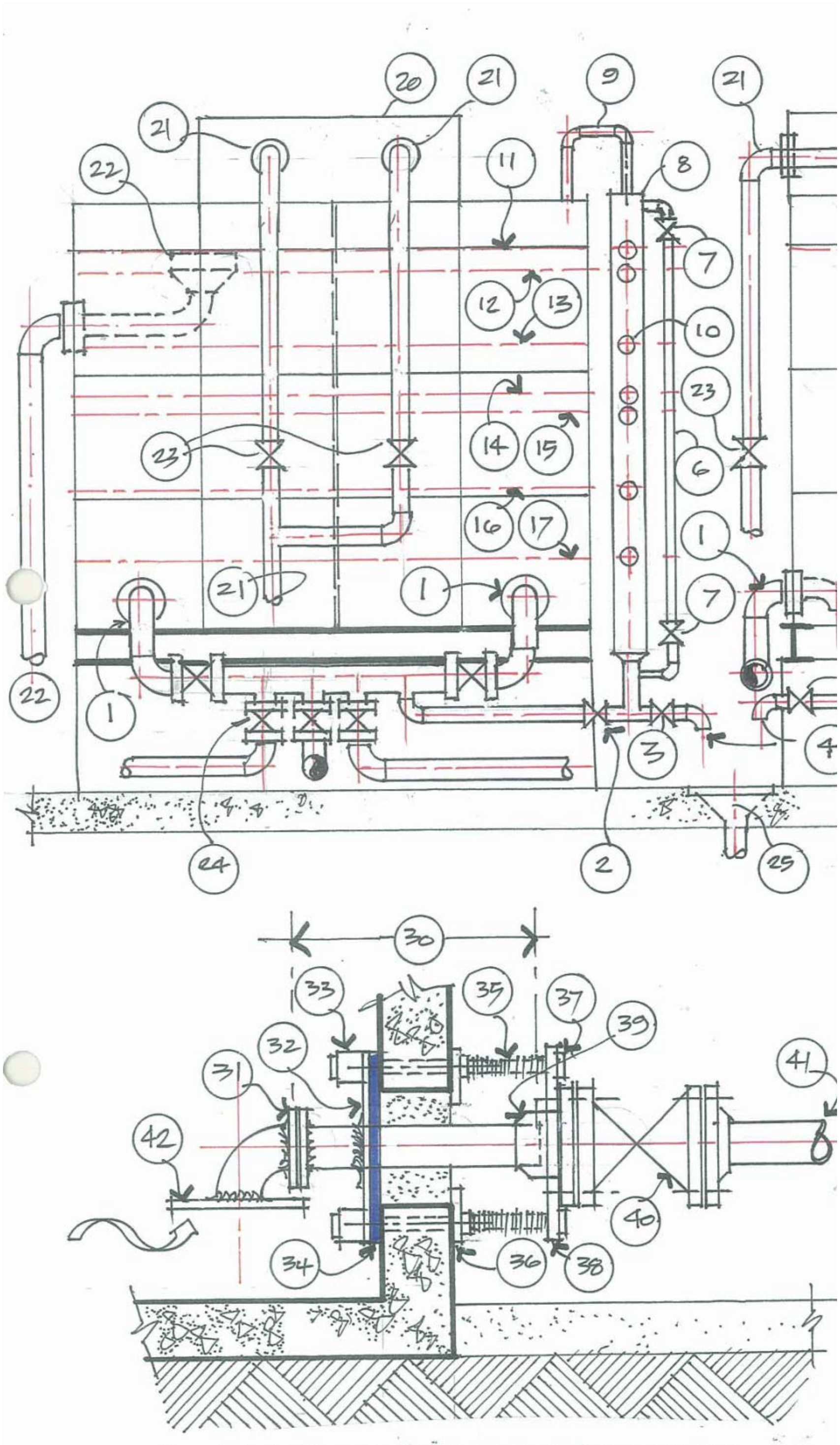
Tanks in tall buildings may be vulnerable to sway and wave generation, or similar conditions may be promoted by cyclic water entry, ball float valves floats and float switches should be protected by stilling baffles. Tanks may also need securing in accordance with the seismic code.

Large ball float valves through tank walls should be avoided in preference to pilot operated valves such as "Bermad" which operate on low water differentials and can incorporate a delayed action function to ensure required pump run times.

Where tanks are duplicated the control system floats or sensors should be simplified by locating in a float switch vessel connected to the tank marriage pipe ,the vessel should be provided with a sight glass , vent ,drain down valve and full way isolation valve , the drain and isolation valve will permit site testing ,commissioning and simulated alarm training procedures.

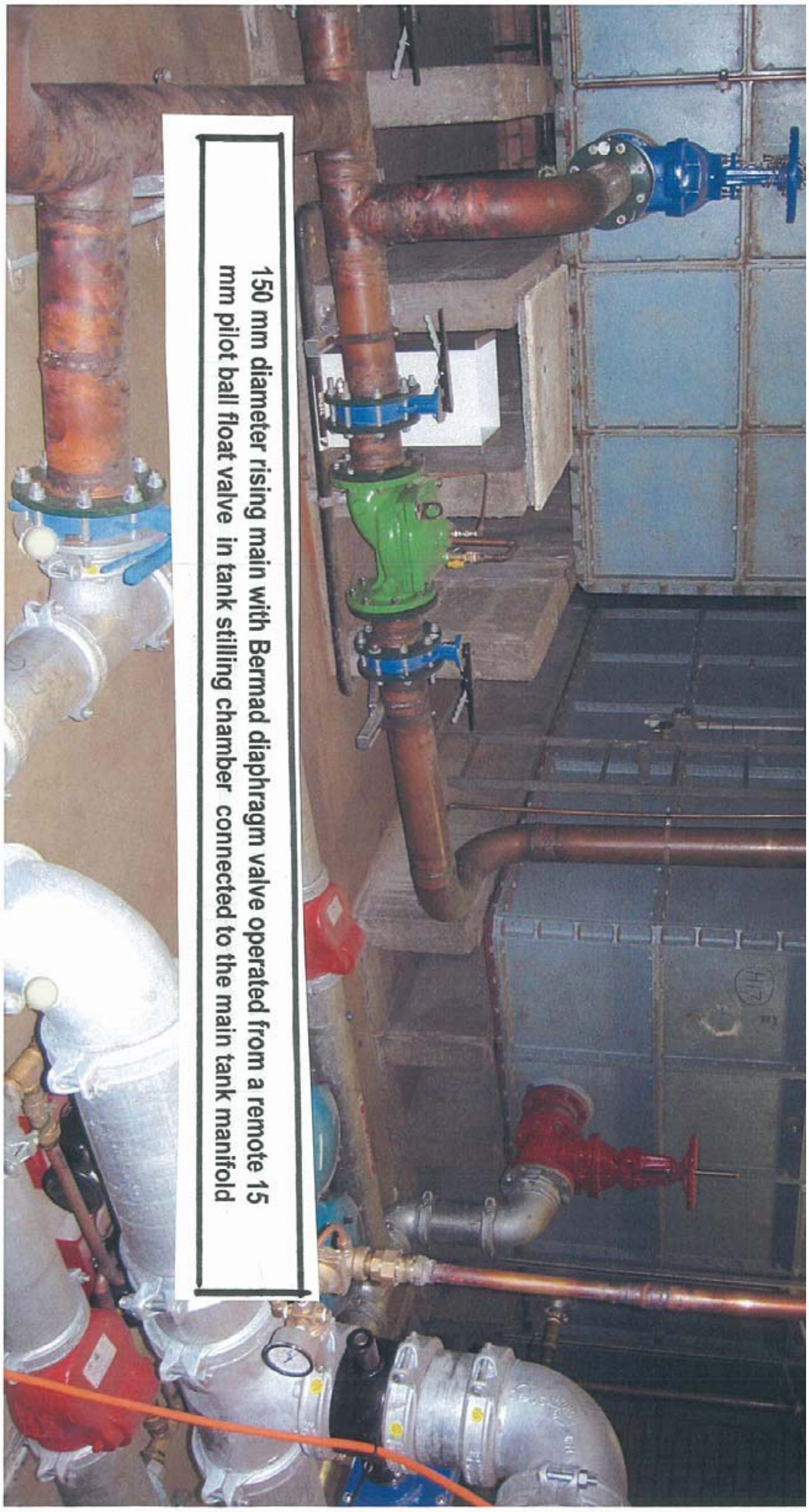
Tank filling pumping controls must consider the frequency of pumping which preferably should not allow the tank storage volume to diminish more than 10% by volume and the acceptable minimum pump running time (6minutes)for the pump starters which can overheat from frequent activation, if pumps are duplicated duty and stand by and an alternating run pumping control program is used, this tends to remove, or mask the starter overheating problem.

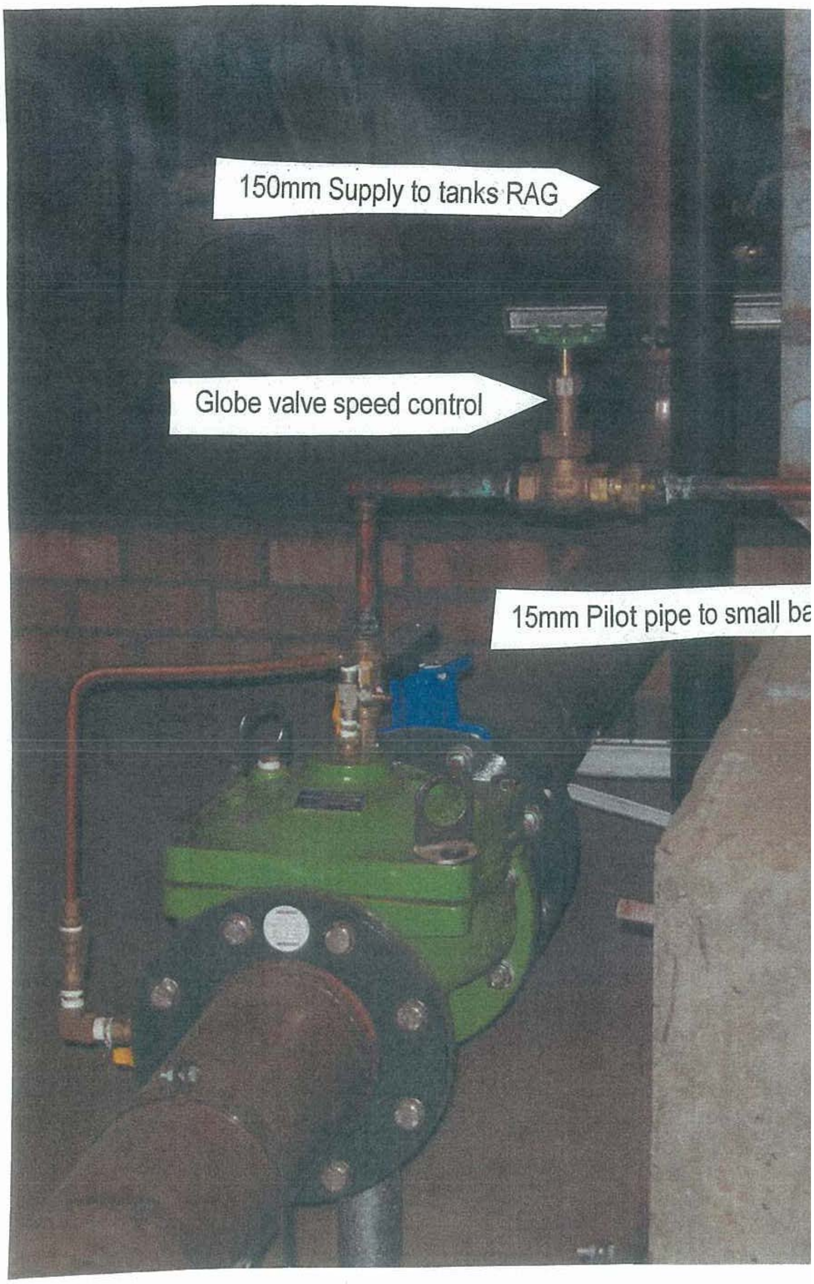
Where pilot operated ball float valves are used a soft close solenoid valve and globe valve should be inserted in the 15 /20 mm pilot valve supply, the globe valve will slow down the closing rate of the remote main diaphragm valve, the solenoid valve should be activated to open with the duty pump for one tank and the standby pump for the other tank, this ensures two things. An equalised pumping resistance for on pump running, or in extreme load conditions where both duty and stand-by pump are called upon to run , the water input will be an equally distributed flow of clean water and residual chlorine content to each tank.



Detail of Concrete Tank Compression Plate connection

No	Tank detail legend of components
1	Tank outlet
2	Spherical ball valve 50 mm
3	Drain valve over tank tray
4	Drain valve over tank tray
5	Drain valve over tank tray
6	Sight glass with protector
7	Isolation plug cock
8	Vessel for level control system
9	25 mm vent
10	Float or other level control
11	Overflow water level
12	Top water level both pumps Off
13	Duty pump On
14	Standby pump on BMS Signal advise high water consumption
15	Low water level alarm Reserve water volume being used
16	Extreme low water level Alarm shut down non priority plant
17	Tank suction outflow Vortex point shut down suction pumps drawing from
18	Anti vortex bend
19	Stilling baffle
20	Access box to water filling air gap
21	Fill pipe
22	Overflow
23	Inlet flow isolation for tank maintenance
24	Isolation valve manifold
25	Tank tray drain
26	Support UBs for sectional tank construction external bolted
	Detail of Concrete tank compression plate connections
30	Nominal 600 mm
31	Table E Flanged joint with bronze or stainless steel bolts nuts washers
32	20mm thick Fabricated and Hot dip galvanised pressure plate
33	50 mm sockets welded over long bolt (35) nut & washer Tighten with tube spanne
34	Flange rubber gasket
35	Long bolts
36	Backing plate
37	Long bolt nuts and washers
38	Anchor joint (39) If not linear secure
39	Anchor for flanged valve (40)
40	Isolation valve
41	Service


150 mm diameter rising main with Bermad diaphragm valve operated from a remote 15
mm pilot ball float valve in tank stilling chamber connected to the main tank manifold



The “Bermad” pilot operated ball float diaphragm valve.

The advantage of this valve over the more conventional mechanically a
ball float valve is that it is hydraulically activated using the system pressu
can be speed opened and closed adjusted by means of a globe valve fl
ball float valve and it removes complex components from within the tank
manageable maintenance area ,in addition solenoid valves can be adde
line to facilitate remote control ,or float switch control .
The diaphragm valve is a durable and simple core component, one mov
isolation, flow or pressure control, this unit that can be linked to other co
uses , including the sequenced opening of fill paths with multiple pump

9.20 HIGH PRESSURE PUBLIC UTILITY MAINS

Where the water supply main has adequate pressure to service most of the building there may be a conflict of interests in the desire to save energy by using as much of the available mains pressure as possible. The conflict may be with a storage tank, if such is required, the tank will rob the main of useful pressure / energy and services downstream of the tank will require boosting, or if the tank is at low level the VSD pumping system will be disadvantaged. When the water storage tank is at low level, the designer should consider a system which brings the tank and booster pumps on line if there is a mains failure .However there must be some regular draw off from the storage tank to ensure residual chlorine content enters the stored water volume, and some use of the pumps to avoid deterioration from immobility.

9.21 COLD WATER RISING MAINS

Rising mains from booster pumps to roof tanks, or as variable speed, or hydro pneumatic direct pressure boosting systems, can in tall buildings involve thermal movement problems in the vertical main, also with copper tube of larger diameters, the safe working pressure should be checked, bearing in mind that hydraulic shock can multiply the static system pressures, and bearing in mind the copper softening effect of high temperature silver solder jointing.

Whilst in Australia hospital design tends to favour building of less than 25 metres high to minimise the impact of fire regulations and to rationalise the cost and time involved in the movement of patients and other services such as food and waste, the construction of much taller health care buildings overseas is not unusual.

A rising main that follows a straight vertical path from ground level to a roof located storage tank can be vulnerable to expansion and contraction activated by seasonal change in water temperatures .5 to 15 degrees centigrade is possible giving a temperature difference of 10 degrees, in a 30 level building with 3.6 metres floor to floor, a 108 metre copper tube rising main will move ºC x 0.0177 mm x metres or 10 degrees x 0.0177 x 108 metres = 19.116 mm.

In a conventional system with a 100 mm vertical tube supported at 3.metre intervals (AS 3500:4) there will be ten supports required for the vertical pipe being considered , the pipe will contain a water volume of 7.595 kg of water ,the total weight of the pipe and the water will be 12.12 kg per metre.

The total weight of copper tube and water to be supported in the 30 level building is 108 m x 12.12 kg = 1309 kg ,as noted the pipe will be supported vertically 10 times ,thus each support will carry 131 kg.

When the pipe expands the 19,116 mm (as calculated) the pipe will move most through the top and most extreme in distance bracket, it may rise through the bracket clear of its connection with the structure, the load carried by the bracket (131 kg) is then transferred to the wall thickness of the pipe and to below, at each floor level some vertical movement will occur transferring the static weight of the pipe and contents to the pipe wall which is then becoming a long column.

If the joints are silver soldered they will deform quite quickly as a bellows type bulge, after a number of such movements the copper will fatigue and fracture.

The rising main as described should incorporate provisions for thermal movement and be fitted with hangers that are spring assisted, each spring of the ten supports should place an upwards thrust of 131 kg at the fixing point.

The example being seasonal water temperature differences deals with significantly less temperature difference and thermal movement than would a domestic hot water main of similar dimensions , the movement and temperature difference being five times as great.

In rising mains material selection is critical, particularly if the building is pump pressurised.

AS 1432 - 2004 Copper tube at the larger diameters has low safe working pressure of1200 kPa which is 300 kPa lower than the normal testing pressure ,and in a building as described ,if the top floor is to be serviced with a minimum 250 kPa (25 metre) head ,at the pumps the pressure will be 1303 kPa ,which exceeds the safe working pressure by 103 kPa ,whilst the copper tube would probably withstand this margin ,the silver soldered joints would be less reliable ,and any hydraulic shock imparted in the system could be a problem

Stainless steel may be considered a more appropriate material for rising mains having greater physical strength , lower expansion coefficient and Victaulic jointing systems with tolerance for movement , also the stainless steel bellows expansion joint which is widely used in mechanical services installations whereas hydraulic services tend to show preference for the natural rubber bellows .In all bellows type joints used on high pressure systems for expansion or noise and vibration isolation it is advisable to also install limit of movement wires across the joint to safe limit the maximum movement range.

9.22 RETICULATION DESIGN

The design of domestic hot warm and cold water services for Health Care are included under a common heading because in most buildings these services logically follow similar routes with common fixings for co-ordination simplicity and for a cost effective installation, they also have a logical relationship in respect to, isolation valves and pressure, which for mixing purposes should be similar.

The supply direction of the water supply is important .E.G Tank fed systems provide minimum head (Motivation energy) at the point of highest demand which affects the pipe diameter, whereas an up feed system has most energy (Pressure) at the point of most load, the pipe diameters tend to be more consistent.

In any institutional type of building it is considered good practice to develop a dogma for the location of valves, repetitive planning of services and the isolation of those services tends to simplify the coordination of services problems in the construction phase and the ongoing maintenance in the occupied and operational building.

Water velocity is critical in respect to soft metal pipes such as copper that are vulnerable to erosion corrosion ,constant noise is also a significant factor with thin walled metal pipe ,generally velocity problems are associated more with pumped systems ,particularly where the pumping induced velocity is constant and at high velocity (Above 0.9m/s in copper) ,velocity problems in draw off reticulation are less related to corrosion and more relevant to hydraulic shock (Water hammer) caused by rapid close down of flow by solenoid valves ,or lever action mixers which do not incorporate a soft close feature.

Fixings for services are extremely critical, as noted herein, vertical rising mains have special considerations, as do the requirements of lateral services particularly for polymer pipes and hot water reticulation which will require sliding and anchorage fixings appropriately located and designed . Most failures in copper tube and rigid polymer pipes can be attributed to stress from expansion and poor fixing design.

Design care must be taken to ensure that the pipe fixings are appropriate, pipe clips of the U bolt configuration will pinch and distort most thermo plastic pipe material and this will result in stress fatigue and pipe failure in a short time frame.

Polymer pipe material is soft and has a high coefficient of expansion **(fibre reinforced polypropylene pipe has a much reduced expansion and contraction coefficient)**and is vulnerable to hoop stress if compressed by an over tight circumference bracket of a clamping type design without a resilient lining, or where the operating temperature has exceeded design specifications (70°C) the life expectancy of polypropylene depreciates.

Where thermal expansion and appropriate anchorage is not a well-considered feature of the design, polymer pipes will exert forces sufficient to shear pipe connections at tee junctions, or precipitate stress fatigue and cracking within the pipe wall in short time frames of less than 5 years.

9.23 LEGIONELLA PNEUMOPHILA

Legionella pneumophila is a small environmental bacterium found in natural water and soil, it causes an uncommon type of pneumonia known as Legionnaires disease after being discovered in 1976 in Philadelphia where 34 people died, cases dating back to 1947 have been identified, the disease escaped detection because it is very difficult to isolate using standard laboratory techniques. It estimated that 1 case in 300,000 cases of identified pneumonia in the U.K is Legionella.

The section of the community most vulnerable to Legionella is the aged and immune system compromised and the generally debilitated, (males are more vulnerable than females), the groups most found in hospital.

Legionella infection person to person is rare ,most infections are inhaled into the reparatory system as water vapour from cooling tower drift ,or showers ,the bacteria grows best at 35ºC in the laboratory ,the near instant kill temperature is 60ºC .The bacteria is believed to feed and colonise in the biological slime and silt in pipes and tanks.

Warm water systems at 43.5ºC downstream of TMV units in individual or central warm water systems are vulnerable because they provide an ideal habitat for colonisation of the bacteria, the central system having more water content and more users being proportionally more vulnerable and for this reason must circulate the distributed flow at all times through an ultra violet irradiation system which will kills the bacteria by exposure to UV.

UV will not pass through glass, the transparent water tubes used for irradiation are silicon, the UV lamp may be located in the center of a flowing pipe, or the water may be in the silicon pipe bombarded from all sides by UV lamps, the latter dry system prevents shadowing of organism by suspended solids.

Ozone dosing, as some times used in health care laundries ,may be an option ,ozone is a dangerous to humans, unstable gas which cannot be bottled and requires a high tech electrical discharge process through dry air to generate ,then after use the residual ozone is removed by activated carbon ,as with UV ,Ozone is instant kill and has no residual sterilizing effect as does Chlorine.

Very hot water clean In Place sterilisation could also be used, however very hot water is also a health hazard, and the practicality of reaching all extremities of a central system are problematic.

Chlorination of water supplies to levels between 1 and 2 mg/l has been used with success in the U.K to irradiate Legionella bacteria from storage tanks.

Bearing in mind that the in the first instance the Legionella bacteria must enter the potable drinking water of the hospital and then be conveyed to the tanks the cooling towers or eventually the shower and shower user as an aerosol vapour.

At face value there would seem to be some responsibility on the part of the water supply authority to prevent this lethal contamination from entering the supply system? Also the supply to residential dwellings with debilitated or aged occupants would seem to face much the same risk?

9.24 AUSTRALIAN BUILDING CODES BOARD (BCA) FACILITIES IN BUILDING SCHEDULES

(NOTE ALL BUILDING CLASSES ARE INCLUDED FOR COMMERCIAL TENANCIES IN HOSPITALS)

This data is included as a guide for reference in those early stages of the design process when only fragmented information is available and the initial concepts are being established, it has been the writers experience the 80% of the significant design decisions are made in the first 10% of the design time, it is the time to be hardnosed and push for those features of the hydraulics design that will be of long term benefit to the final user and improve the state of the art.

User group	**WC Pans**		**Urinals**		**Wash basins**	
Class 3- 5- 6- and 9 other than schools						
Male	1-20	1	1-10		1- 30	1
	>20	Add 1 per 20	11-25		>30	Add 1 per 30
			26-50 >50	Add 1 per 50		
Female	1 -15	1			1 – 30	1
	> 15	Add 1 per 15			> 30	Add 1 per 30
Class 7 & 8						
Male	1 -20	1	1-10	0	1 – 20	1
		Add 1 per 20	11-15	1	> 20	Add 1 per 20
			26-50	2		
			> 50	1 per 50		
Female	1-15	1			1 – 20	1
	> 15	Add 1 per 15			> 20	Add 1 per 20
Class 6 Department Stores Shopping Centres						
Male patrons	1-1200	1	1–600	1		1
	> 1200	Add 1per 1200	> 600	Add 1/1200	> 600	Add 1/1200
Female patrons	1-300	1			1–600	1
	301-600	2			601 – 1200	2
	> 600	Add 1 / 1200			> 1200	Add 1 / 1200
Column 1	2	3	4	5	6	7
User group	WC Pans		Urinals		Wash basins	
Class 6 restaurants ,cafes and bars (*These may be franchised to private operators with discrete standards)*						
Male	1 - 100	1	1 - 50	0	1 - 50	1
	101 - 300	2	51 - 100	2	51 - 200	2

	> 300	Add 1 / 200	101 - 150	3	> 200	Add 1/200
			151 – 200	4		
			201 - 250	5		
			> 250	Add 1 / 100		
Female	1 – 25	1			1 – 50	1
	26 - 50	2			51 – 200	2
	51 - 100	3			> 200	Add 1 / 200
	101 - 150	4				
	151 - 200	5				
	201 - 250	6				
	> 250	Add 1 / 100				
Class 9a Health Care Buildings						
Male	1 -20	1	1-10	0	1 – 20	1
		Add 1 per 20	11-15	1	> 20	Add 1 per 20
			26-50	2		
			> 50	1 per 50		
Female Patients	1- 25	1			1 – 50	1
	26 - 50	2			51 – 150	2
	51 – 100	3			> 150	Add 1 / 200
	101 – 150	4				
	151 – 200	5				
	201 – 250	6				
	> 205	Add 1 / 100				
Class 9b Auditoriums Theatres Cinemas						
Male patrons	1 - 1200	1	1 – 600	1	1 - 600	1
	> 1200	Add 1per 1200	> 600	Add 1 / 1200	> 600	Add 1/1200
Female patrons	1 - 300	1			1 – 600	1
	301 - 600	2			601 – 1200	2
	> 600	Add 1 / 1200			> 1200	Add 1 / 200
Column 1	2	3	4	5	6	7

9.25 IN RESPECT TO WATER VELOCITY

The Water Supply and Drainage for Buildings symposium organised by the International Council for Research and Innovation in Building Construction Sydney Opera House 8-10 November 2010 centred on the new German Standard DIN 1988(4) Technical Standards for Drinking Water Installations. The paper delivered by P Angus S Ingle D King J Turner the effects of using water velocity as a technique to control biofilm development in water supply systems, is of considerable interest and relates to the **Case for Small Bore pipes presented herein.**

The rational for velocity of draw off ,as opposed to a pumped circulation, should be to consider the worst case scenario, should the maximum possible load be placed on the pipe, what would be the resulting velocity be? Can the system material tolerate the maximum velocity without velocity corrosion damage? Is there sufficient pressure to meet the added pressure drop? And would the resulting loss in flow pressure adversely affect the system, particularly the hot cold balance at thermostatic mixing valves.

As noted, measurements of flow in existing buildings show a significant disparity between the design peak load and the actual peak load, water systems which are found to be oversized by a factor of 10 over design in the larger diameter services, **(This may be the result of now defunct pipe sizing systems?)**

Bearing in mind that in full maximum demand with all fixtures running, a rare event for **other than showers, it is probable that a large proportion of the building population is active** and background noise is probably also higher in the hospital, in all areas other than study and meeting rooms, and some critical areas of patient care, in reality noise becomes much less of an issue. For noise, heat release and servicing, arterial distribution pipes are best located above corridors.

9.26 CHECK THE LOGIC

Regrettably and regardless of our experience we do all make mistakes.

When involved in a large project, it is always a good idea to do some practical cross checking on some of the design conclusions, where you can, and where you have data that might help to confirm your design assumptions, data such as the consumption rates of any existing facilities of a similar size.

The writer has checked many projects of all types; in one large industrial project the water supply consumption rates were available from the project water meters from prior work.

The project was to model the load on a proposed waste treatment system, this was achieved by taking the fixture load and converting this to an outflow, and however in checking the calculations, the prior measured water supply inflow was considerably less than the calculated drainage outflow, similarly. I have checked boilers and chillers that had more capacity than the connected pipe work and circulating pumps could reasonably convey, also hot water storage invested in one very large vessel with no provision for maintenance, or repair without the total loss of service .

One major Sydney teaching hospital check revealed a domestic cold water system installation where the service from the tank rises above the water line in the tank and thus the hospital water supplies are totally reliant upon the cold service pressure booster pump, which competes with the siphon effect and could in unusual draw off conditions place a negative pressure on pressured cylinders.

A common error incorporated in large reticulation hot water systems, to
facilitate the one off task of flow regulation and balancing is the location of central plant room located balancing valves.

The resulting forest of valves and incredibly long hot water returns, builds into the system significantlly and constant added thermal loss that could be avoided with a better considered design.

Solar systems that have much too much collection area for buildings which can be vacant ,or minimum staffed on weekends and public holidays .In extreme weather conditions and near vacant buildings with low use , there is nowhere for the solar energy to go ,when pressurised the hot water can become very hot.

Specifications that call for a 15% future allowance added to flow capacity of the system contribute little where there are less than six fixtures being served by a branch. Such specifications show a significant lack of understanding of the accuracy levels involved in diversity calculations.

Solar systems with direct mains pressure, or pump boosted fed high pressure collectors, that if not provided with a relief path would under high sun loads produce steam at the taps because the effect of extreme weather had not been considered. Similarly the fixings of solar collectors which create a glass steel and copper aerofoil wing, ready to launch in the first good blow.

Make certain you have sufficient solar storage to accommodate the maximum output of a solar system; they are difficult to shut down. The design calculations should be logical, even if we do suspect some over-design in some of the basic design data.

Rain harvesting systems that had lost sight of the high intensity storm that would overflow the tank through an inadequate overflow path.   Where the rain harvesting is a spread sheet origin, the basic data needs to be published as part of the design drawing.

Designers should bear in mind that the calculations are useful to those that follow, put them "On the drawing" They should relate, the heating source and storage combination and should prove the system can meet the estimated and calculated demand in heat rise and litres per second demand.

The cold water rising main, and high level booster system must have sufficient capacity to meet the maximum demand from the reserve storage tank, or direct pressurised system .The duty standby plant means exactly that, the system should be able to run on the stand by, if you want to incorporate a low load input for running economy, it must be an added feature. Pumps need sufficient work to run for a minimum number of minutes, if not provided, hunting and overheated motor starters and circuit breaker trips will result.

9.27 PUMPING ON THE FLOW

This subject will no doubt be the most contentious subject of this entire publication. If you follow this advice the systems will work well in practice, but the debates preceding the design will be robust and on-going.

The Plumbing Industry Commission & Australian Standard HB263-2004 Heated Water Systems Page 17 Page 23 Page 24 Page 25 Page 26 Page 27 Page 28 Shows domestic hot water systems with circulating pumps mounted in the return service.

The Handbook of the Australian Institute of Refrigeration Air Conditioning and Heating Section 5 Pipe Systems Page 5.2 Fig 3 a 3b 3c & 3d reviews the Location of a pump in the return, or flow line of the system

Force diagrams showing the pressure distribution in the system accompany each system design.

Since attending a lecture by a NSW Public Works Engineer in the old State office block auditorium in the mid-1960s .The essence of the lecture was to convince the audience of services engineers to pump circulate domestic hot water service systems by means of a pump in the flow main with a parallel by pass check valve for draw off .I have used this arrangement. Projects such as the Westmead Hospital and a host of others operate in this manner.

9.28 QUOTING FROM THE AIRAH HANDBOOK

" When locating the pump care must be taken to ensure that the system pressure is not sub-atmospheric especially in a system containing taps, if a tap were located where system pressures are sub atmospheric air would be sucked in.

In the 1960s the State Public Works Department insisted that domestic systems with pumped circulation should be pumped on the flow, with a pump by-pass check valve located to supply draw off loads that exceeded the pumping system pipe diameter capacity.

Westmead Hospital (And many other buildings) is serviced this way and a host of other buildings designed by the writer over 50 years.

The centrifugal pump is designed to push, the water is flung off of the edge of a high speed disc and this velocity head is doing the pushing .on the suction side of the pump, the NPSH (Net positive suction head) is very small.

Where did the preference for return pumping come from?

It probably originated when pump seals along with steam engines .incorporated seals at the piston ,or with pump seals at the moving shaft which comprised a tallow impregnated rope ,or later an asbestos rope in what was known on pumps and valves as a stuffing box ,a washer sat above the rope seal and this was compressed down onto the rope by means of a threaded joint ,the rope was compressed to prevent leakage ,it also imparted friction on the shaft and some leakage was required to prevent burning the compacted rope .

The best location for this crude seal was in the lower temperature return, the water was a little denser and the leakage rate cost less energy. The AIRAH realised some years ago that technology has moved on from stuffing box technology ,we now have precision ceramic seals ,and O rings ,the higher temperature is no longer a problem ,why not put the pump in the system where it can push ,and will always have a flooded suction and will never cavitate?

9.29 THE THERMO SIPHON

The thermo siphon used much in solar systems at roof level, dates back to the beginnings of piped heating systems, a system using natural convection currents and the density change in water that is heated, and a pump is not required.

All that is required is the heat source at the bottom of the system ,vertical distance ,the more the greater the circulation head ,and a considered pipe design that does not form heat traps.

The Sydney Building Centre HW System works this way, as did the State Office Building .It is energy free circulation system that dates back two hundred years and in the correct project is still viable, but you must understand how it works.

9.30 TABLE: -GRAVITY PRESSURE PER METRE AT (ΔT) SHOWN

Δt	ºC	55	60	65	70	75	80	85	90	95
ºC	**Kg/m³**	**985.7**	**983.2**	**980.5**	**977.7**	**974.85**	**971.8**	**968.65**	**965.3**	**965.25**
50	**988.0**	2.3	4.8	7.5	10.3	13.15	16.2	19.35	22.7	26.75
55	**985.7**	balanced	2.5	6.7	8.0	10.85	13.9	17.05	20.4	24.45
60	**983.2**		balanced	2.7	5.5	8.35	11.4	14.55	17.9	16.95
65	**980.5**			balanced	2.8	5.65	8.7	11.85	15.2	15.25
70	**977.7**				balanced	2.85	5.9	9.05	12.4	12.45
75	**974.8**					balanced	3.05	6.2	9.55	9.6
80	**971.8**						balanced	3.15	6.5	6.55
85	**968.6**							balanced	3.35	3.4
90	**965.3**									0.05

The pressures derived from the Gravity pressure per metre multiplied by the height of the building must be applied to the pipe sizing chart for the very low flows in gravity systems which is included in this book (Courtesy of Roger Gibson).

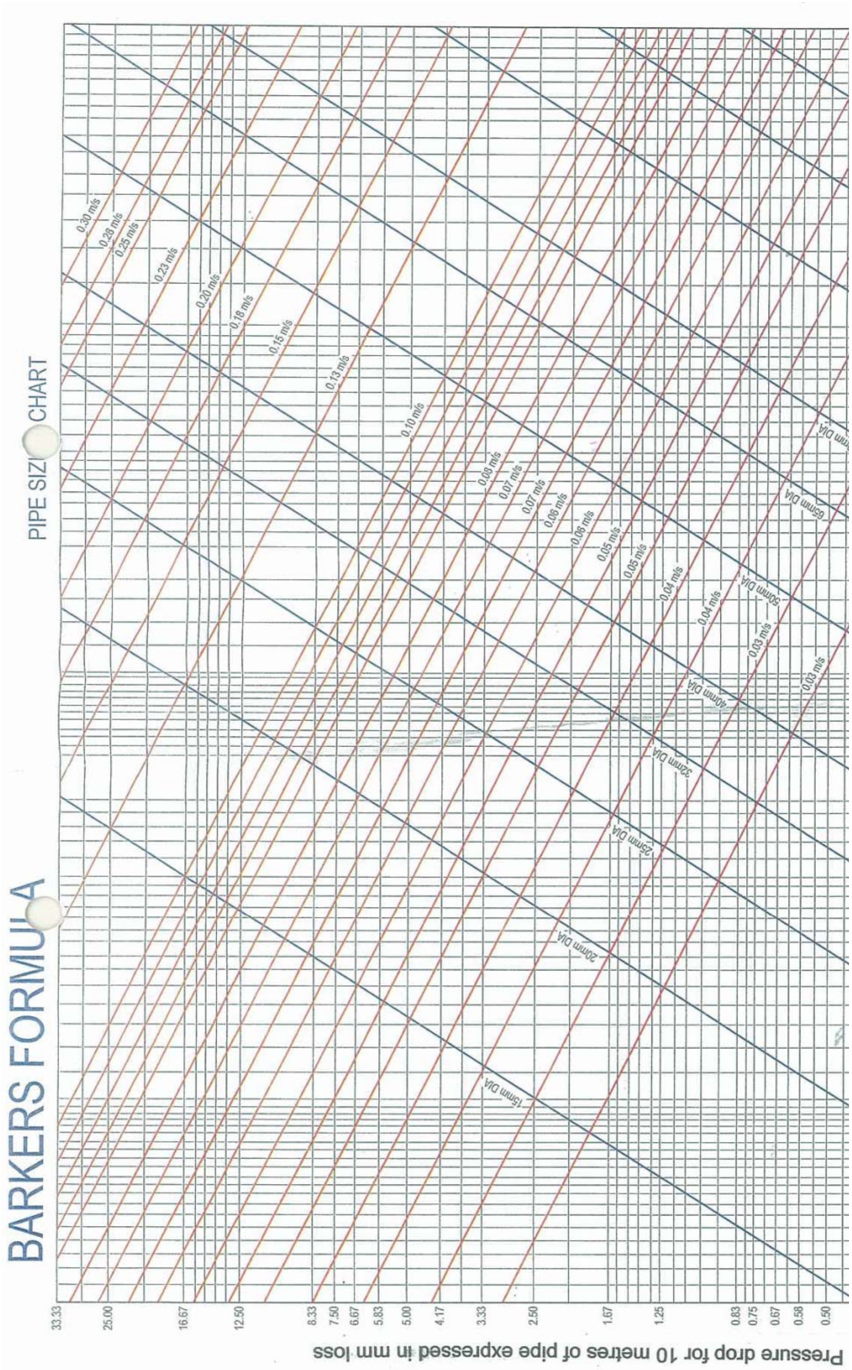
The pipe resistance is for pipe ,fitting resistance must be added as a percentage based on the designers appreciation of the systems design and complexity ,the pipe diameters will be larger than a comparable pumped system ,the sizes shown are actual bore sizes ,an allowance must be made for copper tube diameters ,and flow regulation is not required ,thermo siphon systems require full way valves ,and pipes that rise and that do not form heat traps.

Flow of Water in Copper Pipes (AS1432) @ 10 C

Press Drop	10mm			15mm			20mm			25mm			32mm			40mm			50mm			65mm			80mm			100mm		
	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL
Pa/m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m
42	0.006	0.09	0.1	0.017	0.14	0.2	0.054	0.19	0.4	0.119	0.24	0.7	0.221	0.28	0.9	0.363	0.32	1.2	0.795	0.39	1.8	1.456	0.46	2.5	2.383	0.52	3.2	5.171	0.64	4.8
44	0.007	0.10	0.1	0.018	0.14	0.2	0.055	0.19	0.4	0.123	0.24	0.7	0.227	0.29	0.9	0.373	0.33	1.2	0.816	0.40	1.8	1.495	0.47	2.5	2.446	0.54	3.3	5.308	0.65	4.9
46	0.007	0.10	0.1	0.018	0.14	0.2	0.057	0.20	0.4	0.126	0.25	0.7	0.233	0.29	0.9	0.383	0.34	1.2	0.837	0.41	1.9	1.533	0.48	2.5	2.509	0.55	3.3	5.443	0.67	4.9
48	0.007	0.10	0.1	0.019	0.15	0.2	0.058	0.20	0.4	0.129	0.25	0.7	0.238	0.30	0.9	0.392	0.34	1.2	0.858	0.42	1.9	1.571	0.50	2.6	2.570	0.56	3.3	5.574	0.69	4.9
50	0.008	0.11	0.1	0.019	0.15	0.2	0.060	0.21	0.4	0.132	0.26	0.7	0.244	0.31	0.9	0.402	0.35	1.2	0.878	0.43	1.9	1.607	0.51	2.6	2.630	0.58	3.3	5.704	0.70	4.9
55	0.008	0.12	0.1	0.020	0.16	0.2	0.063	0.22	0.4	0.140	0.28	0.7	0.258	0.33	1.0	0.424	0.37	1.3	0.927	0.46	1.9	1.697	0.54	2.6	2.775	0.61	3.4	6.017	0.74	5.0
60	0.009	0.13	0.2	0.022	0.17	0.2	0.067	0.23	0.5	0.147	0.29	0.7	0.271	0.34	1.0	0.446	0.39	1.3	0.974	0.48	1.9	1.782	0.56	2.6	2.915	0.64	3.4	6.318	0.78	5.1
70	0.011	0.15	0.2	0.024	0.19	0.2	0.073	0.26	0.5	0.161	0.32	0.7	0.297	0.37	1.0	0.487	0.43	1.3	1.064	0.52	2.0	1.945	0.61	2.7	3.180	0.70	3.5	6.888	0.85	5.2
80	0.012	0.17	0.2	0.026	0.20	0.3	0.079	0.28	0.5	0.174	0.34	0.7	0.320	0.40	1.0	0.526	0.46	1.3	1.148	0.57	2.0	2.098	0.66	2.7	3.428	0.75	3.5	7.423	0.92	5.2
90	0.014	0.20	0.2	0.027	0.22	0.3	0.084	0.30	0.5	0.186	0.37	0.7	0.343	0.43	1.0	0.563	0.49	1.4	1.227	0.61	2.0	2.242	0.71	2.8	3.663	0.80	3.6	7.928	0.98	5.3
100	0.015	0.22	0.2	0.029	0.23	0.3	0.090	0.32	0.5	0.198	0.39	0.8	0.364	0.46	1.1	0.598	0.52	1.4	1.303	0.64	2.1	2.379	0.75	2.8	3.886	0.85	3.6	8.409	1.04	5.4
120	0.019	0.26	0.2	0.033	0.26	0.3	0.100	0.35	0.5	0.220	0.43	0.8	0.404	0.51	1.1	0.663	0.58	1.4	1.445	0.71	2.1	2.637	0.83	2.9	4.305	0.94	3.7	9.310	1.15	5.5
140	0.022	0.30	0.2	0.036	0.28	0.3	0.109	0.38	0.5	0.240	0.47	0.8	0.442	0.56	1.1	0.724	0.64	1.4	1.576	0.78	2.2	2.876	0.91	2.9	4.694	1.03	3.8	10.146	1.25	5.6
160	0.025	0.35	0.2	0.039	0.30	0.3	0.118	0.41	0.5	0.259	0.51	0.8	0.477	0.60	1.1	0.781	0.69	1.5	1.700	0.84	2.2	3.100	0.98	3.0	5.059	1.11	3.8	10.929	1.35	5.7
180	0.028	0.39	0.2	0.041	0.33	0.3	0.126	0.44	0.5	0.278	0.55	0.8	0.510	0.64	1.2	0.835	0.73	1.5	1.817	0.90	2.2	3.313	1.05	3.0	5.404	1.18	3.9	11.670	1.44	5.8
200	0.020	0.28	0.2	0.044	0.35	0.3	0.134	0.47	0.6	0.295	0.58	0.8	0.542	0.68	1.2	0.887	0.78	1.5	1.928	0.95	2.3	3.514	1.11	3.1	5.732	1.26	3.9	12.374	1.53	5.8
220	0.021	0.29	0.2	0.047	0.37	0.3	0.142	0.50	0.6	0.312	0.61	0.9	0.572	0.72	1.2	0.936	0.82	1.5	2.035	1.00	2.3	3.707	1.17	3.1	6.045	1.33	4.0	13.047	1.61	5.9
240	0.022	0.31	0.2	0.049	0.39	0.3	0.149	0.52	0.6	0.327	0.65	0.9	0.601	0.76	1.2	0.984	0.86	1.5	2.137	1.05	2.3	3.893	1.23	3.1	6.346	1.39	4.0	13.693	1.69	5.9
260	0.023	0.32	0.2	0.051	0.41	0.3	0.156	0.55	0.6	0.343	0.68	0.9	0.629	0.79	1.2	1.029	0.90	1.6	2.235	1.10	2.3	4.071	1.29	3.2	6.636	1.46	4.1	14.315	1.77	6.0
280	0.024	0.34	0.2	0.054	0.42	0.3	0.163	0.57	0.6	0.358	0.71	0.9	0.656	0.83	1.2	1.073	0.94	1.6	2.331	1.15	2.4	4.244	1.34	3.2	6.916	1.52	4.1	14.916	1.84	6.0
300	0.025	0.35	0.2	0.056	0.44	0.3	0.170	0.60	0.6	0.372	0.73	0.9	0.682	0.86	1.2	1.116	0.98	1.6	2.423	1.20	2.4	4.411	1.39	3.2	7.187	1.58	4.1	15.498	1.91	6.1
350	0.028	0.39	0.2	0.061	0.48	0.3	0.186	0.65	0.6	0.406	0.80	0.9	0.745	0.94	1.3	1.218	1.07	1.6	2.642	1.30	2.4	4.808	1.52	3.3	7.832	1.72	4.2	16.880	2.08	6.2
400	0.030	0.42	0.2	0.066	0.52	0.3	0.201	0.70	0.6	0.439	0.87	0.9	0.803	1.01	1.3	1.313	1.15	1.7	2.847	1.40	2.5	5.180	1.64	3.3	8.436	1.85	4.3	18.175	2.24	6.3
450	0.032	0.45	0.2	0.071	0.56	0.3	0.215	0.75	0.6	0.469	0.93	1.0	0.859	1.08	1.3	1.403	1.23	1.7	3.042	1.50	2.5	5.532	1.75	3.4	9.007	1.98	4.3	19.399	2.39	6.4
500	0.034	0.48	0.2	0.075	0.59	0.4	0.228	0.80	0.6	0.498	0.98	1.0	0.912	1.15	1.3	1.489	1.31	1.7	3.227	1.59	2.5	5.867	1.85	3.4	9.550	2.09	4.4	20.562	2.54	6.4
550	0.036	0.51	0.2	0.079	0.63	0.4	0.241	0.84	0.6	0.526	1.04	1.0	0.962	1.21	1.3	1.571	1.38	1.7	3.403	1.68	2.6	6.187	1.95	3.5	10.069	2.21	4.4	21.673	2.67	6.5
600	0.038	0.53	0.2	0.084	0.66	0.4	0.253	0.89	0.7	0.552	1.09	1.0	1.010	1.28	1.4	1.650	1.45	1.7	3.573	1.76	2.6	6.494	2.05	3.5	10.567	2.32	4.5	22.740	2.80	6.6
650	0.040	0.56	0.2	0.088	0.69	0.4	0.265	0.93	0.7	0.578	1.14	1.0	1.057	1.33	1.4	1.726	1.51	1.8	3.737	1.84	2.6	6.789	2.14	3.5	11.047	2.42	4.5	23.766	2.93	6.6
700	0.041	0.58	0.2	0.091	0.72	0.4	0.276	0.97	0.7	0.603	1.19	1.0	1.102	1.39	1.4	1.799	1.58	1.8	3.895	1.92	2.6	7.075	2.23	3.6	11.510	[illegible]	4.5	[illegible]	[illegible]	[illegible]

Flow of Water in Copper Pipes (AS1432) @ 75 C

Press	10mm			15mm			20mm			25mm			32mm			40mm			50mm			65mm			80mm			100mm		
Drop	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL	Flow	Vel	EL
Pa/m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m	L/s	m/s	m
42	0.010	0.14	0.2	0.022	0.17	0.4	0.067	0.23	0.6	0.146	0.29	1.0	0.267	0.34	1.3	0.436	0.38	1.7	0.946	0.47	2.5	1.720	0.54	3.4	2.799	0.61	4.4	6.028	0.74	6.4
44	0.010	0.14	0.2	0.023	0.18	0.4	0.069	0.24	0.6	0.150	0.30	1.0	0.274	0.35	1.3	0.448	0.39	1.7	0.971	0.48	2.5	1.765	0.56	3.4	2.873	0.63	4.4	6.185	0.76	6.4
46	0.011	0.15	0.2	0.023	0.18	0.4	0.070	0.25	0.6	0.154	0.30	1.0	0.281	0.36	1.3	0.459	0.40	1.7	0.995	0.49	2.6	1.809	0.57	3.5	2.945	0.65	4.4	6.338	0.78	6.5
48	0.011	0.15	0.2	0.024	0.19	0.4	0.072	0.25	0.6	0.157	0.31	1.0	0.288	0.36	1.3	0.471	0.41	1.7	1.019	0.50	2.6	1.852	0.58	3.5	3.015	0.66	4.4	6.489	0.80	6.5
50	0.011	0.15	0.2	0.024	0.19	0.4	0.074	0.26	0.7	0.161	0.32	1.0	0.295	0.37	1.3	0.481	0.42	1.7	1.043	0.51	2.6	1.895	0.60	3.5	3.084	0.68	4.5	6.637	0.82	6.5
55	0.012	0.16	0.2	0.026	0.20	0.4	0.078	0.27	0.7	0.170	0.34	1.0	0.311	0.39	1.4	0.508	0.45	1.8	1.100	0.54	2.6	1.998	0.63	3.5	3.251	0.71	4.5	6.995	0.86	6.6
60	0.012	0.17	0.2	0.027	0.21	0.4	0.082	0.29	0.7	0.179	0.35	1.0	0.327	0.41	1.4	0.533	0.47	1.8	1.155	0.57	2.6	2.097	0.66	3.6	3.412	0.75	4.5	7.339	0.91	6.7
70	0.013	0.19	0.2	0.030	0.23	0.4	0.089	0.31	0.7	0.195	0.38	1.0	0.356	0.45	1.4	0.582	0.51	1.8	1.258	0.62	2.7	2.285	0.72	3.6	3.716	0.81	4.6	7.990	0.99	6.8
80	0.015	0.20	0.3	0.032	0.25	0.4	0.097	0.34	0.7	0.210	0.42	1.0	0.384	0.49	1.4	0.627	0.55	1.8	1.355	0.67	2.7	2.461	0.78	3.7	4.001	0.88	4.7	8.599	1.06	6.9
90	0.016	0.22	0.3	0.034	0.27	0.4	0.103	0.36	0.7	0.225	0.44	1.1	0.411	0.52	1.5	0.670	0.59	1.9	1.447	0.71	2.8	2.627	0.83	3.7	4.270	0.94	4.7	9.175	1.13	6.9
100	0.017	0.23	0.3	0.036	0.29	0.4	0.110	0.38	0.7	0.239	0.47	1.1	0.436	0.55	1.5	0.710	0.62	1.9	1.535	0.76	2.8	2.785	0.88	3.8	4.526	0.99	4.8	9.722	1.20	7.0
120	0.018	0.26	0.3	0.040	0.32	0.4	0.122	0.43	0.7	0.265	0.52	1.1	0.483	0.61	1.5	0.787	0.69	1.9	1.698	0.84	2.9	3.080	0.97	3.8	5.005	1.10	4.9	10.745	1.33	7.1
140	0.020	0.28	0.3	0.044	0.35	0.4	0.133	0.47	0.8	0.288	0.57	1.1	0.526	0.66	1.5	0.857	0.75	2.0	1.850	0.91	2.9	3.354	1.06	3.9	5.448	1.19	5.0	11.693	1.44	7.2
160	0.022	0.30	0.3	0.048	0.38	0.4	0.143	0.50	0.8	0.311	0.61	1.1	0.567	0.72	1.6	0.923	0.81	2.0	1.992	0.98	2.9	3.611	1.14	4.0	5.864	1.29	5.0	12.580	1.55	7.3
180	0.023	0.33	0.3	0.051	0.40	0.4	0.153	0.54	0.8	0.332	0.66	1.2	0.606	0.76	1.6	0.986	0.86	2.0	2.127	1.05	3.0	3.853	1.22	4.0	6.256	1.37	5.1	13.418	1.65	7.4
200	0.025	0.35	0.3	0.054	0.43	0.4	0.162	0.57	0.8	0.353	0.70	1.2	0.642	0.81	1.6	1.046	0.92	2.0	2.254	1.11	3.0	4.084	1.29	4.1	6.629	1.45	5.1	14.213	1.75	7.5
220	0.026	0.37	0.3	0.057	0.45	0.5	0.171	0.60	0.8	0.372	0.73	1.2	0.677	0.86	1.6	1.103	0.97	2.1	2.376	1.17	3.0	4.304	1.36	4.1	6.985	1.53	5.2	14.973	1.85	7.6
240	0.027	0.39	0.3	0.060	0.47	0.5	0.180	0.63	0.8	0.390	0.77	1.2	0.711	0.90	1.6	1.157	1.01	2.1	2.493	1.23	3.1	4.515	1.43	4.1	7.327	1.61	5.2	15.702	1.94	7.6
260	0.029	0.40	0.3	0.063	0.50	0.5	0.188	0.66	0.8	0.408	0.81	1.2	0.743	0.94	1.7	1.210	1.06	2.1	2.606	1.29	3.1	4.718	1.49	4.2	7.655	1.68	5.3	16.403	2.02	7.7
280	0.030	0.42	0.3	0.066	0.52	0.5	0.196	0.69	0.8	0.426	0.84	1.2	0.775	0.98	1.7	1.261	1.11	2.1	2.715	1.34	3.1	4.914	1.55	4.2	7.973	1.75	5.3	17.079	2.11	7.7
300	0.031	0.44	0.3	0.068	0.54	0.5	0.204	0.72	0.8	0.442	0.87	1.2	0.805	1.02	1.7	1.310	1.15	2.1	2.820	1.39	3.1	5.104	1.61	4.2	8.280	1.82	5.4	17.734	2.19	7.8
350	0.034	0.48	0.3	0.074	0.59	0.5	0.223	0.78	0.8	0.482	0.95	1.3	0.877	1.11	1.7	1.426	1.25	2.2	3.070	1.51	3.2	5.555	1.75	4.3	9.008	1.98	5.4	19.287	2.38	7.9
400	0.037	0.52	0.3	0.080	0.63	0.5	0.240	0.84	0.9	0.520	1.03	1.3	0.945	1.19	1.7	1.536	1.35	2.2	3.304	1.63	3.2	5.977	1.89	4.3	9.690	2.12	5.5	20.740	2.56	8.0
450	0.039	0.55	0.3	0.086	0.68	0.5	0.256	0.90	0.9	0.555	1.09	1.3	1.009	1.27	1.8	1.639	1.44	2.2	3.525	1.74	3.3	6.375	2.01	4.4	10.334	2.27	5.6	22.112	2.73	8.1
500	0.042	0.59	0.3	0.091	0.72	0.5	0.272	0.95	0.9	0.588	1.16	1.3	1.069	1.35	1.8	1.737	1.52	2.3	3.735	1.84	3.3	6.753	2.13	4.4	10.945	2.40	5.6	23.413	2.89	8.1
550	0.044	0.62	0.3	0.096	0.76	0.5	0.287	1.01	0.9	0.620	1.22	1.3	1.127	1.42	1.8	1.831	1.61	2.3	3.936	1.94	3.3	7.114	2.25	4.5	11.529	2.53	5.7	24.656	3.04	8.2
600	0.046	0.65	0.3	0.101	0.80	0.5	0.301	1.06	0.9	0.651	1.28	1.3	1.183	1.49	1.8	1.921	1.69	2.3	4.128	2.04	3.4	7.461	2.36	4.5	12.089	2.65	5.7	25.847	3.19	8.3
650	0.048	0.68	0.3	0.106	0.83	0.5	0.315	1.10	0.9	0.681	1.34	1.4	1.236	1.56	1.8	2.008	1.76	2.3	4.313	2.13	3.4	7.794	2.46	4.5	12.627	2.77	5.7	26.993	3.33	8.3
700	0.051	0.71	0.4	0.110	0.87	0.5	0.328	1.15	0.9	0.709	1.40	1.4	1.288	1.63	1.8	2.092	1.83	2.3	4.492	2.22	3.4	8.116	2.56	4.6	13.146	2.88	5.8	28.098	3.47	8.4



9.31 PRESSURE AND FLOW

The maximum pressure recommendations in AS3500 is 500.kPa ,the practical minimum pressure for a modern hospital is 250 kPa ,with a 3,5 metre floor to floor height the practical number of floors that can be served from a storage tank system and with an arrangement that pump boosts from the tank down the first seven (7) floors. The floors in this building from level seven down to one being limited to the recommended maximum 500 kPa at level 1.

Any additional levels from seven down to fourteen will start at 49.5 metres or 500 kPa approximate static head from the tank, then the designer starts thinking about a separate static head service from the tank, or a pressure reduction arrangement for the floors more than 7 levels below the storage tank.

In Australia the tendency to build major hospitals much higher than 25 metres 7 or 8 floors is low, possibly because of land availability, fire regulations, or cost effective design?

The question of pressure reduction to below 500 kPa is seldom an issue.

In high rise Health Care projects pressure reduction will be a consideration. However bearing in mind that flow rates are now limited by flow control valves, and the right flow control valve will regulate irrespective of pressure .What is the point of pressure regulation?

9.32 WHY DO WE NEED TO PRESSURE REDUCE?

The 500 kPa recommended upper limit was not a feature of hydraulics design until the 1970s, prior to that date it was practical to service 20 levels, or higher rise building without compliance to this recommendation, and unlimited pressure distribution buildings are still operational.

EG Attorney General's Office Chiefly Square Sydney.

There are boosted water areas in the Sydney metropolitan area northern suburbs with 1000 kPa+ water pressures that operate satisfactorily solely with fitting flow control , it is important to select a flow control that is not totally reliant on flow restriction ,the flow regulation device that uses the Australian invented principle of interposing jets and proportional kinetic energy dissipation (Jemflow) is not reliant on friction loss from restriction and will give an acceptable ,and practical flow at just about any pressure because the flow rate is by design controlled relative to the pressure.

Most common practice is to utilise a Pressure Limiting device at high pressure branches, this limits the effective distribution of branch HW flow and return pipes, both pressure limit valves and small pressure reduction valves can suffer at low flows from the minute seat clearances and extreme velocities (With sound effects) across the small valve seat area creating high pitched noise, and wire drawing.

The other option is a PRV station and HW return reheat by a small plate heat exchange with circulation pump from one zone to the next zone, a four port Bermad valve with corrosion resistant wetted area coating, or nonferrous construction, the arrangement is however complex, heat emitting, space consuming design provided only to satisfy a doubtful recommendation by an Australian Standard that has not differentiated between static head, and flow pressure.

The question is: -If system will operate efficiently at high pressure with the right flow control, why are we complicating matters with this arbitrary 500 kPa static head limit in high rise buildings which is adding cost, the limit for pressure should be relative to the suitable working pressure of the pipe material, with due consideration of spike pressures as may be generated by hydraulic shock.

9.33 BALANCING DOMESTIC HOT WATER SYSTEMS

Most of the domestic hot water service failures that it has been the authors task to inspect and report on have been the result of inadequate circulation and the application of a quick fix remedy by turning up the boiler thermostat .or a total disregard in the design for the expansion and contraction movement that must be catered for with movement potential and cold stressing to minimise the movement range.

The reader should be fully conversant with the formula for determining the amount of water to be circulated.

$\underline{kW}$ = L/s Flow circulation to replace heat lost

4.186 kg/kj x C°Δt (Flow and return)

Where the kW calculated thermal emission from the pipe work through the piping system and associated plant.(For branch returns this may be a very small FLOW, MAKE sure it is large enough TO BE regulated within the flow range of the valve)

4.186 kj/kg is the amount of heat required to raise one kilogram/litre one degree Centigrade

t/d, or (Δt) Is the temperature difference between the flow and the return pipe service water temperature ,for a hot water system this will be 5 degrees C for a warm water system 1.5 degrees Centigrade

9. 33.1AS AN EXAMPLE

A Polypropylene hot water service ring main system is to be installed in a nurse's home for a 100 bed hospital.

The Nurses home will accommodate 250 nurses working on an 8 hour three shift roster.

The peak demand is estimated to be a shift change shower load where 83 nurses come off duty and are replaced by 83 nurses going on duty, the probability is estimated as being 75% will shower prior to going on duty 50% will shower when they leave duty, the shift change will take 30 minutes

The calculated maximum load is

75% of 83 users maximum = 62.25 showers

50% of load in each leg of the ring main = 31 .25 showers largest flow in pipes

Shower flow rate 12l/min 50% 15ºC 50% 65º = 6 l/min

Average shower period 8 minutes

Hot water consumed 8 min x 6 l/m x 31.25 showers = 1500 litres

Flow rate from heat source 62.25 x 6 l/m x showers = 373.5 l/m or 6.225 l/s in ring main

The shipping system ring main allows flow in both directions thus the hot service must cater for 6.225 l/sec in a 75 mm SDR7.4 Faser composite main which will operate on draw off between 2.24 m/sec velocity, and a maximum 7.24m/bar/m loss the maximum at 3 m/s at 7l/s.

This notional nurses home building is two levels and square on plan with an internal courtyard and access balcony, each side of the building has 32 en-suite rooms at each level and a plant room interfacing an adjoining building .Each room is 3 metres wide and 4 metres long, the ring main is 384 metres long with an additional 20 metres used for plant room services.

9.33.2 THERMAL LOSS

The hospital is served from a central thermal station. 15ºC ambient 65ºC Hot water flow 60°C Return

75 mm pipe 54.4ID SDR 7.4 Heat loss 70.27 kj/h/m x (384+20) =28389=7.8kW/hour

Using kW 7.8kW =0.372 l/s circulation

4.186 kg/kJ x t/d

This is a very low heat loss flow rate system (0.372l/s) a 25 mm (18mmID) pipe will carry the heat replacement load ,if for instance there were 10 branch secondary returns each with a globe valve the flow rate would be

0.0372 l/s a flow rate that for practical purposes is not manageable with a 15 mm valve ,in this type of situation the temperature difference must be lowered and the flow rate increased to an amount that can be determined by valve manipulation , or by using a TA Therm or similar type of thermostatic valve ,these also require a minimum flow for operational purposes.

9.33.3 EXPANSION CONTRACTION AND COLD STRESSING

The means of dealing with thermal movement in a copper system is shown in AS/NZS3500 and the AIRAH Handbook, the system and the methods of absorbing polypropylene pipe stress and expansion movement is provided in the “Aquatherm” installation Principles manual.

The long leg of the 75 mm domestic hot water ring main in an example project is going to be say 100 metres long and it will be subjected to a maximum temperature range of 15ºC cold water ambient to an upper temperature of 65ºC a Δt °C of 50 degrees, the coefficient of linear expansion for Fusiothermstabi composite pipe is 0.03 mm/mk (polypropylene Faser pipe is less).

The expansion will be 100m x 50ºΔx 0.03 mm/m = 150 mm.

Assume two expansion loops giving 33 metres between 50 mm of movement from cold to 65º

The calculation is to determine the L.s or long side of the expansion loop.

Ls = K x √d x (Expansion)

Ls = K x √ 75 x 50

Ls = 15 x 61.23

Ls = 918.55 mm long

Where

Ls = the long leg’

K = A constant for the material selected.

D = the pipe OD

The re-occurring problem that the writer has observed with expansion loops, is the installer’s lack of experience with anchorage fixings (How anchorage can be achieved by clamping a soft material is hard to comprehend?) and cold stressing , the lack of understanding stress and tension in the pipe system, is probably because in Australia Plumbers do little, if any? Heating work.

It is a problem believed to be compounded by the explanation given in the plastic pipe manufacturer’s instructions for the materials use, this implies preference for stress and not tension, in the system, this often results in the poor appearance of pipes that are under stress and inclined to flex at any opportunity, it is not a good look and is inconsistent with good trade skill.

In practice when a plastic pipe is installed the material will be at the ambient air temperature of the local environment.

When the pipe is installed the L.s legs of the expansion loop **should be pulled apart** by (Cold draw) by the amount of the calculated movement ,thus the connecting pipe is in cold draw “tension “ When it expands, the Ls leg will move together to the vertical leg neutral point ,this procedure will help to ensure straight pipe lines

,rather than the expansion movement taking advantage of any flexibility it can find in the system ,which will inevitably result in very poor pipe geometry , and bends impacting on building fabric where insufficient clearance is available .

9.34 TRAPS FOR YOUNG PLAYERS

When pipe sizing a large project the designer must consider the probable demand, or the diversity, this being the difference between the maximum possible demand, and the expected probable demand, it is critical to the performance of the system, too little load is an extravagance and, too much load will impact on pressure drop and may destabilize the pressure balance between hot and cold services and the temperature mixing of hot and cold water.

The writers experience is that, for other than the obvious high use fixture groups, the diversity or probable demand for mixed systems that is based on a residential demand can be generous, when compared with measured flow rates in health care and commercial projects.

There is a margin of error available that relates to the velocity of flow, whilst 1.5 metres a second may be the desirable acoustic velocity in plastic pipe , is noise going to be a concern for a few fleeting seconds? .If the system has the viable pressure to function, and pressure parity is maintained within limits, under these conditions consideration of utilising the 50% safety net of a higher velocity should not be discredited in polymer systems, or confused with erosion corrosion problems in copper tube pumped circuits.

An understanding of how the building is to be used, the “Moduse Operandi” is important to minimise the possibility of oversized or undersized pipe work.

The traps for young players are the non-standard departures from recommended probable demand given in standards; the fine print is not always read.

Showers which have a long running time are more probable to coincide in there use profile, where there are groups of showers for staff, assume a 100% load, the Architect would not have provided them had he not believed that they would all be used, possibly at a shift change, or subsequent to a particularly long operating room session. Surgeons Scrub ups will be used 100% and over a pre-determined minimum time frame.

Kitchens can be a high peak contributor, the peak may well be in the middle of the night, and after meals when the cleanup takes place. Check the program of the meals preparation and cleanup operations.

TMVs like to work hard, it is a mistake to oversize them .The problems arise at very low flows, the valve that is designed for a high flow has trouble regulating down to a very small flow because the valve seat openings become minute clearances, water velocity over such clearances can be a velocity problem in both TMVs and as significant noise in PRVs or PLVs.

Balancing large hot water systems with many return flow regulation valves can be a problem if the heat loss is low and when sub divided over all of the return valves the flow adjustments required are too small to be manageable.

Because thermal loss can be satisfied by quiet low flows, ensure that there is sufficient flow to satisfy each regulating valve at 50% open capacity, this will probably result in pumping more hot water circulation than is required to replace thermal loss ,however this will only mean a lower Δt

Be wary of the very big hot water reticulation system (150mm) ,check the circulation head required at 15º C water density ,it may exceed the pump head for the system at 60ºC Strategic drain points to motivate hot water flow can overcome this infrequent start up problem.

When the mechanical engineer is providing the primary heat from the comfort heating system, the hydraulics designer must be aware that the comfort heating system is probably designed for maximum efficiency at air heating coils, this means temperatures of 75ºC +, coordination of the thermal control to Domestic systems is very important.

A high limit 70º C shut down is recommended in the secondary system to avoid malfunction damaging expansion provisions, and the breakdown of polymer materials, by overheating.

Rising mains may be part of a mains pressurised system or a storage tank feed, the pipe will in some instances be conveying the total domestic hot and cold water load into the building, it will be large diameter AS1432 Type B copper tube in larger diameters 65-90-100-125-150-200 has safe working pressures that are lower than the test pressures required by table C1 Appendix C AS4809-2003 .Bear in mind that copper tube with annealed joints has been softened.

Cooling Towers are a large consumer of water, the evaporative lose being greater in hot dry weather conditions.

Other activities that can impose unusual high peak loads on water demand are de-contamination areas, changing facilities for playing fields that may be part of the hospital campus.

The Commercial Building Sector of Sydney has approximately 6500 cooling towers registered. Current best practice in Sydney indicates a consumption of 0.8 (kl) per square metre per year, this is 22kl/dayfor a 10,000 m^2 office.

It should be noted the Commercial areas such as offices and Health Care logistic support areas have a significant return air component to reduce energy costs.

Biologically critical areas of the Hospital may not have return air; there may be an air heating cooling run around coil system to separate air borne bacteria?

The volume of water used in Health Care Cooling Towers is a question for the Mechanical Services Engineer.

Make up water to a cooling tower replaces condenser water lost from

88 % Evaporation

5% Bleed to reduce salts

7% Drift and Splash

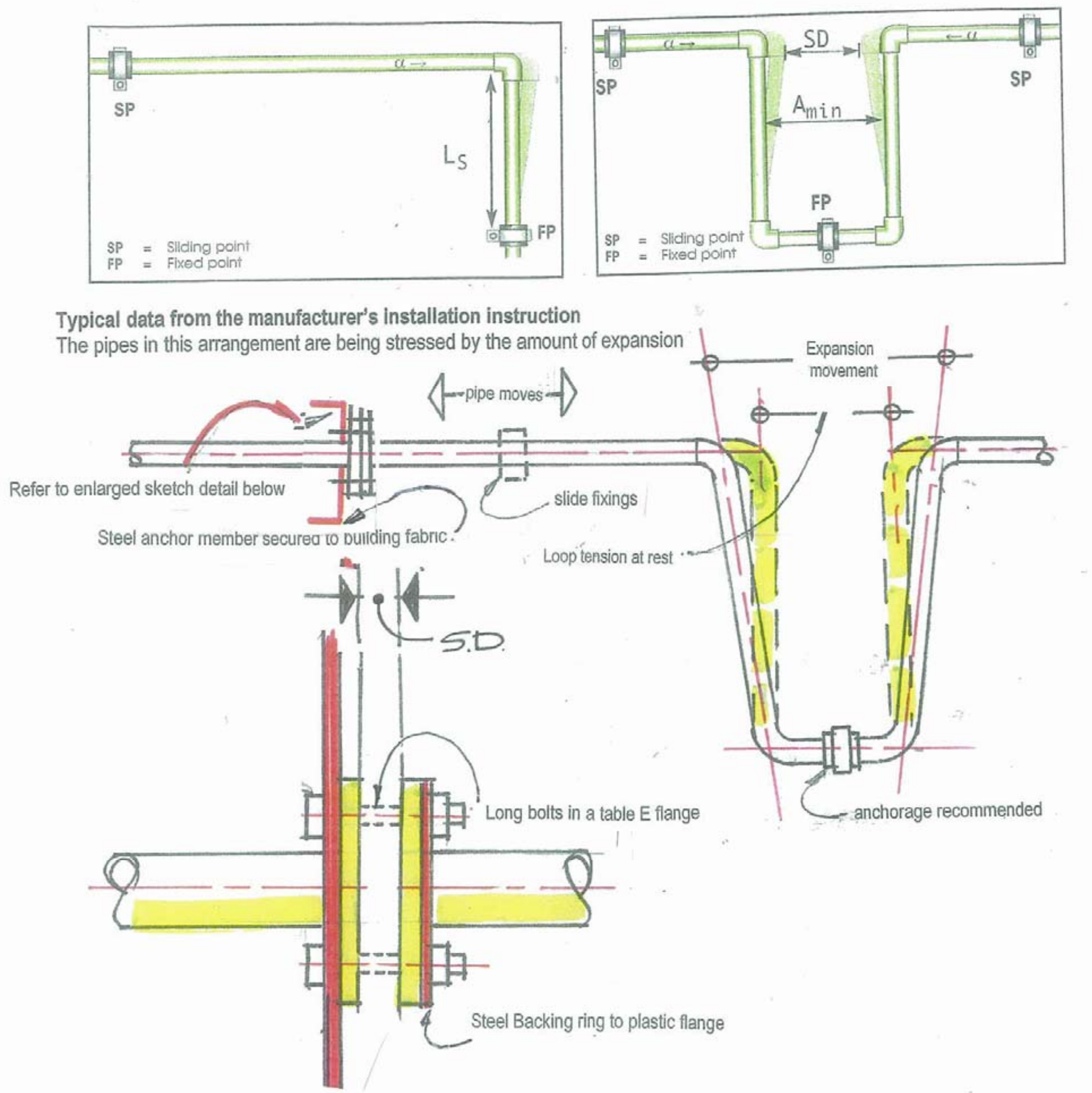
Fire Collars required to prevent the transmission of fire at plastic services pipes as determines by AS1851.

Reference should be made to Clause 17.4.9.2 and the Table of the same reference number .Inspection, Test, Preventative maintenance, Survey and records Schedule –Fire Stopping Hydraulic Services Penetrations.

The schedule requires 6 monthly and yearly label checks in accordance with Clause 17.2.4.2 also fire test evidence to AS1530.4 and compliance with AS4072.1 in respect to FRI. The practicality of undertaking this type of inspection effectively in a crowded false ceiling space is considered doubtful, and casts some doubt on the authors understanding of modern buildings and the economics of maintaining them.

As a Consultant it is considered prudent to exclude such inspections and compliance audits from the scope of the commission. (Refer Scope Creep)

Expansion and contraction in Polypropylene pipes



This distance is SD or the calculated expansion, when the flange bolts are tightened the system is cold drawn or Cold Stressed and when the material is heated it is in tension, the pipe will move towards the stressed expansion loop legs until the reach a neutral position, a system in tension is much preferred to a system in stress, controlling stress movement in pipes runs is not a practical proposition and in the writers opinion it should not be recommended. Anchors that rely on a clamping action and friction between the clamp ring and the pipe wall is also considered a doubtful means of ensuring anchorage without stressing the pipe wall at the fixing point , similar cold stressing principles are preferred to absorb expansion growth at all other points in the pipe system

9.35 THERMOSTATIC MIXING VALVES

Thermostatic valves were introduced as mandatory to the Australian
Health Care scene in the 1980 .they were not mandatory at the time of Westmead Hospital construction in 1973.

The thermostatic mixer valve used in hospitals in NSW must be Health approved and listed as such.

The thermostatic mixer valve differs significantly from the Mechanical mixer valve and the Tempering valve, both of which are not recommended for use in Health Care.

The thermostatic mixer valve has an internal thermally activated motor element, historically these were first manufactured as a bimetallic helix (Rada -Leonard -Walker Crossweller), and this type of valve also incorporated a failsafe mechanism to protect the user in the event of a cold water supply failure to the valve mixing chamber.

Most current approved TMVs are operated by a bees wax filled capsule, the capsule for most brands is manufactured by a French company, and two manufacturers manufacture their own capsule.

The **fail safe feature** (A term to be used with care) is incorporated in most TMV valves. It is not a feature of Mechanical mixers or Tempering valves which are not recommended for use in Health Care applications.

In the history of Health Care and TMV there have been a number of patient scalding fatalities.

HOT WATER BURNS LIKE FIRE

Move to cut grim toll

EACH year, 600 NSW children face hospital admission as a result of scalding, a figure that can be significantly reduced by simple precautions.

Australia-wide, burns and scalds are a major health issue for children, with 6,000 a year going to hospitals at the rate of 16 a day, 1,800 being admitted and 20 to 25 youngsters dying every year.

They are the third leading cause of hospital bed days due to injury in children aged up to 15 years.

Dr Brian Pezzutti, Parliamentary Secretary to the Health Minister, said that each year 150 children suffered hot tap scalds in the State.

"Most of the severe scalds are caused by domestic tap water and simple precautions would prevent most of these injuries," he said.

The NSW Health Department has launched a campaign, *Hot Water Burns Like Fire*, to get parents to lower household water temperatures to reduce the incidence of scalds by at least a third over the next 10 years.

Most houses carry hot water temperatures between 65C and 70C but the Department recommends a safer bathroom temperature of about 50C.

Ian Scott, manager of research and policy for the Child Accident Prevention Foundation (Kidsafe), said scalds occurred because most systems delivered hot water at dangerously high temperatures.

"Water at 60C will scald a child in one second, " he said.

"While water at 50C is still too hot to immerse your hand in tap water, this temperature increases the margin of safety to around five minutes.

"This simple change will save childrens lives and prevent injury."

Mr Talbot said hospitals estimated the cost of a serious child scald is from $60,000 to $100,000.

International experience had demonstrated the value of controlled water temperature and half of the States in America had legislation requiring new hot water systems to be pre-set to 49C.

"A Washington State study showed that scald admissions had nearly halved after five years of regulation and that total body area burned, scald deaths, grafting, scarring and time in hospital had all fallen," he said.

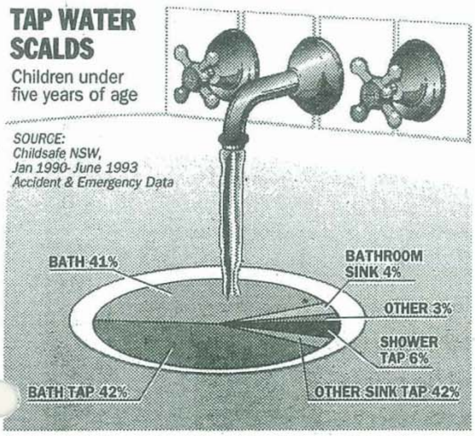
Similar regulation is one of the prongs of the campaign by the Health Department and already Ku-ring-gai Council leads the way by introducing such requirements in new building applications.

A range of safety options is available to all residents with gas, electric or solar hot water systems including tempering valves, thermostatic mixing valves, single lever mixing taps, child resistant safety taps and temperature controlled flow restriction devices.

Households with gas systems have the additional option of turning down their hot water temperature at the system by the adjustable thermostat.

The bathroom is the key danger area. A survey taken between January 1990 and June 1993 showed that more than 90 per cent of water burns to children aged up to five happened in the bathroom, with most of them involving the bath.

SAFETY: Brian Pezzutti.



From The Sun Herald August 21 1994

As a group of Professional Hydraulic Services Engineers, the significant question that we should have been asking was "Why" as a group did we feel it acceptable to design systems to reticulate 65° C water in buildings of all types, and why did we promote the inevitable Nanny State philosophy and not take responsibility for recommending good and safe practice in our expert field?

In the 1960,s the writer assisted Steensen Varming (Aust) Pty Ltd Mr Edward Mortenson by undertaking a peer review of the domestic hot and cold water services design drawings for the Sydney Opera house then under construction, the significant issue that was apparent to an immigrant from the UK was the lack of thermal control on the delivery of domestic hot water in the toilets to a transient population. My client being Swedish understood the problem well and the design was changed.

It is our role as a Professional Group to draw attention to poor design practice ,however unpopular it may be.

9.36 CENTRAL COAST EXPRESS ADVOCATE 25-2-2000

Joanne McCarthy reported.

The death of Jill Barker

Fatal Scalding deaths were reported In June 1998 and a prior death in 1992.

The 1998 death was due to the failure of a Rada 15BK valve which carried a recommended life span of three years and had been in operation for 7.5 years.

The unfortunate scalding deaths prompted rigorous regulations in respect to valve maintenance, valve core component replacement and installation training, the ongoing cost of regular and mandatory maintenance has to some degree, compromised the TMV as a competitive choice, particularly in PPP contracts.

TMVs are available which include an electronic monitor system that reports temperature irregularities to the BMS.

TMV units may be thermistors monitored by a Hub system which predicts uneven temperature control and possible component wear .However Evidence that proves monitoring provides sufficient pre-warning of TMV failure has not been found, as with all monitoring systems that safeguard human life, the risk is high and the weak link is the human participation.

There is a significant cost attached to this arrangement and an added burden of electronic failure and human error.

Most thermostatic mixing valves have limitations on the acceptable input hot water temperature (This is an issue to consider with a solar contribution) and the difference between the hot water service and cold water service pressure to the TMV.

The Swedish “Mattsson” valve incorporates an added pressure balance shuttle valve that negates pressure differential prior to mixing, the valve will compensate for static and dynamic pressure differences, this valve is recommended.

TMV valves in Australia where used in Health Care are often mounted in a Stainless steel box, this is not the case in Europe where the valve may be an exposed chrome plated unit mounted at high level in the shower cubical, or at low level below a basin above a floor drain, the valves have a lock shield temperature adjustment and chrome plated hex couplings for unit replacement and work shop repair of the defective valve.

The upper limits for water temperature in NSW for patient care are set by NSW Health as a Practice memorandum. As noted there is a selection of NSW Health approved TMV valves for dead leg thermostatic control ,there are also approved Central Warm Water Systems ,the cost of mandatory maintenance for TMVs has in some instances (Mount Druitt Hospital) turned the Hospital Engineers attention to the alternative of a Central warm Water systems .

9.37 CENTRAL WARM WATER SYSTEMS

The most common Central warm water systems is considered to be the two or three parallel piped large flow rate TMVs as the supply source which is constantly circulated through a UV irradiation unit as part of the system .

The UV irradiation is a 24 hour 7 days a week requirement, the system must not circulate without UV irradiation at any period, if shut down for maintenance EG Lamp change is required; the UV irradiation system must be duplicated as a duty / stand-by configuration.

The warm water return which must be cooler than the warm water 43.5 ºC upper limit also joins the TMV cold water port with the cold water, a branch warm water return is connected to the heat source and in this way the system reticulates warm water.

The permissible temperature drop through a warm water system is 1.5ºC , this very low temperature drop is essential to prevent complaints of cool water at the extremities of the system ,thus using the standard formula for circulation

<u>kW loss</u>

1.5ºc-Δt x 4.186 kjSpecific /heat = l/s circulation required

The flow rates required in warm water systems are high, particularly in a high thermal loss system of pipe work such as copper tube.

The pressure drop through the central TMV system is also high.

In warm water systems pumping the much larger water volumes to maintain small losses becomes more relevant. Should the reader be a .never to change return service pumping designer, then as a matter of good practice place a pressure gauge each side of the return pumps, the wavering that will be seen on the suction side of the pump is caused by draw off and cavitation.

9.38 A CONVERSION TO WARM WATER

The Mount Druitt Hospital warm water conversion project noted involved an existing reticulation system and long runs in an exposed to ambient weather conditions location ,the loss was approximately calculable from the performance of the original system ,this performance was served as a design criteria base for a new circulation pump system which pumped on the flow main round a draw off by-pass (Refer pumping on the flow) .The circulation pumps have Variable speed drive ,with a digital speed control sensor reading the return temperature and making speed adjustment according to the thermal loss variation in changing weather conditions. Such circulation systems should be standard for all hot and warm water systems.

The most significant disadvantage with central system TMV units is as noted, the pressure drop at maximum flow, which is high.

TMV units perform best when they work hard, overloaded is better than under loaded.

9.39 THERMISTORS AND MOTOR DRIVE TMV

The Rada Company manufactured some years ago a large 32 mm (32M) TMV that was not driven by a capsule or expanding element ,it was driven by a precision engineered low voltage encapsulated electric motor with a reversible drive to the thermal mixing valve unit ,the opening and closing of the valve for temperature adjustment being controlled by thermistors

To give precise thermal control over a range of one shower running, to all showers running .In the writers opinion this valve represented a most progressive and innovative departure from the dated technology currently used Such a valve could be over heat protected with a thermally activated solenoid valve if required However it is regrettable that the thermistors controlled TMV is not used or approved, for health care central systems.

Prior to the discovery of Legionella the standard NSW Public Works Department Design for geriatric psychiatric and Paediatric wards was a system served by a thermally insulated warm water storage tank, the system was flow pump circulated at a very low temperature difference and a proportion of the pump flow was returned to the storage tank to prevent stratification, the standard floating draw off was also a feature of this tanked system. In the haste to remove the potential breeding grounds for Legionella the Standard warm water tank was no longer considered acceptable .However, bearing in mind that reticulated warm water must be UV treated, the validity of removing this simple and effective system from the approved range would appear to be questionable.

9.40 MATERIALS FOR HOT AND COLD SERVICES

Where temperatures can exceed 70° C Such as Solar installations Thermo plastic pipe systems are not recommended.

9.41 PVC AS1477 AND ABS

Should not be fixed in U clamp brackets that stress the invert of the pipe wall against a ridge or flat surface which distorts the pipe out of its circular shape, PCV under stress or vibration will undergo a molecular change and stress fracture. Generally PVC and ABS materials will not be used in connection with the distribution of Potable Water for consumption; more probable applications could be Harvested rain water, or Therapy pool pipe work.

9.42 POLYMER PIPES: -POLYPROPYLENE POLYETHYLENEAND POLYBUTYLENE

It should be noted that.

All Polymer pipes are considered vulnerable to the adverse effects of metal trace elements in the water flow carried by the pipe.

The adverse action is accelerated when the water is heated .When combined with stress resulting from improper fixings ,or inadequate provision for thermal movement stress cracks are believed to accelerate the chemical reaction with the de-metalisers of the polymer .Reference should be made to the work of Professor Graeme George University of Queensland in respect to this subject

Cross linked Polyethylene (PEX) is a much used semi flexible hot and cold water service pipe material for smaller diameter pipe sizes ,jointed with brass tool activated compression fittings for normal reticulation and stainless steel for Ultra-Pure water systems this pipe is suitable for high temperature sanitisation methods (Clean in Place C.I.P) .

Polybutylene is a similar product to Polyethylene, the compression fittings are a lighter design, and it is an approved material which can be used in hospital but is associated more with the residential market sector, not recommended for Ultra-pure water systems.

Polypropyleneis a rigid fusion welded system with a very wide size and product range ,suitable for hot and cold water services, considered to be vulnerable to overheated water (65º+) and trace

copper in the water caused by erosion corrosion, a combination that can result in stress cracks followed by Polymer oxidisation, a chemical reaction to metal levels and a secondary effect of stress cracks in the polymer pipe surface .PPR differs in reaction from PP the oxidative being less stable in the PP.

9.43 STAINLESS STEEL GRADE 316 & SAF 2304 TO AS1432- TYPE B DIMENSIONS

An established material ,but a reasonably new material for general use in heat exchangers and hydraulic pipe services ,new mechanical jointing systems render this a significant and versatile material, with high purity standards for water distribution, particularly where trace metal elements are considered a health hazard ,or where high temperature clean in place sterilization systems are used in conjunction with the reticulation of Ultra Pure Water ,or for the generation of Clean Steam or reticulation of reverse osmosis water to Dialysis patients, or pathogen free animal breeding facilities in research units

There are many grades of Stainless steel such as the duplex stainless steels or ferritic – austernitic (Sandvik SAF2205) that has high resistance to corrosion cracking in chloride bearing environments. Stainless steel it is a dynamic technology, seek advice in respect to corrosion resistance.

9.44 CAST IRON AND DUCTILE IRON

For water reticulation below ground in cement lined rubber ring jointed pipes and above ground with flanged pipes has been used since the sixteenth century (Cast Iron),

Cast or Ductile iron with rubber ring joints should be electrically bonded for anodic corrosion protection where ground conditions are aggressive or stray electrical currents probable E.G Near rail installations

The introduction of plastic pipes as HDPE and ABS has been a fairly rapid change because of the corrosion resistance and ease of installation of the newer materials.

9.45 ASBESTOS CEMENT

Water mains of asbestos cement were installed for some years prior to the discovery of associated health problems when cutting or working asbestos. It should be noted that many asbestos mains remain in service.

9.46 GALVANISED MILD STEEL

This material is vulnerable to corrosion from certain water qualities (EG Sydney's soft water) GMS will be found in hard water areas of the world, for example London.

9.47 GLASS LINED STEEL

This material is used prolifically for Domestic Hot Water Service storage vessels with heat exchangers such as immersion electrical or gas .The material has a 10 year life expectation and requires a sacrificial anode system to give corrosion resistance in aggressive soft water areas such as Sydney, the sacrificial anode will deposit trace metal and sediments of magnesium and zinc which can be in sufficient quantities to effect the small water ways and mesh strainers of thermostatic mixing valves , a life expectancy of 10 years and extraneous deposits are not considered suitable for health care.

9.48 LEAD

Whilst now not considered safe for contact with potable water Lead was once widely used for mains water connections and water meter connections. Lead lined Aqueducts which extended to remote Plumbo-Solvent waters from the expanding area of ancient Rome were believed to have transmitted lead poisoning to the aristocracy leading to the degeneration of Roman society .Lead has a significant place in the history of plumbing design as evidenced by the Latin name for lead and the Tradesman that crafts it.

As an interesting side issue that has little connection with health care, in 1987 the writer undertook the Fish Life support system for the Darling Harbour Aquarium that opened as a feature of the 1988 Australian Bi-

Centennial. The Aquarium specialises in indigenous aquatic life much of which requires a heated sea water habitat. Trace metal elements are fatal for fish metabolism, hence copper heat exchangers were off the agenda, the writer contacted the curator of fishes at Taronga Zoo who advised the most common materials for sea water heat exchange were Titanium .Borosilicate glass, or as was the case at the Taronga aquarium, lead. This information came as some surprise; however it is the rapid forming oxidisation of leads surface that evidently prevents the release of trace elements.

9.49 COPPER TUBE AS1432 TYPE B

This traditional plumbing material requires a high degree of trade and design skill to achieve a long life expectancy; it is vulnerable to velocity corrosion at hot water speeds and Electrolysis or bi-metallic corrosion as an ion exchange reaction with other less noble metal if an electrolyte (water) is present.

Copper can with expansion movement work harden particularly at the softened silver soldered joints; the design must accommodate movement in an AS3500 compliant manner that does not stress fatigue the material .Attention is drawn to the safe working pressures of some copper tube diameters when annealed.

The recent press fit joints such as the German Viega unit which utilises an O ring seal and clamped linear restraint joint are options which minimise copper joint heat softening problems.

Jointing copper tube with site formed joints and silver solder need particular attention to the capillary gap in interference fit joints, a gap that is too large will not stimulate capillary action, Copper is also vulnerable to chemical attack from high levels of chlorine, copper in common with other metals, is also vulnerable to electromagnetic (Stray Current) leakage and should be bonded and sacrificial anode protected in certain ground conditions.

9.50 COPPER CORROSION AND POLYMER REACTION

IT SHOULD BE NOTED THAT ALL POLYMER PIPES ARE CONSIDERED VULNERABLE TO THE ADVERSE EFFECTS OF METAL TRACE ELEMENTS IN THE WATER FLOW CARRIED BY THE PIPE, PARTICULARLY WHEN THE WATER IS HEATED. Failures have been recorded in Polyethylene systems and Polybutylene systems .However Polypropylene being supplied in a much larger range of pipe diameters has a much higher probability of being located within a circulating pumped system that is also connected to a copper pipe system, or a corroded glass lined mild steel heater.

Copper corrosion from velocity erosion is believed to occur in circulated hot systems at water speeds that are over 0.9m/s which is half or less of the AS3500 recommended maximum of three metres per second.

Water velocities in Australia also exceeds the recommendations of authorities in other parts of the world and the Australian Institute of Refrigeration Air Conditioning and Heating (Inc) Handbook first published May 1989 ISBN O 949436 17 8

The vulnerability of copper tube, copper core boilers and storage mild steel glass lined vessels, to corrode by erosion and impart trace metal elements from the parent metal, or sacrificial metal anode, into the drinking water system is avoidable and it is considered to be an undesirable feature to add any extraneous chemicals into a Health care potable water system.

The Design Consultant should consider that few Public Utilities use Copper to reticulate supply, in the event of a health hazard contamination level in the drinking water service that could be attributed to copper trace elements the liability and possible litigation would be directed to the expert consultant and his professional indemnity insurance holders.

With Steel Copper or polymer pipe, expansion and contraction can cause problems if the system is not designed with due consideration, the pipe will be stressed and may rupture at the weakest point.

Copper and Polypropylene are both rigid materials with a high coefficient of expansion ,adherence to the manufacturers recommendations and AS3500 Expansion and Contraction recommendations is essential,

The Polypropylene pipe configuration should be cold stressed and allow flexing and secure anchorage, it is important that brackets are compliant to the manufacturer's recommendations, with soft inserts to prevent distortion, or grommets to prevent damage to smaller polyethylene pipes passing through steel stud perforations.

An adverse copper / polymer oxidisation interaction can follow stress fractures caused by constraint of expansion, hoop stress from clamping type fixings and copper deposits released by high velocity corrosion and extreme heat that exceed Polymer pipe specifications.

This is now a well-documented phenomenon unique to Australia and New Zealand hot water systems (Refer Hunter Water Investigation Holy Spirit Hospital Queensland).

Why then is it that such failures do not happen in Europe? Many areas of western Europe are hard water areas , heating systems the high temperature heating pipe work is a recirculating system to avoid the deposition of calcium which lines cooking utensils and pipes, Boilers with cast iron or copper cores are separated circuits to avoid calcium deposits .domestic temperatures are much the same but are precisely controlled , multiple heaters (Boilers) do not come on line simultaneously because of poor control systems ,heat input is modulated . The interesting issue to observe will be the increasing use of Polymer in Hot water systems in the USA.

Velocities in copper tube conveying cold water should be limited to not exceed 1 to 1.5 m/s lower velocities (0.9m/s) are recommended in pumped primary hot water systems, or copper core boilers and heat exchangers that require constant pumping duties and high water velocities to achieve high heat exchange efficiency.

AS3500 notes that permissible velocities of 3 metres / second are considered acceptable in distribution systems .This velocity is not consistent with the velocity limits recommended by AIRAH and internationally for copper tube (Refer to Copper corrosion).

The significant difference in the published recommendations of AS3500 and the AIRAH recommendations is curious and of concern, the latter being about half of the upper limit set by AS3500

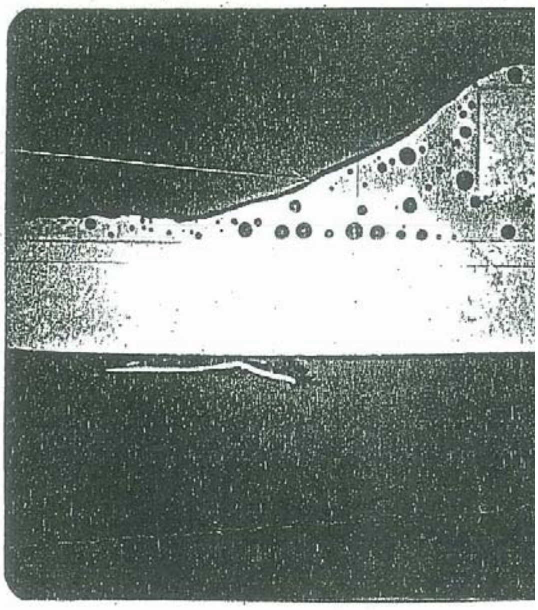
REQUEST FOR

INVESTIGATION/ LABORATORY REPORT

The joint had been overheated causing porosity i
See fig 3. Porosity such as this is the result
brazing alloy absorbing gases at a high temperat
these gases on solidification.

FIG 3.

Brazing Alloy containing porosity.



The joint gap is 0.029". The recommended joint
phosphorous brazing alloy is 0.002" - 0.005" for
The outside tolerance is 0.0015" - 0.008". With
the joint gap must be controlled to allow the me
action.

The grain size of the copper on the outside of t
and the grain size of the copper tube on the ins
0.022 mm. The grain structure away from the hea
the cold worked condition.

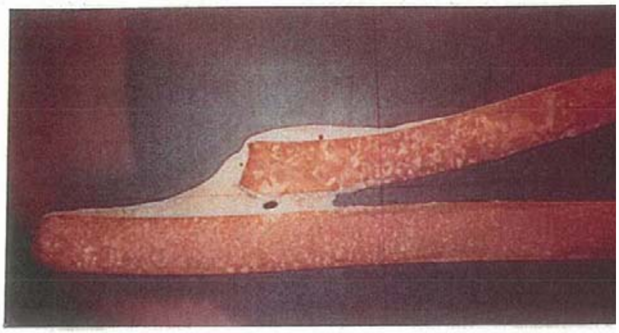
This indicates the outside tube has been heated
for an extended period, while the inside has onl

Copper Tube Failures

Laboratory Test Samples of 150 mm type B copper tube that failed under test becaus
soldering and annealed joints that do not comply to maximum recommended working

No. 3.

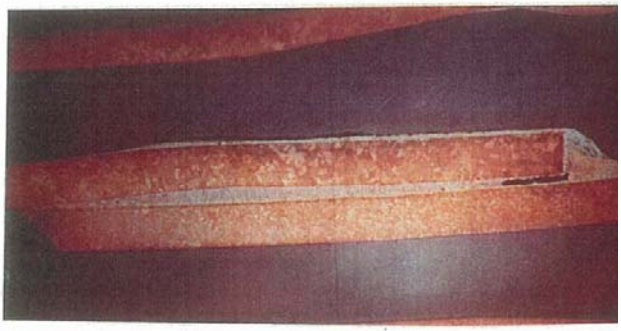
X 20



SHOWS POOR PENETRATION AND DEFORMATION DUE T

No. 4.

X 20



SHOWS SURFACE FLUX, COMPLETE PENETRATION AND

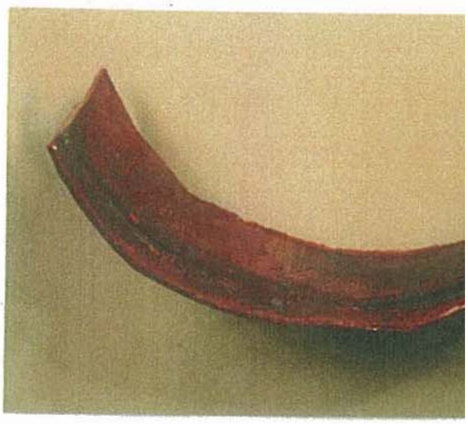
OF POROSITY.

No. 5.

X 20

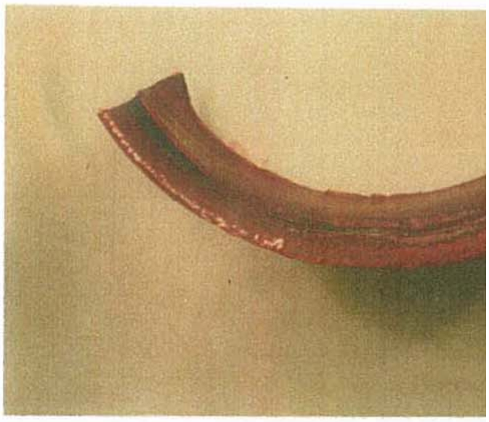
SHOWS COMPLETE PENETRATION, SMALL GRAIN SIZE

No. 1.



SHOWS SEPARATION DUE TO ACTION OF
POORLY PENETRATED BRAZED JOINT.

No. 2.



SHOWS SECTION WHERE 80% OF JOINT

9.51 AIRAH AUSTRALIAN VELOCITY LIMITS

Australian Institute of Refrigeration Air Conditioning and Heating (Inc)

Handbook first published May 1989 ISBN O 949436 17 8

Design Parameters Velocity

Water Coils Heating 1 to 1.5 metres/second

Mains pressure water services 1 to 2.10 m/s

Gravity flow from upper level storage tanks 1 to 1.50 m/s

9.52 WATER QUALITY

Where metallic pipe or heat exchange or storage vessels are used in conjunction with Polymer pipe stainless steel is recommended. Water quality that is considered potable, can have qualities that adversely affect copper tube, copper should not be used under any circumstances in connection with the reticulation of ultra pure water for dialysis, or animal house watering systems, or the generation of clean steam. Considerable information on copper poisoning is available on the internet ,the following are examples of interest in respect to water services for Health Care Installations

POISONING AS A RESULT OF COPPER TRACE ELEMENTS IN DRINKING WATER HAVE BEEN REPORTED IN GERMANY

The upper limit for copper in Australian drinking water is 2 mg/l

The United States of America has the Copper and lead rule which limits the copper content in water to 1.3 mg/l

Copper corrosion has been reported in NSW Hospitals and reported in a Queensland Hospital in an investigation report by the Hunter Water Board

Institution of Hospital Engineers Australia Corrosion Report for the 53 National Conference October 2002 Dr Russel Taylor Principal research scientist CSRIO reported a number of corrosion issues in hospitals.

MIC Microbial Induced Corrosion

It is considered reasonable to assume that sever copper corrosion is going to increase copper trace elements in the drinking water supply and possibly also the breakdown of sacrificial anodes constructed of zinc, or aluminium magnesium which will release into the potable water stream as trace elements.

In respect to this Design Guide, the issue that is of significant interest to the Hydraulic Services consultant or designer is the health risk and the associated professional indemnity riskvulnerability of providing a system design that is fit for purpose. In respect to risk it should be noted that copper tube or pipe is not a material used by public utility water undertakings, few if any Copper water mains exist in streets or the public domain.

As a minimum response to the considerable information that associates copper with significant health issues, we should as a profession seek clarification of the matter.

9.53 THE MUNICH EXPERIENCE

German Paper by Rudolf Eife, Prof. Dr. med., Kinderklinik der UniversitätMünchen {Munich University Children's Hospital], Lindwurmstrasse 4, D-80337 Munich, telephone 0049-89-5160-28054, eife@kk-i.med-uni-muenchen.de

Summary of the article in “VGL-Information” 3/98 under the same title

Diseases that are attributable to copper in drinking water have been emerging in Germany. Water containing copper should not be consumed by infants at all and only in small quantities by older children and adults.

Concurrently with the increasing use of copper pipes in drinking water installations illnesses have been emerging in Germany that could not be connected with any of the diseases previously known to us here. The search for a cause and “blind” clinical trials were initially unsuccessful.

In 1987 it was proved for the first time that the illnesses are triggered by copper poisoning: copper had been passing from domestic installations (copper pipes or boilers) into the drinking water and been absorbed by the patients.

Only the most severe form of copper poisoning was initially recognised as such, namely fatal or severe copper-related cirrhosis/fibrosis of the liver. At that time we called the illness copper-induced cirrhosis of the liver, a definition that has proved to be far too narrow. In the following years further findings led to the recognition that copper poisoning can trigger a broad spectrum of disorders.

Subsequently an overview of observations was carried out based on 62 patients, for whom the examination findings and courses of the diseases were evaluated.

9.54 AUSTRALIAN INSTITUTION OF HOSPITAL ENGINEERS

The following paper reviews the Australian experience:-Institution of Hospital Engineers Australia Corrosion Report for the 53 National Conference October 2002 Dr Russel Taylor Principal research scientist CSRIO

9.55 SUMMARY OF SURVEY RESULTS

Region	Total Reports	Total corrosion problems	%	Pinholes Total	Pinholes %	Total Blue Water	Blue water %	line
A.C.T	1	0	0	0	0	0	0	1
N.S.W	36	17	47.2	14	38.9	10	27.8	2
Sydney City	5	1	20	1	20	0	0	3
Northern Beaches	3	0	0	0	0	0	0	4
Western Suburbs	7	3	42.9	2	28.6	2	28.6	5
Central Coast	1	1	100	1	100	0	0	6
North Coast	4	1	25	0	0	1	25	7
West of Divide	13	8	61.5	7	53.8	5	38.5	8
Queensland	3	3	100	2	66.7	1	33.3	9
S.A.	7	3	42.9	2	28.6	1	14.3	10
Tasmania	1	1	100	1	100	1	100	11
Victoria	31	27	87.1	19	61.3	17	54.8	12
Melbourne City	16	15	93.8	7	43.8	13	81.3	13
Melbourne Country	15	12	80	12	80	4	26.7	14
WA	15	13	86.7	13	86.7	3	20	15
	94	**64**	**68.1**	**51**	**54.3**	**33**	**35.1**	**16**

The random nature of the occurrences and our observations suggests that there is no correlation with copper manufactured at any time or from any particular source.

Corrosion appeared to occur in both hot and cold systems with pin holes more prevalent in domestic hot water 65-75 C 48 occurrences'.

According to the Australian drinking water guidelines there is a health limit for copper of 2 mg/l above which some individuals suffer ill effects including vomiting, a small minority of individuals are susceptible to Wilson's disease a condition of genetic origin.

Whilst it could be considered reasonable to assume that copper corrosion might add to the copper content in the water supplied for drinking and the Australian health limit of 2 mg/l (USA 1.3 mg/l) might, as a result be exceeded, the report does not address this issue.

9.56 COPPER CONNECTION

Plumbing Connection Page 26 Autumn 3012

"Study proves new technology kills bacteria that cause hospital infections and reduces infection rates Boston MA Results from a comprehensive multi-site clinical trial demonstrated that the use of antimicrobial copper surfaces in intensive care unit rooms reduced the amount of bacteria in the rooms by 97% and resulted in a 41% reduction in the hospital acquired infection rate"

Presented Friday October 21 at the annual conference of the infectious diseases society of America.

The author notes that the report does not have specific application to the plumbing industry.

This might not be considered true? The tactile interface with copper and its dramatic effect on bacteria conveys to the writer that there is indeed a significant biological process taking place.

Bacteria live in the domain of prokaryotic micro-organisms, there are more of them than all other life forms combined on this planet, they live in your digestive tract and are vital in recycling nutrients .Not all bacteria are harmful to the human machine it could be considered misleading to associate surface contact with copper, with ingesting it?

Most of us are aware that the human body requires levels of chemical and metal substances as are gained from our food intake, we also ingest low levels of Chlorine, but this does not imply we should drink concentrations of it.

In the face of an ongoing internet surge of research material that links copper with brain activity , and the lessons of the past which saw an ambivalent social response to lead in petrol ,asbestos and many other apparently docile environmental substances ,which were after some time , discovered to impact on the quality of life .

Should we, as a group of expert professionals, not have a care about the material that conveys drinking water in buildings which are delivering health care, to debilitated persons who have no control over the water they drink?

9.57 THE SOUTH EAST WATER EXPERIENCE (MELBOURNE)

As published Plumbing Connection 2005 South East Water serves more than 1.3 million customers in Southern and Eastern Melbourne, the operations water engineer stated that they have less than 100 Blue Water Cases Dr Roger O'Halloran CSIRO stated that the problem can be wide spread in soft water regions, the CSIRO team have been studying the problem for 15 years, it is most often found in copper services that are infrequently used, or those that are a long way into a building. The reason for this is that these conditions lead to a decay of the chlorine content which allows certain copper tolerant bacteria to grow on the pipe walls and destabilise the natural protective scale.

9.58 THE UK EXPERIENCE

MIC Microbial Induced Corrosion comprising pitting of copper in potable water systems operating in large institutional buildings has been the cause of failures in Scotland Germany and Saudi Arabia .The characteristic features of MIC in copper pipes are apparent on the bore surface when examined by optical and electron microscopy

Discrete mounds / tubercules of blue / green corrosion products consisting principally of basic copper sulphate

The surface between these mounds and the mounds themselves are covered by a powdery black deposit of cupric oxide and an organic biofilm .Removal of these mounds reveals a loose crystalline cuprous oxide and beneath them roughly hemispherical pits

The black cupric oxide along the bore surface has been shown to be composed of roughly hemispherical nodules, each with an outer layer of organic biofilm material which is believed to be associated with microbiological activity. Also the presence of rod shaped bacteria is observed with the corrosion products and the biofilm of exopolmetric material.

9.59 FROM THE USA.A REPORT THAT CONFIRMS EXPERT INVESTIGATION

University of Rochester Medical Centre USA (2007, November 7)

Copper damages the protein. That Defends Against Alzheimer's.

Science Daily.

Retrieved March 12, 2012,

From http://www.sciencedaily.com/releases/2007/11/071107074329.htm

Copper can damage a molecule that escorts out of the brain a substance called amyloid beta that builds up in toxic quantities in the brains of people with Alzheimer's disease. The new findings demonstrate one way in which copper might contribute to the development of the disease, though scientists say much more research needs to be done to clarify what role, if any, copper ultimately plays.

The research by neuroscientists at the University of Rochester Medical Centre was presented at the annual meeting of the Society for Neuroscience in San Diego Nov. 3-7, 2007. The work was highlighted as part of a press conference on potential environmental influences on Alzheimer's disease.

For decades, many scientists have hypothesized that a variety of metals, including aluminium, iron, zinc and copper, might play a role in Alzheimer's disease, but no link has ever been proven. In the past few years, several scientists have reported that copper is one component of the amyloid beta clumps --tiny trash heaps filled with all sorts of molecules and substances -- that speckle the brains of people with Alzheimer's disease.

The new results go much further, showing that copper damages the major known system the brain uses to get rid of amyloid beta. The find marks perhaps the first time that scientists have found a specific way -- a "molecular mechanism" -- that a metal could contribute to the disease process in Alzheimer's disease.

"Metals like aluminium have been suspected for years, but the mechanism through which metals might act has been unclear," said Rashid Deane, Ph.D., the lead author of the work who presented the results in San Diego. "We've demonstrated one mechanism through which copper increases levels of amyloid beta in the brain, by damaging the molecule that gets rid of the substance."

The team found that copper damages a molecule known as LRP (low-density lipoprotein receptor-related protein), a molecule that acts like an escort service in the brain, shuttling amyloid-beta out of the brain and into the body. The molecule's role in Alzheimer's was revealed more than a decade ago by another author of the work, BerislavZlokovic, M.D., Ph.D., professor of Neurosurgery and Neurology and director of the Frank P. Smith

Laboratory for Neuroscience and Neurosurgery Research. Zlokovic is widely recognized for demonstrating that blood vessels, blood flow, and the blood-brain barrier are central to the development of Alzheimer's disease.

The study was done in mice as well as on cells from the brains of people who died from Alzheimer's disease. Deane's team compared mice that drank water containing trace amounts of water (.12 milligrams per litre, less than one-tenth the 1.3 mg/l level of copper allowed in drinking water by the Environmental Protection Agency), to mice that drank distilled water.

Mice that drank water with trace levels of copper had about twice as much copper in the cells lining the blood vessels of the brain as the mice that did not. They also had about one-third fewer LRP molecules in those blood vessels and about one-third more amyloid beta in their brains than the control mice, after 10 weeks.

Using human cells, the team discovered that copper damages the protein LRP to such an extent that it stops working. The team has shown previously that having fewer functioning LRP molecules results in higher levels of amyloid beta, which ultimately aggregates together and kills brain cells.

"We all have some amyloid beta in the brain normally," said Deane, associate professor of Neurological Surgery. "When you age, a little bit more accumulates in the brain naturally. But the process is greatly accelerated in people with Alzheimer's disease."

While it's clear from the study that copper can damage LRP, Deane says it's preliminary to draw the conclusion that copper causes Alzheimer's disease based on the study.

"There's a great deal more work that needs to be done to fully understand the role that copper may play in Alzheimer's disease," said Deane. "We need to explore the mechanism of how copper breaks down LRP much more fully. Then, of course, we must see if the same is true in people. There are different ways to measure copper in the blood, and indeed, there is some research linking low levels of copper to Alzheimer's, while there is other research linking high levels of copper to the disease."

Deane emphasizes that having appropriate levels of copper in our body is crucial for our health. Copper helps keep our bones our strong and our skin toned, and it helps our nerves fire crisply and our cells to generate the energy we need to live. It helps keep our blood healthy so we can get the oxygen we need to all our organs. And it plays a role in keeping our immune system strong.

While drinking water is the most obvious source of copper in our diet, because of copper pipes, the substance is also quite common in red meat, nuts, shellfish, and many fruits and vegetables.

The research highlights the importance of the blood-brain barrier, an intricate filtering mechanism that lines the inside of blood vessels inside the brain and is designed to keep toxic substances out. It's as if the ultra-sensitive brain is designed to be isolated from the common blood supply. Thousands of molecules act as sentries, decided exactly which substances are allowed into and out of the brain, and which aren't allowed to cross the barrier. LRP is one such sentry, specializing in the removal of amyloid beta from the brain.

"The body needs to maintain the environment of the brain pristinely so that our brain cells stay healthy and are able to function effectively," said Deane. "It's the job of the blood-brain barrier to keep the brain safe and healthy. It may very well be a breakdown with the barrier that is at the root of Alzheimer's disease."

In addition to Deane and Zlokovic, others who contributed to the study include post-doctoral researchers AbhaySagare, Ph.D., Mireia Coma, Ph.D., and Itender Singh, Ph.D.; and technical associates Bob Gelein and Margaret Parisi.

The work was funded by the Alzheimer's Association and by the National Institute of Environmental Health Sciences.

9.60 USA STORY SOURCE:

University of Rochester Medical Centre USA (2007, November 7). Copper Damages Protein That Defends Against Alzheimer's.

Science Daily. Retrieved March 12, 2012, from http://www.sciencedaily.com-/releases/2007/11/071107074329.htm

9.61 THE CANADIAN EXPERIENCE

Canadian Copper and Brass Association Information Sheet 97-02

The following was published in response to inquiries regarding corrosion in hot water recirculating systems due to velocity effect .The CCBA is providing the following information concerning factors which may affect the service life of copper tube and fittings in such systems.

1) Water velocities exceeding 5 feet per second (1.524metres/second) .*This is half of the maximum velocity permitted by AS/NZS 3500.*

2) Undersized distribution lines creating high velocities.

3) Oversized circulating pumps with no by-pass creating excessive velocities.

4) Multiple and / or abrupt changes in direction.

5) Failure to remove burr on the inside of the tube after cutting

6) Improper solder or brazed joints.

7) Improper use of throttling valves for system balancing.

9.62 EXCESSIVE VELOCITY

Excessive velocity in circulated hot water reticulation (0.9 l/s) can happen in copper core boilers, and is also typically the result of over sizing the pump, or under sizing the distribution lines.

There are several choices to eliminate the problem of erosion corrosion pump. All are based on reducing the water velocity or eliminating the excessive turbulence at connections and fittings .Options include a bypass around the pump to reduce its effective output, a smaller capacity pump, or throttling balancing valve downstream (This can stimulate pump cavitation) of the pump to restrict flow, and larger pipe sizes in the areas affected.

9.63 EXCESSIVE TEMPERATURE

Limit the domestic hot water to a maximum 65 C since increasing the temperature of potable water can increase the corrosion effect on copper and breakdown of polymer. In the writers experience of reviewing failures in Polypropylene pipe, a reasonably high proportion have been attributed to poor circulation resulting from an undersized circulation pump and lack of thermal insulation, the quick fix remedy has been to turn up the boiler control thermostat and increase the system temperature to 70°C +, this reduces the life of polymer significantly and increases expansion in the polymer.

The Australian industry may not be sufficiently well informed on this subject, it could be considered prudent design to limit rigid polymer pipe such as polypropylene to cold water services and limited upper temperature of warm water services, few problems are experienced with these services.

9.64 EROSION CORROSION BY CAVITATION

Cavitation can occur in systems when the flow velocity is high and either the direction of flow is sharply changed or is obstructed by a burr .In a fitting the centrifugal force flowing around a short bend radius at high velocity causes an increase in pressure at the outer portion of the bend and resulting lowering of the pressure at the throat. The pressure in the low pressure area at the inside of the bend can drop below that of atmospheric which permits bubbles to form ,the bubbles in turn collapse when they flow into a normal pressure are with enough force to erode microscopic pieces of metal .

9.65 WATER SERVICES RETICULATION

The reticulation of domestic hot and cold water (Including non-potable water for flushing systems) must be reasonably accessible and have sufficient capacity to service the inevitable future changes in hospital planning that will be required to facilitate changes in health technology.

The service distribution range, or coverage provided, and the mandatory dead leg limits of hot or warm water must be coordinated with the cover determined for sanitary services where a common service duct is a design feature.

9.66 HOT AND COLD WATER RETICULATION

In a repetitive architectural floor plan, in most cases there will be an opportunity to standardise the geometry of the pipe work ,this will enhance coordination, reduce costs , allow off site prefabrication and the application of factory production methods with quality control and pre testing.

9.67 THE PREDOMINANTLY HORIZONTAL SYSTEM

The one or two level health care building is generally found in rural / country areas, possibly because land is less expensive and population catchments are smaller.

The building may be spread over a large area with courtyards to access light and air, such architecture has little choice of services reticulation there are few if any viable options to a horizontal system, parallel flow and return mains which provide maximum flexibility

A horizontal building reticulation system for smaller units such as Cancer care units or Clinics serving remote communities, the system may a ring main that will feed up to level 2 and down to level 1.

9.68 DEPARTMENTAL SHUT DOWN

Larger hospitals, particularly overseas where land area is more limited the health care building may extend to 20 or more levels

In NSW the break point in floor height would seem to be that health care buildings that do not exceed the 25 metre fire regulation change in design requirements level.

For the large area floor plans different departments may benefit from zone isolation, For example 9 AM to 5 PM for areas such as clinics and other logistic support departments of the hospital that do not provide a 24 hour service, for thermal economy these departments could be shut down for out of use periods by the management system, to save the running costs of 24 hour thermal emission from pipe work.

In considering departmental shut down as energy conservation means (The heat input is saved), the designer must consider with considerable care the expansion and contraction requirements of hot and warm water systems and the inherent increase in cycles of expansion and contraction that result.

The expansion of copper tube and Polypropylene pipes is high and the temperature range variation of the system is in the order of 50 degrees Centigrade considering a 15 degree ambient water temperature to a 65 degree heated maximum temperature.

Providing adequate provisions are made for movement the system will not suffer ,however the thermal movement will be twice per day five days a week for energy conservation shut downs ,this introduces considerable movement and opportunities for stress fatigue in most materials .

For very large pipe work shut downs the conventional circulation pump systems may require duty point consideration, the effect of shutting down a large portion of a circulating system by valves will mean that the isolated circuit will cool over 16 hours, or more before re-heating, the water density will change as the water cools, as will the frictional resistance and the circulating pump head, when the pumping is reactivated in a cooled state.

In a system served from central circulation pumps, the valve closure of a significant loop in the system will alter the flow rate to other sections of the system that are on line, such closure should be achieved in the hot water return with by-pass three way solenoid valve with globe valve to reduce flow gain and balance the remaining circulated portion of the system to prevent increasing the thermal loss by added circulation flow, an affect that would minimise the objective of saving energy.

An option to zone isolation valves is to circulate zones with a dedicated circulation pump to each circuit or zone, this has the advantage of reducing the size of the circulated system pumping load and the water content to be moved, this reduces cold start friction drop to lower margins.

A recent development in Germany by the WiloGeniax Pump Company utilises very small low voltage direct current pumps that are located in fan coil units, or radiant heating or cooling panels, the pumps are thermostat controlled and a saving of 20% energy is claimed.

The concept would appear to be adaptable to departmental or much smaller zone shut down of domestic hot water system, or possibly the activation by movement sensor of hot water return circuits that have long and random periods between uses.

9.69 PREDOMINANTLY VERTICAL RETICULATION

The opportunity may exist to locate hot cold and non-potable water in the same duct space as sanitary plumbing adjacent to structural columns; this location has immunity to planning change, and will compliment coordination with structure and other services.

A column duct interval of between 7 and 8 metres in two directions will facilitate fast track construction because it is feasibility to undertake early installation when the pipes are fixed to structural fabric that exists, this also has the coordination advantage of using a similar path to an established obstacle and element of the structure that must be avoided by duct work and cable trays.

With columns at the centres noted the dead leg range for domestic hot water services (Currently 10 metres irrespective of pipe diameter) will in most instances have sufficient cover from the column centre point to feed in three directions as a compliant dead leg branch, thus each riser will be a flow main, this system concept may be modified to provide a return at alternate columns as a means of extending the viable range of the domestic hot water circulating system.

9.70 MIXED VERTICAL /HORIZONTAL SYSTEMS

An alternative system for less frequent spaced ducts comprising one or two main flow and return service located in the central core or equal spaced duct locations and serving one or two high level circulating loops per floor area ,such a system minimises floor perforations and leaves some opportunity to incorporate valved zone shut downs if required

The common denominator that determines duct spacing and services sharing, can be the depth of beams and the viability of pipes that grade being contained within beam patterns and the false ceiling zones

9.71 UP-FEED OR DOWN-FEED

The question being, will there be any advantage to the system if it is fed from a horizontal lateral pipe at the top, or from a similar pipe at the bottom of the system?

Assuming this is a large teaching hospital also designated as a disaster centre hospital it will probably have a high level storage tank, if it is over 300 beds, there will probably be a number of buildings, some patient occupied others dedicated to treatment or logistic support.

The proposition of coming out of the tank and distributing to the floors from a just below a roof level main would appear economical in pipe reticulation, however such a system would provide minimal energy (Or head pressure) in the system at high level where most of the load will be, in practice the system under gravity conditions would run into system hydraulic gradient problems.

The preferred reticulation should drop from the tank in a vertical duct as quickly as possible with minimal lateral reticulation at the tank level; the supply from the tank should drop to ground level, or to an accessible below ground floor level plant space and reticulate out from this point to the various risers serving the floors above.

Such a system places most energy at the point of most load, the riser size will for most of its journey upwards remain the same size, this is a desirable feature for future expansion, and it compliments fast track construction where detail design of floor occupation may not be resolved until much later in the construction program .Such a system allows considerable carcass work to progress prior to detail design resolution.

9.72 THE SHIPPING SYSTEM (A TRUE HW RING MAIN)

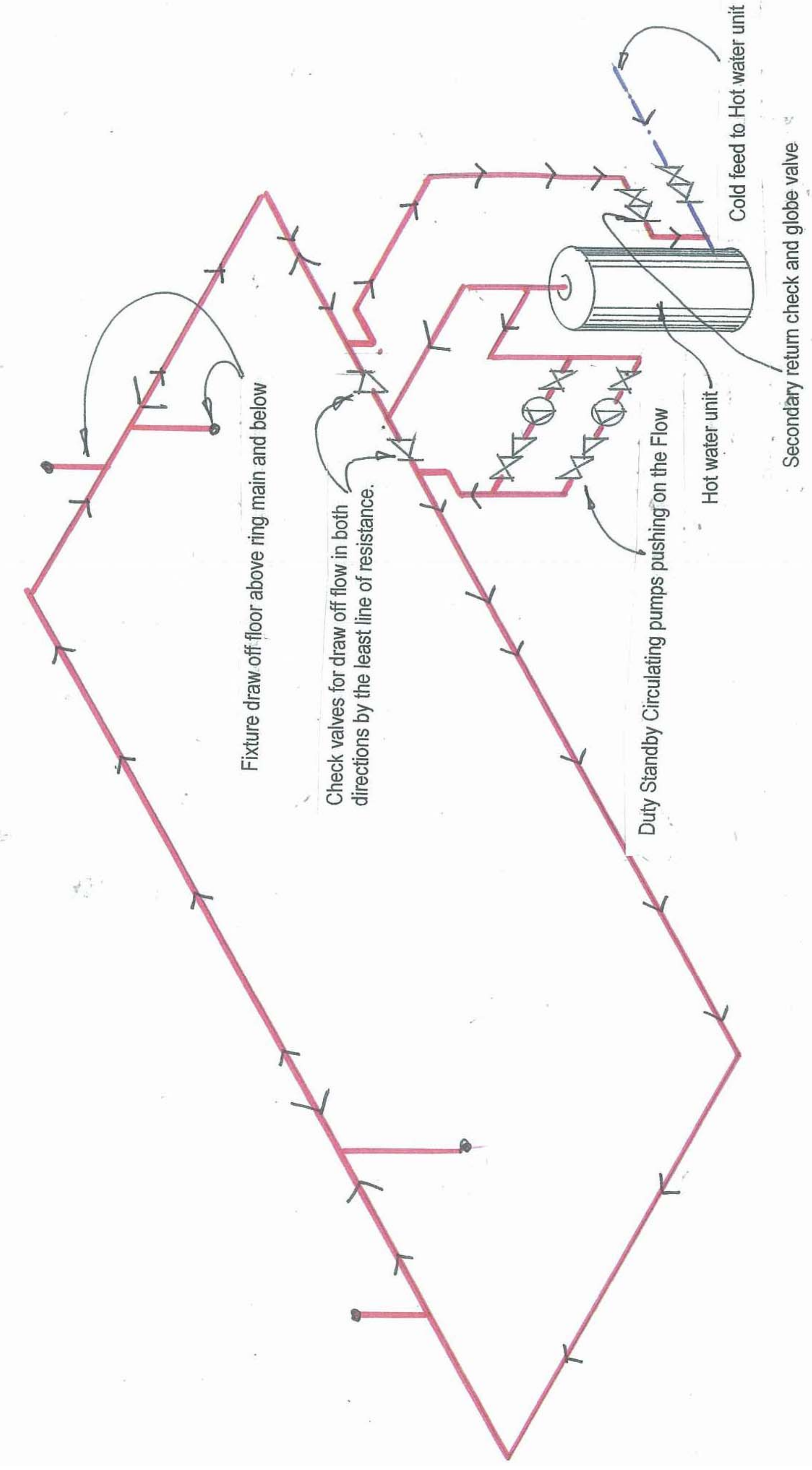
A seldom used system in Australia (Other than by the writer) and probably best described by the diagram, this very economic hot water reticulation system is much used in ships plumbing, but seldom used in land based installations possibly because it transgresses some established dogma which the writer considers to be erroneous.

The system can be described as follows. From the heat connection the hot water service splits into an equal sized ring main, the ring main is sized by providing 50% of the determined load to each side of the ring. Immediately after splitting into a ring main, each leg of the ring main has a non-return valve fitted, thus draw off flow to the consumer can move in both directions to any branch connection.

Circulation is overlaid on to the system in the following manner.

The circulation pumps draw from the section of pipe between the heat source and the ring main split, prior to the non-return valves. The pumped flow circulation joins the ring main a short distance from one of the ring main non return valves (Say the NRV on the right hand side), the return connection joins the ring main just downstream of the other NRV (The Left hand side) and the return is extended to join the heat source at low level with a globe valve and NRV, it can join the cold feed if required.

Such a system is extremely efficient and cost effective, more suited to one or two level buildings, it does not facilitate branch return pipes, and all branch connections are dead legs limited to a maximum 10 metres long , or using Notional Hospital technology 2 litres content 7.5 mm diameter PEX pipe Refer to Shipping System diagram.



The Shipping System

The shipping system is so called because of its use in maritime architecture to circulate water through ring mains without loss of the ring main concept for draw off loads.

9.73 SEPARATING WATER SYSTEMS

In Health Care Buildings that exceed a certain number of levels the water pressure at the consumer point become critical and may require both boosting and pressure reduction, this is not a significant technical problem for cold water services, it does however become more complex for warm and hot water services that cannot circulate past a pressure reduction valve and need a reheat system for the low pressure zone. Refer to diagram.

Similarly in buildings that undertake research and have chemical and biological laboratories undertaking wet research , and animal houses, there will be a need for separation of water systems for reasons of bio-logical containment, this containment may be to protect drinking water (Potable) from potentially contaminated water, or it may be to protect the integrity of one laboratories biological research from contamination from an adjoining laboratory, or it may be to protect the biological integrity of the animals used for testing. .

9.74 SAMPLE SEPARATED SYSTEMS

A LARGE RESEARCH BUILDING WITH PS3 LEVEL LABORATORIES COULD END UP WITH THE FOLLOWING SEPARATED SYSTEMS.

1) Pressure zone separation Potable cold water (Emergency showers Eye wash Drinking Hand rinse)

2) Pressure zone separation Potable hot water

3) Pressure zone separation Laboratories cold water

4) Pressure zone separation Laboratory hot water

5) Biological separation cold water to animal houses

6) Biological separation hot water to animal houses.

7) Animal drinking water (Ultra-pure) separation

8) Biological separation cold water laboratory to PC 1PC 2&PC3 laboratory.

9) Biological separation hot water laboratory toPC 1PC 2&PC3laboratory.

Note:- A PC 3 Laboratory rating has been described as three boxes one inside the other, the inner most box (PC3) being a hermetically sealed cabinet with remote controlled robotic arms ,or rubber gloved and arm sealed manipulation of the activities within the box , or manipulation of apparatus by remote electronics and high magnification video .

The second PC2 Box being a hermetically sealed lab room with air introduction limited to a treated supply 10mm x 10mm.

The third box being the conventional seamless construction laboratory with standard facilities other than those noted

The means of water separation may be by a Registered Air Gap (RAG) or approved Reduced Pressure Zone Device) However the RPZD is mechanically reliant upon the action of three check valves to create a reduced pressure zone in the valve that introduces a drain to waste action preventing back flow ,these are literally back flow prevention devices ,there is no current (2012) evidence available that supports the concept that these valves will prevent the transmission of bacteria against the direction of flow . Based on the assumption that bacteria develop in a manner conducive to their environment, it would seem logical that bacteria would have more difficulty in bridging an air gap? (It is noted that this is conjecture on the part of the writer.)

The Animal house drinking water can be a dedicated RO Ultra-pure system a similar system may also serve surgical instrument sterilisation (Clean steam)

9.75 GRADE OF WATER CONNECTION

A Grade 2 water mains is desirable for hospital supplies, particularly if the installation is to be direct mains fed, the Grade 2 Supply should allow manipulation of water main valves to direct flow from alternative mains network supplies from within the hospital with check valves (RPZD) located to prevent back flow should one service fail.

Dual services connections in Sydney are seldom permitted from different reservoir supplies.

9.76 WATER METERS AND APPURTENANCES

A plant space is desirable for the larger hospital water meter and its associated and duplicated valves RPZD unit's filtration and possibly UV Irradiation. Plant items that are electrically energised or critical to normal function and which are exposed to the weather or damage are considered vulnerable.

Whereas in the residential sector a Blue identified water meter is required when the system serves a dialysis patient, similar statutory regulations are not found for health care installations. . Whilst it may be obvious to those involved in the maintenance and service supply of a large Health Care installation that closing down the water supply could represent a danger to the safe operation of the installation, it is recommended that a large and conspicuous drawing posted in the meter room identifies all valves and there location and function in respect to critical effects that may result in closure .Valves that are considered as a threat to life and safety. "If closed. " Should be locked open with local signage posted to advise the required procedure and personnel to contact prior to closure.

Water meters are generally supplied by the Water Authority ,electronic pulse meters may be part of the Building Management system ,pulse meters that provide both accumulative and instant flow rates are preferred, prior to any meter should be located a course strainer, or dirt box ,in the event of unusual high pressure loss this is the first item to check.

Most authorities and water utilities regulations are framed to locate water meters near or on the building boundary, the reason being to avoid long lengths of accessible and back flow unprotected and unmetered water main located in private property, the exceptions can be fire services or private water mains. A compromise with authorities may be required to facilitate a secure location for this critical plant, or possibly a separation of components subsequent to metering by the public utility.

9.77 WATER METERS

The Water meter may not be the same diameter as the connecting pipe work, it will in most instances be preceded by an isolation valve of the full way type for larger diameters and a dirt box, or course strainer, It will be noted that maintenance work on water mains can inadvertently introduce sizeable material into the mains

.The meter may be a mechanical helix drive device or magnetic pulse which provides for electromagnetic monitoring of flow and consumption.

9.78 BACK FLOW PROTECTION

Health care installations require a back flow prevention device, where a mains supply is critical the RPZD should be duplicated. With tank storage and a RAG the main is not vulnerable to back flow or critical and for maintenance temporary mains shut down is viable. However few Authorities in practice accept tanks with an RAG as sufficient protection of the public system and RPZD units are installed regardless.

9.79 PUMPS

The RPZD installation may be followed in the pipe work by a low level storage tank (Mandatory in the UAE) where the public utility water service could not satisfy the immediate or future peak load estimates (E.G Westmead Hospital).

Pumps may not be required if the mains pressure were considered adequate and reliable, many smaller hospitals are mains supplied.

Where pumps are required they may serve the system in the following ways

The pumps will elevate water from low level storage ,or the water main to an elevated storage tank ,possibly located at roof level with lift motor rooms ,cooling towers and similar such plant.

The “No tank”, system will be direct mains fed preferably from a Grade 2 supply that is considered reliable; if pumping is required, the pumping system may be a triplex variable speed drive system that is controlled by a digital pressure switch.

The system could be a hybrid of the two, storage and, direct mains feed systems. However such systems can result in complex pressure zones and hot cold mixing problems.

Storage may be provided at low level because it is mandatory to the locality, or because the mains supply does not have a good history of reliability, or possibly the client has a preference for storage at low level for structural reasons, or as a water supply fail safe feature.

9.80 VSD PUMPING SYSTEMS

Variable speed drive has been available for many years ,the first such units used an oil filled variable slip clutch and were used mainly for pressure boosting systems ,some remain in service ,the operation does not save significant energy ,but is an effective means of pressurising a system to meet the load.

The VSD we use currently is an electronic device the changes the nature of the power supply to the driving motor and in doing so reduces the energy consumed at lower speeds.

When linked to a positive displacement pump, or helical screw moving cavity pump, the relationship between speed and output is direct.

When linked to a centrifugal pump relationship conforms to the Affinity Laws

Pump flow rate (Q) varies directly with speed (N)

$Q1/Q2 = N1/N2$

Pump Head (h) varies with the square of the speed (N)

$H1/H2 = (N1/N2)^2$

Pump Power (P) varies with the cube of the speed (N)

$P1/P2 = (N1/N2)^3$

Efficiency in the above remains constant ,in practice it varies a little ,the Affinity laws do not apply to Net Positive Suction Head (NSPH)

Speed can controlled according to a digital signal that will respond to Pressure .Level .Temperature

Pumping systems that are controlled by tank located float switches seldom have justification to use Variable Speed Drive systems, soft stop soft start pump motors which are similar technology may be used to prevent hydraulic shock

The only justification for variable speed drive to a storage tank might be the desire to maintain a minimum storage reserve level at all times, thus the required reserve level is the point where the booster pumps are running at full speed and flow output in an endeavour to meet the peak outflow demand.

The more probable scenario is that on some occasions the tank outflow may exceed the inflow and the tank level will fall ,a buffering effect of peak loads, It is the writers experience that in practice peak loads make very little impact on tank levels ,our design assumptions of peak demand due to draw off activity are overstated, however insufficient measurements have been taken and correlated to provide reliable data in this subject , it is sufficient to note that where existing installations are measured for actual load profiles ,the original design assumptions are often proved very high.

It is common practice for critical pumping systems to install a flow switch in the delivery main, the flow switch circuit being in conjunction with a time delay of a few seconds, this mechanism is an alarm check that the pump has been activated but water is not flowing through the paddle of the flow switch. Where used in conjunction with a VSD pump motor sufficient time must elapse to allow pump motor speed to reach the optimum required to activate the paddle switch.

A pump for a pressurised system will often comprise a duty stand-by or triplex VSD motor drive pump set with a rubber diaphragm pressure cell, pumps mounted on rubber in shear mounts, pipe vibration isolators with limit of movement wires and non-slam check valves (Rienzi rubber diaphragm are recommended) The need for non-slam check valves is reduced considerably where soft start soft closed pumps are used, this feature is also applicable to most VSD units.

VSD Drive can also be used in large filtration systems to modulate the pump flow rate to increase as filter resistance rises.

9.81 PUMP TYPES

Pumps come in several configurations and types, for pumping clean cold water a centrifugal pump is the most common selection, the performance characteristic curve of centrifugal pumps varies with the design of the impellor, some curves give constant flow rate and variable head, others the reverse .This selection is probably best handled by the pump supplier who has a good range of products and a good understanding of the performance curves.

Centrifugal pumps may be vertical or horizontal or multi stage design, which tends to give a performance curve that, is more suited to variable speed drive applications.

Pumps may be horizontal split case, such pumps are favoured where onsite maintenance of seals motor to pump shaft couplings and bearings is probable .This type of pump will permit major maintenance without the removal of pipe work, it is larger and more costly than comparable performance multi stage pumps, the vertical split case pump equivalent is the back pull out pump which also allows removal of the motor whilst leaving the pipes in place.

The mono construction pump with a common shaft for the motor and the pump minimises cost and both the number of bearings and the need for a motor to pump coupling.

9.82 PUMP DUTIES

Care in sizing mains pressure booster pumps and pump motors must be exercised when pump inlet pressures are variable ,a pump which is sized for a given flow delivery at a certain head duty will try to pump more water than the design requirement ,if the inlet pressure is increased and the head duty point changed ,the added flow rate may require more energy supplied to the motor .The pump is effectively calling for more current than the design load and circuit breakers may respond to a perceived overload situation .Pump motors should be specified as non-overload to avoid this problem. Circulating system pumps are found in ultra-pure water systems and domestic hot water systems. Circulation pumps have long running times compared with booster pumps, the life expectancy is appreciably less. Small hot water system circulating pumps have a very low N.P.S.H (Net positive suction head) as with most centrifugal pumps the energy is delivered at the discharge as a result of a very high peripheral impellor edge speed, these pumps deliver their work load by pushing the water out, and they do not suck well. It is poor design to subject the suction side of the pump to a high pressure drop from friction loss, the result will be cavitation, animplosion of bubbles at the impellor edge, this is detectable by a wavering pressure reading across the pump and possibly noise. Cavitation becomes more probable with temperature rise which changes the vapour pressure of the water **(Refer also to pumping on the flow).**

9.83 PUMP MATERIALS

Pump materials vary from Cast Iron, Bronze Stainless Steel and composite plastic materials including carbon fibre although this type of pump is rare in health care other than for therapy pool work. Cast iron should not be used for domestic hot water services or ultra-pure water.

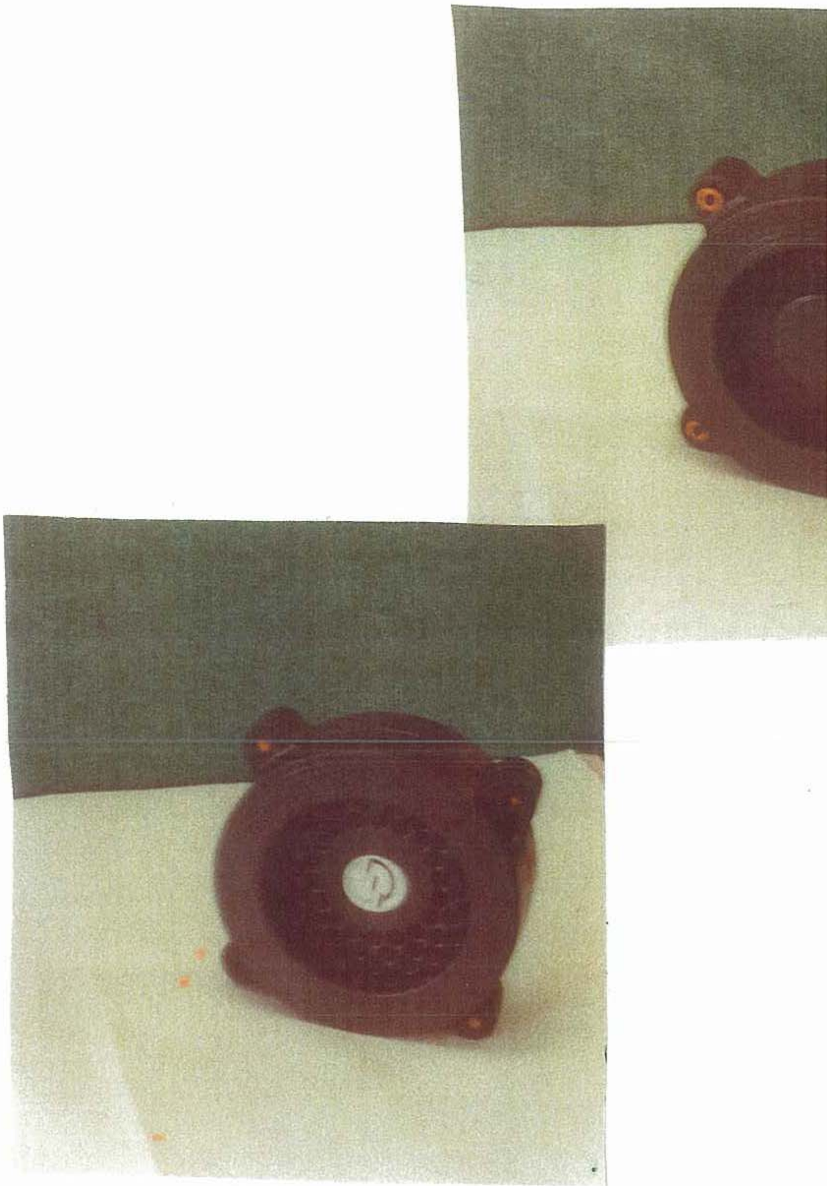
Standard centrifugal pump speeds vary from 1450 RPM to 2900 RPM, high speeds generate high centrifugal forces which make the higher speed range pumps more performance and cost competitive, bearing life will be less than the slower pumps.

9.84 PUMP SEALS

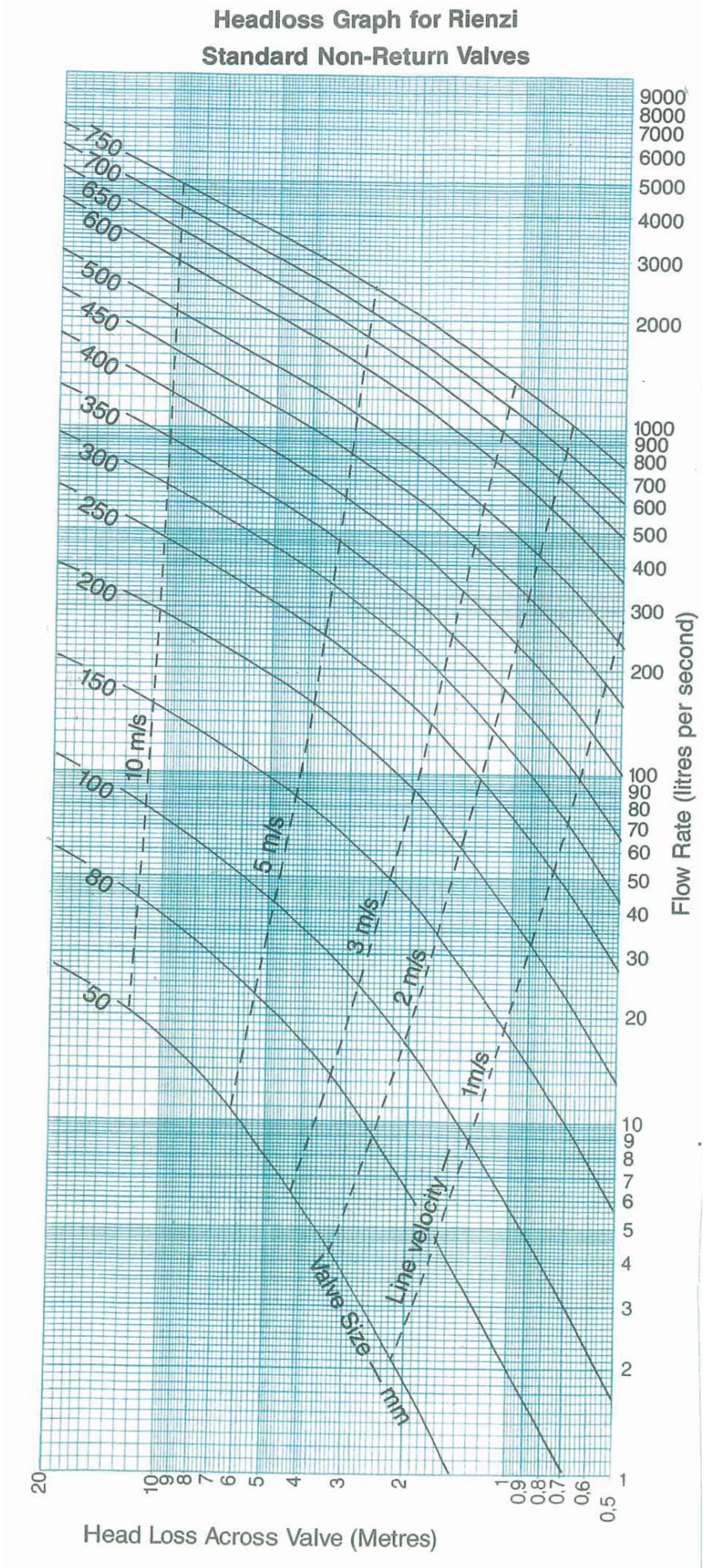
The construction of most pumps requires seals which rotate and prevent water passing along the path of the pump shaft past the bearings as a leak point. The friction at the seal and to a lesser degree the bearings at both the pump and the motor are the moving parts that consume pump efficiency.

Recent advances in technology has resulted in special materials with low friction hard surface seals that are the patent property of specialist seals companies (Crane) Seals may incorporate water cooling and small cyclone separators to remove solids that might otherwise score the machined seal faces . Existing pumps may be encountered that have stuffing box seals set to allow a known leakage rate for cooling.

In smaller pumping applications gland less pumps are used for applications where ultra-pure conditions must prevail or where the pumped media is corrosive, as is the case with domestic hot water that must be pumped with stainless steel or bronze. The glandless pump may incorporate a magnetic drive which removes the need for seals and allows wet bearings lubricated and cooled by the pumped fluid. The magnetic drive comprises two magnetic cores one separated from the other by a thin pressure resistant stainless steel sheath, the magnetic flux operating through the sheath.



This photograph shows the front and rear face of a Rienzi rul
slam check valve .The rubber diaphragm is flexed to accomm
flow will allow the rubber diaphragm to reseat in a time frame
flow reversal of hydraulic shock ,the valve is a wafer design g
with very long bolts pulling the flanges together on to the valv
valve pattern because of the high tolerance of grit and mater
jamb most other types of check valve .Resistance through th
other types of check valve.


Headloss Graph for Rienzi
Standard Non-Return Valves
750
700
650
600
500
450
400
350
300
250
200
150
100
80
50
10 m/s
5 m/s
3 m/s
2 m/s
1m/s
Line velocity
Valve Size – mm
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
Flow Rate (litres per second)
20
10
9
8
7
6
5
4
3
2
1
0,9
0,8
0,7
0,6
0,5
Head Loss Across Valve (Metres)

9.85 STRAINERS

Downstream of the pumps will be located automatic back wash duty and standby micro mesh strainers which have duties ranging from 5 to 100 micron capture size of suspended solids in the water flow ,consideration should be given to the acceptable level of suspended solids (50 micron) as the removal of very low micron sized material (5 Micron and below) can be an expensive use of back wash water ,consideration of utilising back wash water for none potable use should also be considered .Where ultra-pure water systems are supplied the design will incorporate point of use micro filtration as a primary treatment .

The automatic micro-mesh strainers are located downstream of the pumps to ensure sufficient pressure is available the strainer to overcome screen resistance and operate the back wash function.

The automatic strainer back wash may be activated by a high pressure drop reading across the micro mesh strainer, the back wash first flush flow will be more polluted than the water that follows, if back wash is to be reclaimed the first flush may be discarded. The automatic back wash device is vulnerable to failure which can result in significant water loss if not recognised, a paddle switch in the back wash drain linked to a time delay should be fitted to alarm excessive running times. In addition to back wash overrun, when the duty filter is in back wash mode the flow must be diverted to the clean standby filter, this automatic change over function must be a seamless transfer without interruption of the service flow.

The advantage of suspended solids removal is found in the wear rate reduction of moving parts that interface with water as the lubricant, valves o ring seals, pumps and thermostatic mixing valves that have very small water paths and valve seat clearances and are vulnerable to sediment interfering with the sensitive moving parts ,in addition the presence of suspended solids tends to provide a habitat for bacteria ,and can also form a shadow that protects bacteria / virus from ultra violet irradiation in other systems.

9.86 ULTRA VIOLET IRRADIATION

UV irradiation comprises an ultra violet emitting lamp or lamps bombarding a thin stream of water through a silicon sheath ,there are both wet and dry systems ,the dry system is recommended ,this system uses a number of lamps surrounding the silicon water stream column ,few shadows are possible ,the wet system comprises the lamp as the core of the silicon water stream.

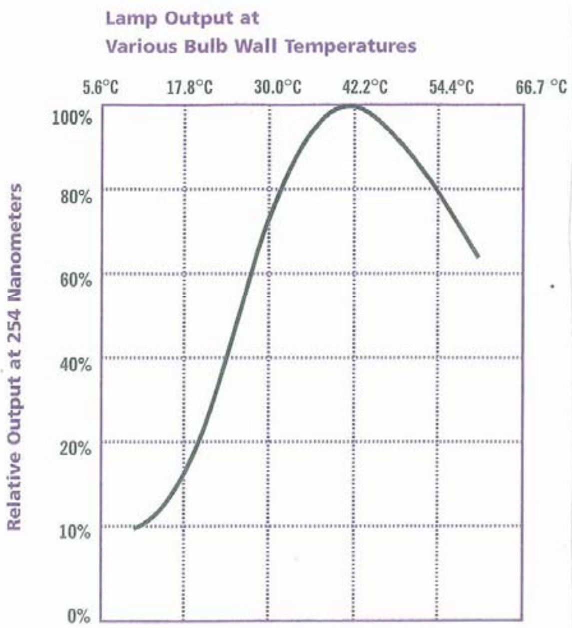
UV is used to sterilize the water delivery stream of central warm water systems, however the terminal point of a warm water system will mix the warm UV irradiated water with a small proportion of Non-irradiated cold water.

Whilst the most probable location for Legionella to survive and multiply is in the near blood heat warm water system, the terminally mixed cold water is not treated for Legionella, but it is cold water that is the source of dormant Legionella that becomes the contamination problem.

Whilst not currently practiced for the pre-treatment of cold water to be used for potable water use, UV irradiation at the potable cold water source could be considered a good health care investment.

UV lamps have a limited viable sterilising effect life span, but will continue to produce visible light with no apparent difference; U.V systems must incorporate useful lamp life warning systems to the BMS, where multiple lamps are use the life spans should overlap. Intense UV light is dangerous to the human eye; systems must be duplicated for constant UV exposure and shall incorporate automatic shut down as an OH&S initiative. UV systems should not be by-passed.

ULTRAVIOLET TECHNOLOGY OF AUSTRALASIA PTY LTD - WATER DISINFECTION AND TREATMENT EQUIPMENT
ENVIRONMENTALLY SAFE - PROUDLY AUSTRALIAN MANUFACTURED



100L

The Model 100L will disinfect up to 8 litres/sec. (480 1/m) of clean, clear quality drinking water *(with < 5 N.T.U turbidity, 5 HU units of colour)* or 4 litres/sec. for secondary treated effluent.

The Model 100L will disinfect cooling tower* water, control Legionella pneumophila bacteria and also reduce algae growth with some Hydrogen Peroxide.

Model 100L will disinfect hydrotherapy, swimming and spa pool water in conjunction with an oxidant residual.

Operating pressure: 207 kPa (30 psi) at 24°c

100M

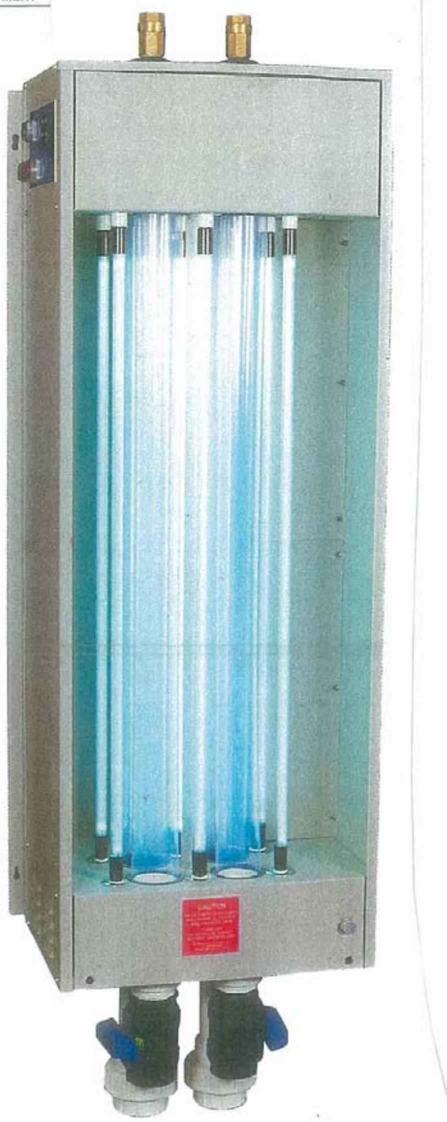
The Model 100M will disinfect up to 8 litres/sec. (480 1/m) of clear, clean water.

Operating pressure: 313 kPa (45 psi) at 24°c

100H

The Model 100H will disinfect up to 6 litres/sec. (360 1/m) of clear, clean water.

Operating pressure: 552 kPa (80 psi) at 24°c



model shown with cover removed

AFP tube UV systems, future disinfection - delivered today*

In all UVTA units water flows through *Activated Fluoropolymer (AFP) tubing with germicidal UV lamps on the outside.

The Dry UV Irradiation system

9.87 WATER STORAGE TANK LOCATION

Where the water authorities main cannot supply the peak demand of the hospital including the future projected load, it may be considered cost effective to lessen the structural burden imposed by a high level tank, and store the bulk of the water at low level in the building using building volume that is considered more suitable for plant than medical services, and locate a smaller Day and peak load buffer tank , at high level in the building to provide a measure of reserve gravity fed water capacity.

To save pump energy and to take advantage of any available viable mains pressure, the upper level tank could be fed from both the direct mains connection, and the lower tank reserve, such a system should ensure that a proportion of the daily consumption is supplied through the lower reserve tank, this is to ensure turn over and residual chlorine content.

Bearing in mind that the modern hospital requires a working minimum pressure of 25 metres head at the most disadvantaged fixture location, it is most probable that the potable cold water reticulation from the tank will require a line pressure booster pump, in most cases this pump will be a flooded suction centrifugal with VSD motor drive triplex pump set, this should be power supplied from the essential services electrical supply.

Such a system imposes a critical component label on the pumping plant; it also negates to some degree the advantage of a high level tank.

The cost implications to structure of a high level tank, and the absorption of prime floor area and the added pumping costs to raise the water to the storage level and then boost that pressure are considerations that may favour low level mains fed storage tank.

9.88 COMPARTMENTS

The Potable domestic cold water tank must have a minimum of two interconnected compartments which allow 50% shut down for cleaning and maintenance. The material of the tank including any linings or water proof sealing paints must be nontoxic and approved for the purpose ,concrete tanks should be sealed ,the walls of a concrete tank at low level in the building ,should not interface ,or be a structural component of an outside retaining wall that has direct contact with ground water ,or cannot be inspected. Tanks storing different use water supplies should not have common partitions. There should be a leak detecting air gap .Bolted sectional tanks require internal supporting stays of grade 316 stainless steel ,sectional tanks should be external bolted with a smooth face interior. All large tanks should be secured according to the local Earthquake Code. All tanks should be provided with OH&S compliant access.

9.89 PIPE WORK TO TANKS

The two compartments for tanks in most cases means a manifold or marriage pipe with valves at each tank connection ,the tank connecting valves have conventionally been gate type ,however this is a low pressure application and a butterfly valve or similar low resistance full way valve should be equally acceptable.

Each compartment of the tank will require a fill point, very large ball float valves are cumbersome and tank depth demanding valves, a remote pilot operated Bermad diaphragm valve is recommended, such valves require only a 15 or 20 mm pilot ball float valve, the system can if required accommodate a delayed action ball float valve to allow a predetermined pumping period, and the pilot line can incorporate a globe valve which will regulate the closing time of the main valve.

9.90 CONTROL FLOATS

Control floats or other level control , in each tank compartment is poor design, floats ,or electromagnetic level control units should be located in a vertical vessel fed from the marriage pipe by a valved connection ,the vessel should be provided with a 20 mm drain and sight glass for control system testing and readjustment of levels as may be required. Snap action on off float switch levels may comprise the following, Digital float switches will require a modified design.

Overflow alarm.

Level Alarm.High

All pumps (Supplying the tank) Off

Pump 2 Standby On

Pump 1 Duty Pump On

Abnormal Low Water Alarm non-essential fixture supplies may be closed; this will almost certainly draw attention to the problem.

Dangerous low level alarm. Pumps drawing from the tank de-activated, also alarm given

9.91 HOSPITAL HOT WATER STORAGE GENERALLY

A storage volume of 35 litres per bed with a one or two hour re-heat potential provides a level of comfort that there is a reserve capacity of hot water available to allow maintenance and repair of the heat source that provides the hot water.

Westmead Teaching Hospital has an allowance of 35 litres per patient bed; a total of 35,000 litres approximately spread over 7 storage vessels each 5000 litres volume. (A 5 Star Hotel may have hot water storage based on 70 litres a room residential varies to the probable population 25Litres for a Studio dwelling going up the scale to 90 litres for a large dwelling, pretty much a pro-rata to the shower load).

In addition to the maintenance facility, the provision of hot water storage will act as a peak load buffer thus spreading the thermal load to an average input and less expensive plant.

Pre-heating cold feed water to Domestic Hot water systems is a preferred method of capturing waste heat, and solar heat that will be available in time frames out of phase with domestic demand. The size of cold feed preheat will be determined by the temperature and quantity of waste heat available, for solar catchment area, it will relate to the consumption estimate.

Health Care Research units ***(Which have few, if any patients or beds***) with very large laboratories, and animal containment, including non-human primates, which have cages that require pressure jet washing and sterilisation the cage washer consumption will be provided by the equipment manufacturer or supplier and it will relate to the animal population and of the frequency of washing required.

Laboratory Fume cupboards do not often have hot water supplied, laboratory glass ware will require washing machines which will have load data load and cycle data.

Where lab sinks require hot water (And they all may not require hot water) the load estimating will vary with the type of work undertaken. E.G Biological or Chemical, the user group for the laboratory may provide guidance on hot water consumption, however a laboratory is essentially a work shop, the experimental work undertaken will vary, and it is a flexible work load.

Load assumptions based on the maximum, or peak flow to fixtures, and the number of persons working in the laboratory that may use those fixtures, over a given time frame, can provide a reasonable basis of design.

The Green Star design rating tool based on a review of 23 international case studies shows a maximum annual energy use 1650MJ/m² (70% proportional lab area) and maximum annual water consumption of 65L/ m² ***(Target reductions of 40% approximately equate to a 5 star rating inoperation, this is considered an optimistic target, bearing in mind that harvested rain water use in Laboratories would not be considered an acceptable proposition by most designers.)***

For hot water services a heat exchanger that has peak load buffering capacity (ROTEX or similar) and a one hour heat up period is a near unbreakable system of instant load capacity plus a buffer for or unusually high loads ,or design error. Heat loss recovery in laboratory no potable hot water may require a small pump and SWEP welded double plate heat exchanger circuit.

In the initial estimating stage, where little is known of processes and personal numbers, the actual volume of the lab sinks served, multiplied by a pro-rata volume assumption is a simplistic preliminary design methodology.

9.92 STORING HEAT OR WATER? THAT IS THE QUESTION

The concept of hot water storage is simplistic and common place in hospital installations .However by comparison the Edwards and ROTEX and more recently released RinnnaiHEX 250 unitconcept of the storage of heat is not well understood and less used in health care, which is unfortunate. Our mechanical services cousins have used ice and thermal storage for decades to minimise plant peak loads.

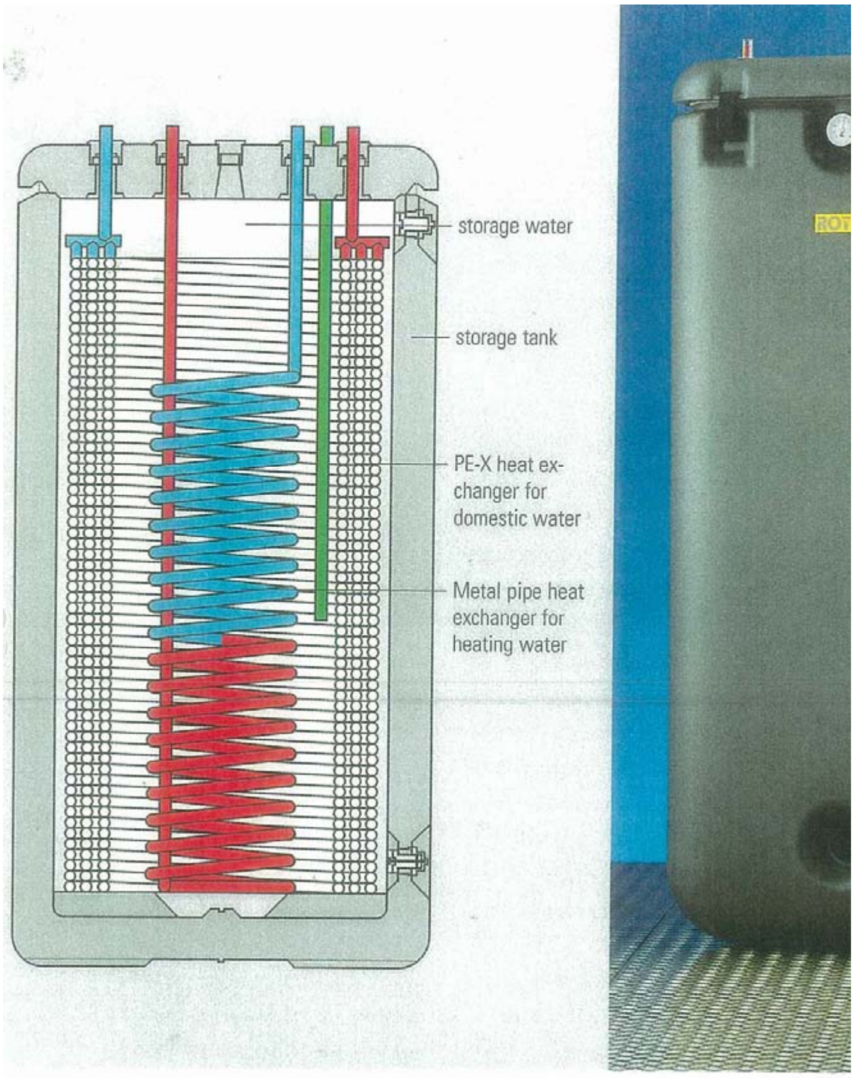
The heat storage system has considerable advantage in respect pressure balancing of hot and cold water services, corrosion resistance, and Legionella resistance.

The habitat for Legionella in a heat storage system is very difficult to evolve because the high velocity flow that scours the heat exchanger wall with velocities up to 5.5 m/second for high grade stainless steel exchangers, and prevents the formation of biological film, whereas a water storage cylinder will accumulate sludge and will have a lower temperature zone below the heat source that provides an ideal habitat.

Note:-

Velocity above 0.9 m/s is not recommended in copper heat exchange tubes or boilers

As noted the proposition of storing hot water for direct use, or storing hot water as a means of storing heat energy is demonstrated by the 500 litre ROTEX Sani-cube and the Edwards system both of which store heat energy , and differ from the hot water calorifier ,or pressure cylinder ,or atmospheric insulated tank ,that all store hot water for direct use.



ROTEX
The 500 and 250 litre Rotex thermal storage polypropylene bucket is most use
heat in a manner that reduces Legionella probability and pressure problems, S
exchanger tubes are available and recommended for Health Care work.
Similar systems are marketed by other companies.

9.93 DESIGN DAY COMFORT HEATING LOAD

The Design day load is calculated based on the outside air temperature conditions that can be expected at 6AM on the shortest (And coldest) day of the year.

The heating appliances that deliver the hot air or radiant heat are sized to heat the entire air content, and accommodate the thermal loss of the system, and heat the cold building fabric in the coldest possible climatic conditions that the geographical area has historically determined as the design day .In most cases when the hydraulics designer requests heat for heating domestic hot water, it will be added to the design day load.

9.94 THE DOMESTIC HOT WATER LOAD PROFILE

The reality is that the peak domestic hot water load is unlikely to be at 6 AM, not even on the coldest day of the year. The hospital domestic hot water load profile will come on line when the active patients wake up and later wish to shower (The main domestic load other than laundry and kitchen and sterilizing) .The kitchen load will probably happen in the night shift who will prepare meals for the coming day and clean up the residual work of the day before, the laundry may even be off site or a 9 to 5 operation and sterilizing loads are consistent and steady to maintain stocks as required.

Considering the domestic hot water load, the active patients may wake up in a similar time frame for breakfast, however some will be unconscious for medical reasons, some will be incapacitated and not able to shower and some will need assistance to shower which requires staff who are in limited supply, and some will shower unassisted in their own time frame.

In some hospitals the patients will not have an en-suite shower and will be sharing, the simultaneous demand is not high. It is a load that would in most situations not impact on the comfort heating load that has already met

its peak load demand probably two or three hours before and in doing so
endowed the building fabric with some thermal inertia, and is probably facing improved outside air conditions.

The proposition to have the boiler flow passing first through a very efficient plate heat exchanger that first heated the domestic hot water certainly works on modest sized projects, a minor problem might be that comfort heating systems that heat air, tend to need higher than 65 degrees centigrade for efficient water to air heating coils, the flow may be at 85 degrees C .However the comfort heating return would be a viable source, with three way modulating valve thermal control to avoid very high temperatures.

9.95 PRACTICAL CONSIDERATIONS REGARDING WATER STORAGE UNITS

The size of the storage tank modules should be decided by the size that can be transported to the site, the site crane capacity, and the size that will fit the plant space and that could be replaced at a future date with the provision of plant room access for replacement of major items.

The life expectancy of hot water storage vessels that contain changing potable hot water should be consistent with the life expectancy of the building; vitrified mild steel with sacrificial cathode corrosion protection as manufactured for the White goods market, is not considered appropriate because of the release of Magnesium and Zinc into the potable water stream. Such systems have a satisfactory domestic use life expectancy and are not considered sufficiently durable for the life required and arduous use that is imposed in health care buildings.

Fabricated Copper, particularly for insulated atmospheric tanks is a historic material with a long life, but has limited pressure resistance, silicon bronze alloy is a suitable material for hot water pressure vessels but is high cost with a long life, stainless steel of the appropriate grade is excellent, welded alloy pressure vessels will require stress relief heat treatment to prevent long term stress corrosion.

9.96 PRESSURE DIFFERENTIAL BETWEEN HOT AND COLD SYSTEMS

Pressure differential between the Cold water services system and the hot water services system or warm water system should be minimal, particularly where a central system is to be used, pressure parity with a maximum differential of 10% is important to ensure the satisfactory operation of thermostatic mixing valves.

9.97 INSULATED DOMESTIC HOT WATER STORAGE TANKS

The storage method of domestic hot water as favoured by the N.S. W Department of Public works from about the period 1950 to 1975 was the insulated In all of the storage options available for health care it is important that pressure parity is maintained corrugated copper sheet atmospheric tank, these are manufactured to maximise economy of construction by a number of specialist copper, bronze and steel fabrication companies.

The tanks, or hot well as sometimes referred to, are circular in plan with a fixed domed cover to stiffen the construction, the cover was provided with an access port. The point of the dome cover provided a point for venting usually a Shepherds crook type, the base of the tank was located on a structurally sufficient foam glass pad and the sides and cover insulated with an option of materials ranging from fibre glass to expanded foam, the total package being zinc anneal or steel sheathed.

Connections to the tank comprised a primary and often thermo siphon circulated flow and return connection ,these connections being in the order of 100 mm or larger in diameter are located at low level and at a level near the minimum top water level ,the primary flow and return connections would on many projects drop several levels to the ground or basement level plant room and connect to a shell and tube heat exchanger that would be supplied from the hospitals main boilers ,these being low temperature , or high temperature ,or possibly in older systems steam ..

Thermo siphon systems develop comparatively low circulating pressures
measured in mm of water gauge, an 8 level building with 25 metres of flow and return columns would develop in the order of 300 mm of circulating head, hence the primary flow and return and return mains are large and fitting resistance kept to a minimum and the pipes are required to grade in the direction of flow.

The cold feed for this system will join the heat exchanger and originate from a cold feed tank located at the same level as the hot water storage tanks. In some systems the cold feed is combined with the thermo siphon return with the inclusion of a heat trap in the cold feed.

As with any vertical vessel storing hot water the internal convection currents in the vessel will stratify the hot water layer from the cooler water below it ,this separation of temperature zones is resolved by a uniquely Australian devise "The floating draw off" Which comprises two interconnected screwed thread elbows at the low point ,the second elbow is extended to a bell mouthed scoop facing down to ovoid vortexing ,the arm is supported by a 225 mm copper float which raises and lowers the scoop and draw off arm to a point that remains in the hottest water zone of the vessel .

Whilst the thermo siphon and atmospheric storage tank may appear antiquated, there are advantages to these systems.

The atmospheric 65°C hot water storage tank is a safe and cost effective manner of containing very large volumes of hot water; the tanks have a minimum life expectancy of 40 years. The tanks do not require any pump energy to circulate, or any pump maintenance or replacement, they do not require balancing valves, the laws of physics takes care of balancing and they do not require any sophisticated control system, that is limited to the control at the heat exchanger.

9.98 INSULATED CYLINDER STORAGE PRESSURE VESSELS

The mass produced pre-insulated vitrified glass lined corrosion protected with sacrificial anodes pressure vessels are possibly the most familiar and successful type of domestic hot water storage vessel marketed in recent history ,used prolifically in the residential market as electrical heated ,gas heated ,or for storage volume only ,the domestic market cylinders whilst eminently suited for the speculative trend of the domestic market , as noted, corrosion protected mild steel systems are not considered to have a life expectancy consistent with the requirements of a health care installation .

Where pressurised hot water (As opposed to heat) storage is required the preferred option is pre-insulated stainless steel cylinders of a suitable steel grade are considered suitable for health care use (Wilson)

The nature of a domestic hot water vessel is that they are in fact a large vertical pipe and in that large pipe the water velocity will be very low, in the laminar flow range. (***Also true of tanks)***.The domestic hot water storage vessel is supplied with changing water for consumption, unlike the comfort heating system that uses water only as a medium to convey heat, in the domestic system there will be a near maximum of availability of oxygen and possibly some chlorine residual, all of these factors compliment the corrosion activity of glass coated protected ferrous metal.

The changing water also contains suspended solids some of which are the result of corrosion due to the breakdown of protective coatings and sacrificial anodes, and some suspended solids in the water supply, despite point of entry micro mesh straining, the material which is not gram negative has weight and gravity which will act on them and they will accumulate over time at the low point in vessels of all kinds that have near stationary water movement.

In vertical hot water cylinders, much the same as in tanks, the heated water content will stratify .A heating tube element in a calorifier, or the electrical element of a domestic heater which are located near the bottom of the vessel will stimulate the flow of heat upwards, below the heating input will be a cooler zone.

We find in a corrodible hot water storage vertical cylinder in a health care installation the following undesirable proposition.

Corrosion fed microorganism in a sludge habitat in the base area cool zone below the heat input.

A resident user population that are physically debilitated, including possibly their immune systems.

9.99 THERMAL STORAGE HEAT EXCHANGERS

Thermal storage heat exchangers or Thermal Storage Stations, do, as the name implies store heat and not water. Thermal storage can be a purpose designed plant or can be purchased as a supply item. Such heaters are manufactured by Rinnai Boilerland Edwards and ROTEX sani cube which is a unit imported from Germany.

The Thermal Storage Station is a composite of standard parts and warranties for those parts , comprising a static water storage media which may in the future be enhanced with eutectic salts phase change compartments ,circulation pumps for exchange efficiency and external self-cleaning heat exchangers ,refer drawing

The advantages with the thermal storage are.

They can effectively deliver hot water instantly transferred from a stored volume of heat.

The atmospheric thermal storage vessel is not a pressure vessel, or back flow hazard. Refer Sydney Water diagram designed by R Allerton dated 29-1-1965 approved W Harris Engineer House services .The design of this diagram was many years ahead of its time and resolved the cross connection issue of heat exchange with High Temperature Hot water services and Steam services by interposing an atmospheric transfer medium which would remain at a lower pressure than the primary and secondary services ,thus insuring back flow protection having equal security to the now popular RPZD Unit .

The water velocity in the stainless steel heating coils or plates is high, suspended solids or corrosion residue is not an issue.

The bucket or container can accept two coils for primary heat input at a high pressure (steam ,HTHW solar)

The Thermal Storage Station (TSS) can accommodate any number of contributing heat sources, solar. Hot gas to water, primary services high temperature hot water, or steam, it is eminently suitable for hospitals, where the domestic load may need to be buffered in favour of the comfort heating load, or where numerous waste heat sources can contribute.

Very high insulation values with the ROTEX Polypropylene bucket

The units cold feed can be the pump pressurised cold water system VSD pump common pump sources and balanced hot cold pressures are feasible.

The atmospheric pressure of the heat media (water) is very low pressure compared with the coil ,this is added protection from direct water exchange cross connection contamination

The bucket or storage water heat content can theoretically be amplified by eutectic salts or similar phase change materials that take advantage of latent heat output.

The system is eminently suitable for solar contributions where heat availability and load profiles do not synchronise and high heat outputs can damage components in the distribution system.

9.100 THE BOILERLAND SYSTEM

The Australian Boilerland system is a sophisticated and unique system that combines the advantages of a high efficiency downdraft gas burning boiler with plate heat exchanger technology and quality automatic temperature control motorised valves.

This unit will deliver domestic hot water up to 85°+ for kitchens or sterilisation departments ,and water controlled to 43.5°C for patients use .The efficiency of plate heat exchange is complimented by pump circulation as is the secondary return reheating process .

The water content of these units should give a thermal reserve that prevents hunting and the pumped boiler side circulation should minimise heat loss through a dead standby unit.

System Design

Rinnai's commercial team can design a solution utilising HEX250 Systems to meet your brief, whatever t
approach: HEX250 tanks, pump kits and manifolded HD heaters are packaged separately for easy handlir

Designed and made in Australia and backed by Rinnai's global commitment to quality

HEX250 systems are engineered and manufactured by Rinnai in Australia. Our systems are backed by Rinnai technical service and support, providing a complete solution with the assurance of 40 years of trusted quality and workmanship.

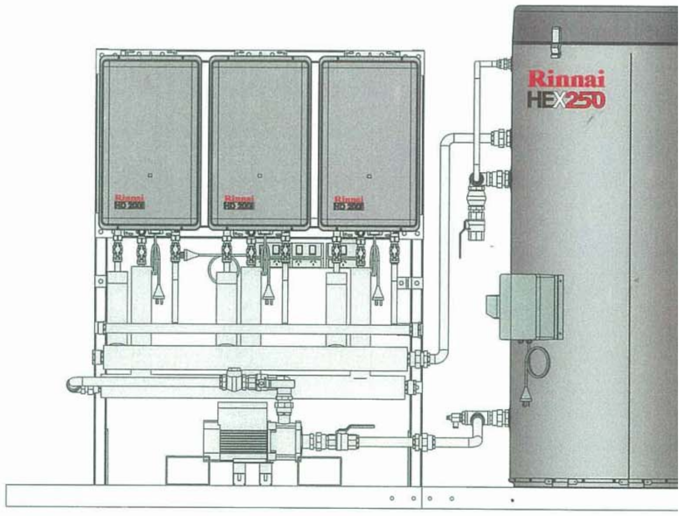
The Coils

The HEX250 coil set is made up of 4 replaceable 316 stainless steel / inox coils in parallel, delivering high thermal capacity, high flow rates and low pressure loss. As the 32mm headers are also stainless steel, all wet areas are designed to withstand corrosion and deliver long life. Alternate Coil material is available on request.

The HEX250 coil set is designed to deliver the hourly hot water demand as well as the higher than average peak flow rates experienced periodically. Selection for accommodation (apartments and hotels) will usually consider both the peak hourly demand and peak flow rate. Selection for shower blocks will usually consider the peak flow rate, as that is the key parameter.

Filling System

The HEX250 tank includes an industrial grade float valve to automatically maintain primary water levels, without the need for an external header tank.



Skid Mounted

Complete systems can be assembled and skid mounted in Rinnai Australia's state of the art factory us
Complete systems can be split into individual skids for transportation and lifting into position. Skid mount
electrical, cold, hot, return and gas connections before operation.

Design Consideration

Dual Circuit Hydronic Heating

The HD units heat the stored water in the tank. The thermal energy in this primary circuit can be considere
external processes, such as hydronic heating

Alternate Heat Sources

Other external heat sources can be used to heat the primary water, in place of HD gas continuous flow wa
heat sources will influence the performance of the heat exchange coil set.

9.101 THERMAL MASS STORAGE-HEAT TRANSFER

A consultant designed variation of the Boilerland Edwards and Rotex and Rinnai design is the thermal mass exchange system which has high efficiency and is very flexible in that it can accept application to varying heat sources .E.G Waste heat Solar Heat Direct fired steel boilers.

Comprising bulk thermal storage (The bucket) as required and with a Secondary thermally engineered plate exchange for the domestic hot water delivery system, with a one hour heat up delivery of the base heat storage, this provides a near unbreakable delivery system.

To accept the differing system pressures of central heating hot water systems the primary source is a thermally engineered SWEP plate exchanger which will accept primary temperatures of 95 degrees centigrade. Where a local boiler, or as an option an instant gas heater is the designers choice these are an acceptable option or auxiliary heat source, as is waste heat or solar heat.

The mass storage system has a control system that will regulate by variable speed motor control the flow rate through the heat exchanger to give a predetermined delivery temperature to fine limits.

The mass thermal storage for this unit ensures that changing water corrosion is limited to the secondary reticulation system. The mass storage may comprise insulated copper tanks, or insulated sectional steel tanks, or should the opportunity prevail concrete storage tanks .retro fit applications with the sectional plate tank is viable, as is the use of decommissioned storage tanks used for other purposes.

9.102 ARTICULATED SURFACE CONTRA FLOW PLATE HEAT EXCHANGERS

Plate heat exchangers are made in two basic types .The SWEP Brazed heat exchanger which can be used for water to water or for refrigerant gas to water to recover waste heat from the hot gas line of chillies and similar refrigeration plant .In hospitals the waste heat from kitchen refrigeration and mortuaries is available for heat recovery and use, but is seldom used. Coles and Woolworth's super markets have no problems in understanding that such systems are environmentally positive and commercially profitable.

The resistance to hot gas to water exchange as a design innovation applicable to AC Chillers appears to come from the chiller suppliers who do not manufacture the machines locally and possibly fear that such modifications will compromise warranties.

The sealed and brazed heat exchanger cannot be taken apart and cleaned in the same manner as a demountable plate heat exchanger , the sealed plate design is self-cleaning but when used in very hard water conditions at high temperatures cleaning with 5% phosphoric acid or 5% oxalitic acid ,this may be perceived as a disadvantage by the maintenance team .However the SWEP units are designed to have a very high and turbulent water flow velocity across the articulated plate surface (5.5 m/sec minimum) This high velocity serves two functions .It increases the transmission of heat by destroying any film resistance to heat transfer ,and it prevents the accumulation of minute suspended solids that may have passed through strainers or filters ,it is a self-cleaning design.

The option to a sealed plate heat exchanger is the demountable plate exchanger with seal gaskets as marketed by Alfa Laval, the demountable units can be serviced with a replacement module which removes as a unit the dirty plate pack and replaces a new unit in 2 hours, the dirty plates are acid cleaned to remove scale and returned to the project for the next maintenance of plates.

The cost of a replacement pack or the option of site replacement of cleaning and replacing gaskets is higher than the cost of replacing a sealed plate exchange unit which can if required be work shop cleaned. As with most plant that may require servicing a 50% or 33.3% plant configuration is recommended

The contra flow articulated surface plate heat exchanger is a most efficient device; it requires pumped circulation on both sides of the system. A less efficient and 25% more expensive plate heat exchange version with an air gap protection layer between plates is available for both types of plate exchanger and is used where the primary heating service will be at a higher pressure than the secondary service, and the primary service is chemically treated and considered a probable contamination source in the event of a plate perforation. The logic of the plate failure assumption is doubtful bearing in mind the quality of the plate engineering; however logic and mandatory regulations do not always travel together.

As noted minimum constant flow across both sides of a plate heat exchanger is desirable to allow precise calculation of the heat exchange efficiency, also storage in the secondary, or cold side of the system will act as a buffer to spike loads, the storage reduces some of the heat exchange variables that will occur when the hot side of the exchange is 65º- 80ºC and the cold side 15- 65ºC.

The variation in water velocity, as will be expected with the varying cold feed source serving the varying hot water draw off load, also the variation in temperature from the 15° cold feed to 60°C the return temperature mix, can be removed as a variable in minimum flow if a branch connection from the flow mounted secondary system circulating pumps is also diverted to join the secondary return and cold feed,this configuration gives a near constant flow rate through the heat exchange system, however this is not a conventional arrangement.

As an example. If a notional hot water system requires a domestic hot water supply of 2 litres per second of water heated from 15-65°C the Plate heat exchanger must transfer

7200 kg x 4.186 kg/kj x (15-65) /3600 = 418.6 kW

The plate heat exchanger varies in its transfer rate efficiency dependent upon the speed of the water over the heat transfer plates also turbulent flow gives much more efficient transfer than laminar flow ,the 2 l/s supply load of the example will be a gradually rising surge to the peak ,if the system provides a constant flow in the low flow times there will not be any low velocity low efficiency cooler flows through the exchanger plates, when the peak cold feed demand cuts in ,it will do so at a much greater pressure than the pumped flow, thus the temperature / demand gradient will be more constant .

Simplistically the circulating pump in the example would be 2 l/s + system pipe loss say 0.75 l/s

It is noted that heat exchange calculations for plate heat exchange should be based on the Log to base e mean temperature difference ,calculations of this complexity will be undertaken by Alfa Laval and SWEP if provided with the basic heating requirements ,also SWEP provide computer down load spread sheet data for this type of calculation

Abnormally high pressure drop across the plate heat exchanger at constant flow is an indication that the small water passages of the system are being obstructed and the unit needs replacing or cleaning, or a plate pack exchange.

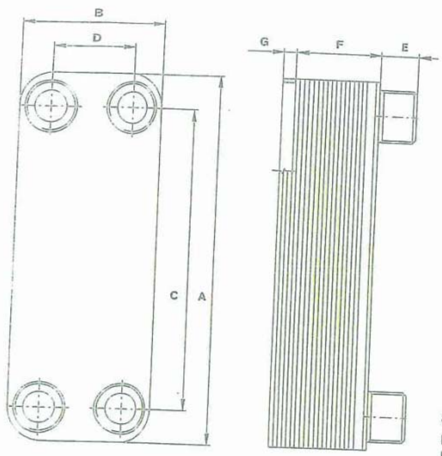
The domestic temperature gradient will normally be 65° flow 60° return.

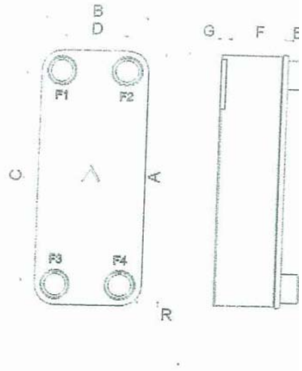
The mechanical services heating system may differ from the domestic temperature gradient to provide more cost effective coil design for air heating at 85 flow 65° return or temperatures of that order. (Systems vary)

The important issue on the secondary side of the system is that the hydraulic designer incorporates thermal controls that do not allow temperatures of above 65 degrees centigrade to enter the domestic services system.

The control of temperature is located in the primary system and the control sensor is in the secondary system, a three way modulating valve in the primary system gives better control for instantaneous water heating than a simple on /off arrangement which can be appropriate where storage provides a buffer to spike temperatures.

NOTE: -MOST THERMOSTATIC MIXER VALVE TEMPERATURE
CAPSULES HAVE A SAFE UPPER TEMPERATURE LIMIT, AS DOES POLYMER PIPE MATERIALS.
THIS IS ADESIGN ISSUE ALSOVALID FOR SOLAR SYSTEMS.





Model	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	G (mm)
B10DW	287	117	243	72	20	4.4+2.34×NP	6

NP: Number of plates

Standard material

Plates and connections	AISI 316
Brazing material	Copper 99.9%
Channel plate thickness	2×0.20 mm
Connection	1"
Weight (empty)	1.5+0.126×NP kg

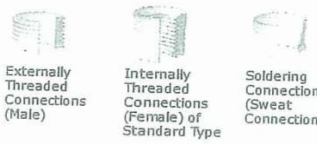
Operating conditions

Operating pressure	up to 31 bar
Operating temperature	up to +185°C
	down to -195°C

SWEP reserves the right to change the design without prior notice.

Standard connections

For specific dimensions, or information about o
representative.



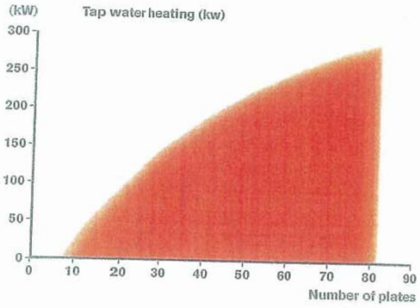
TECHNICAL DATA

Max working pressure at 155°C:

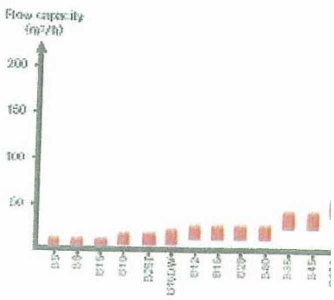
Max working pressure at 225°C:

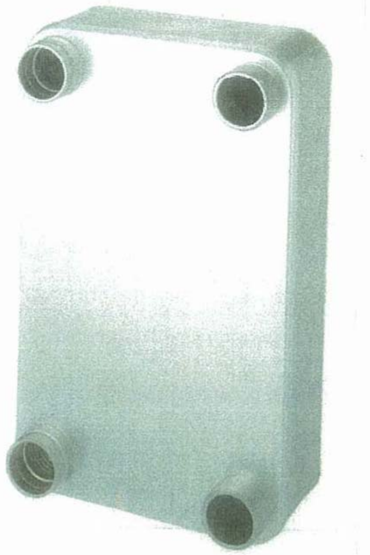
Test pressure:
Min temperature:
Max temperature:
Max number of plates (NoP)
BPHE weight
Plate material:

Brazing material:
Standard connection material



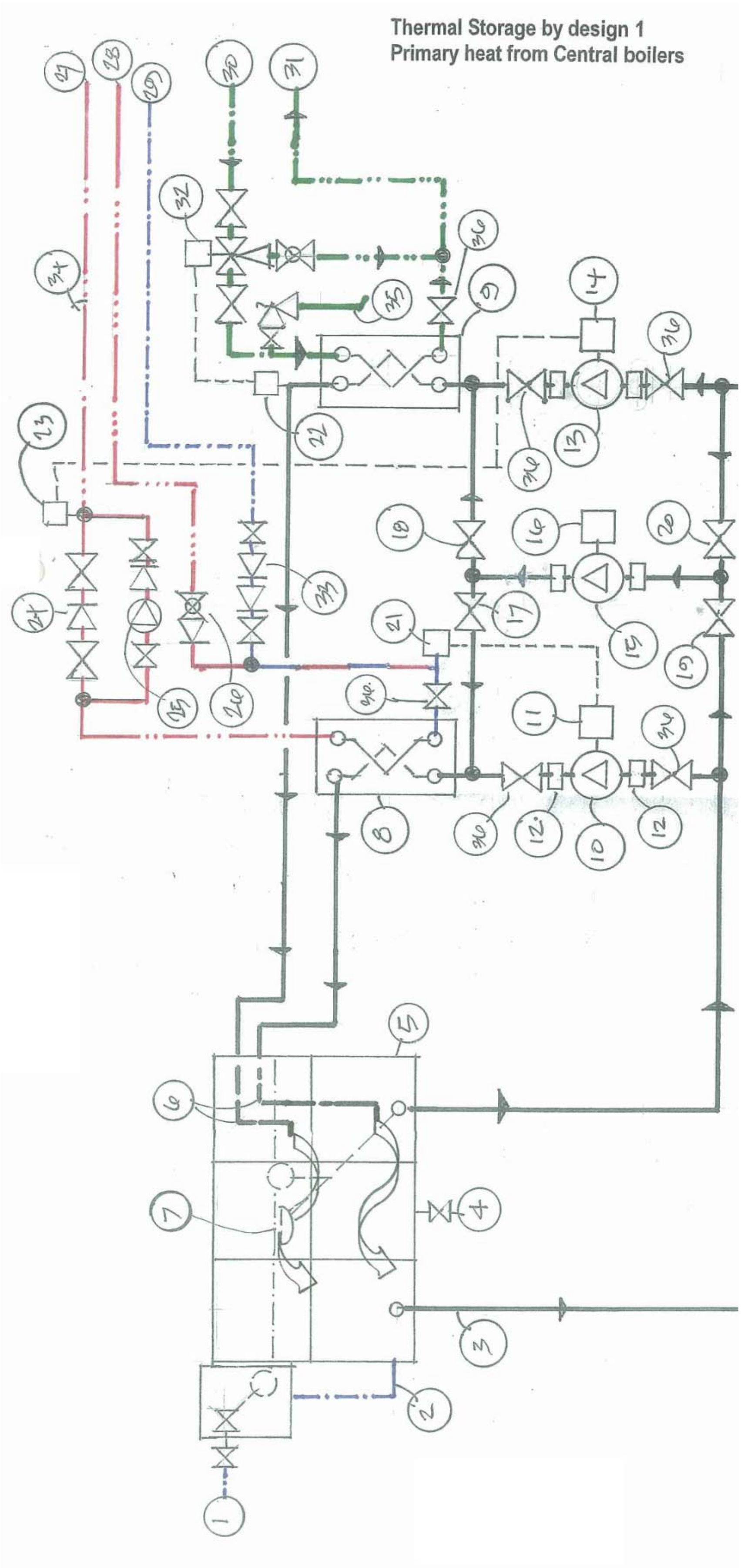
Capacity Graph

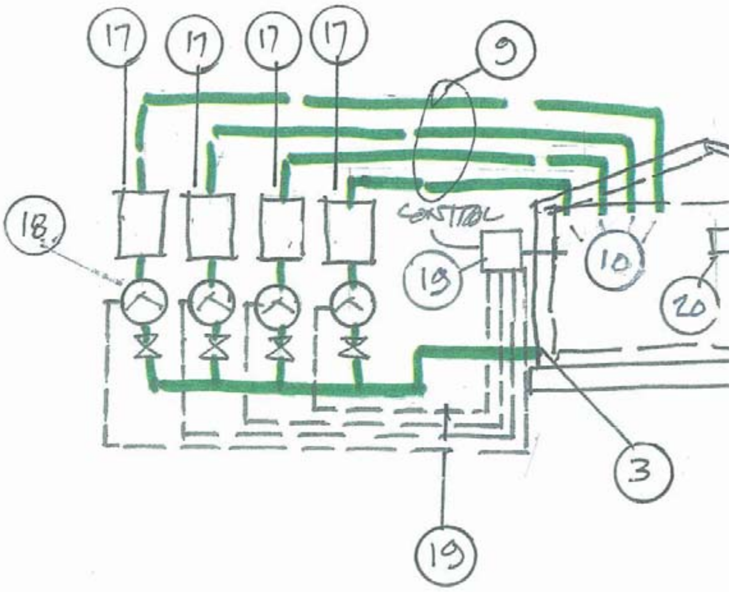




SWEP Heat Exchange'

The all welded high velocity self cleani
heat exchanger is a high efficiency ins
minimises biological slime (The Legior
water velocity in the plates, available a
health regulations require .Maintenanc
acid washing or exchange units .Duty a
units are recommended. Often used in
storage to provide a load buffer on hea


Thermal Storage by design 1
Primary heat from Central boilers



1	Make up water 20 mm	9	Multiple flows	17
2`	Cold feed side tank	10	Set input to mix below draw off scoop	18
3	Suction primary heat pumps	11	Constant flow boiler pump	19
4	VSD Circulating pump	12	Secondary HW loop	20
5	VSD Circulating pump	13	VSD 4/5 Digital speed control thermostat	21
6	Draw off by-pass check valve	14	Relief valve (typical)	22
7	Secondary circulation pump	15	SWEP Heat exchanger	23`
8	Secondary circulation pump	16	SWEP Heat exchanger	24

Red scheduled items are shown on the associated diagram using a large boiler unit

Local to load Thermal storage system using multiple 50kW Condensing boilers

Notes (19)

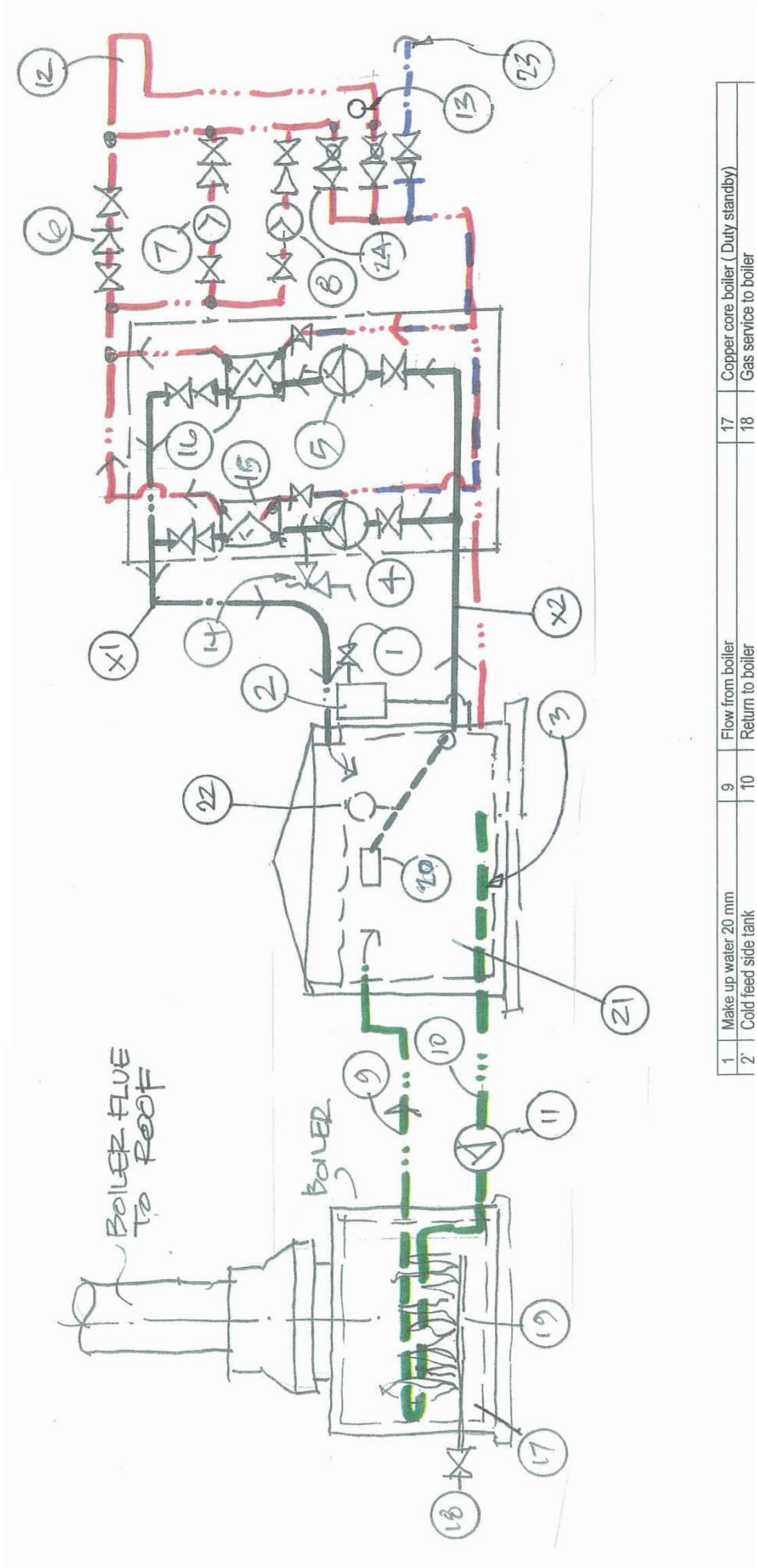
There are several advantages with this system providing that the control system is designed to allow a pr each individual pump and connected gas heater ,this must be based on the temperature of the bulk stora extremely efficient ,it is important that the control system is sensitive to low load situations and applies he heaters activating within a few seconds because one pump is used and the control is crude defeats the o arrangement. The life expectancy of the closed circuit thermal storage is very long ,the water lacking oxy heaters will also reap an advantage from this but have a life expectancy reduced by thermal fatigue , bea pump exchange ,the unit efficiency and the capital cost ,the life expectancy is considered acceptable.

As with all heat storage and plate heat exchanger delivery systems, the critical plant is the plate heat exc temperature at varying flows as determined by the draw off,the calculated peak draw off demand will be t will be the lower limit , the efficiency and exchange rate of a plate heat exchanger is related to the velocit sides of the exchange ,in most systems the primary side velocity is constant ,the secondary side in the sy elevated minimum flow (24) and variable velocity controlled by a VSD drive circulation pump on the prima the system from overheating , an important feature if polymer pipes are used.

Local to load storage and Multiple 50kW (Approximately) Gas Heaters

X1 and X2

Interface as options to the heat exchange plant shown on Local to load thermal storag boilers



9.103 LOCAL TO LOAD OR CENTRAL HEAT SOURCE

Some logic is seen in providing gas hot water systems local to load as a means of avoiding high thermal loss from extensive pipe reticulation. (Westmead Children's Hospital).

The pressure differential of multiple hot and cold systems, the thermal and "on going" maintenance and the efficiency of many small local to load systems of a domestic scale construction, compared with the efficiency of a large industrial quality engineered system that needs to run full time for various loads, would on a large project favour the central thermal station design.

However for much smaller loads where comfort heating will be seasonal and probably a reverse cycle system, the small modular local to load heat source and Hydronic heating both become more viable and cost effective.

It is probable that the life expectancy of modular systems using 50kW Gas fired condensing instantaneous heaters will be 5 to 7 years, however the units are small, portable, and replacement is an estimated maximum 2 hour operation, and such an arrangement could prove to be acceptable and convenient to an isolated and modest sized health care unit.

It is understood that flame technology renders the optimum efficiency results at systems with a heat output in the 40 to 60 kW range, where the system needs to provide greater thermal power the units are used in a modular arrangement, each heater unit may have a preheated combustion air supply usually by means of a double skin stainless steel flue which is fan powered on the cold air side. Or may use a cold feed (15ºC) to hot flue gas (200°C) heat exchanger, the result of lowering the flue gas temperature will probably result in condensation forming which will contain carbonic acid and as typical for all condensing boilers it will require drainage provisions for condensate .

Such boilers are in common use in the Europe for domestic dwelling comfort heating and domestic water supply units, the boilers are condensing boilers and have a condensate trap that captures flue gas condensate released at the flue gas heat exchanger unit.

9.104 THE ROTEX A1 BOILER

The ROTEX A1 Boiler is possibly the most advanced 50kW boiler of its type having a cast aluminium combustion chamber with integral cast in stainless steel heat exchange pipe and a variable speed combustion air fan to allow precise combustion modulation and control, to indicate the thermal efficiency of this boiler the flue pipe material is PVC,however the high technology comes at a high price that can only be justified where huge fuel savings recover the investment

9.105 THE KEMCO BOILER

The American Kemco boiler which has a direct water to flame interface and stainless steel heat exchanger is considered to be the most unique engineering design, few such boilers are used in Australia.

9.106 CENTRAL ENERGY

Where the propositions of local or central hot water plant comparisons are researched the advantage for larger projects is generally with the central system that is also provided for comfort heating and steam generation for sterilizing.

As noted the smaller to medium sized system may reap advantages from local to load, or independent potable domestic hot water, some installations have used domestic hot water to also provide the comfort heating, however in most cases the heating units used are basically domestic appliances and the life expectancy is in the order of 5 to 7years.

The Central system may be boilers or Tri-Gen plant with waste heat from
steam driven electrical generators, or waste heat from compression ignition engines or both or all.

The central system boilers are conventionally much larger than potable water boilers and as such are generally part of the mechanical services engineering scope; the boilers are more robust and utilize better engineering technology such as low nox gas burners and variable speed drive modulated burner air supply, and may incorporate dual fuel use (Gas or Oil)

Most large mechanical services boilers are constructed of steel or smaller boilers may be sectional cast iron, in order to limit corrosion to a minimum, the boiler water and primary system water content is a closed system, the water will not change, and the oxygen content of the primary water is reduced to a minimum thus the oxidisation corrosion process is significantly less than would be the case with changing water.

In some cases the comfort heating boilers will be support for, or coupled to a co-generation or tri-generation system which provides the added bonus of waste heat recovery as a pre-heat for the domestic hot water service cold feed. Pre heat can be provided from Flue gases, or a more intense heat from the hot gas line of the AC chiller, or from the cooling system of a combustion ignition engine that drives an electrical generator or as a retro fit proposition from the condenser water system flow to the cooling tower which will be running at about 38°C giving a temperature difference of 23°C which represents a significant saving in domestic hot water, and a lesser saving in cooling tower load. Where there is a Co-Gen or Tri-Gen system the boiler may be considered as the standby unit to the generation plant. Whilst it is desirable that the hydraulics designer has an understanding of Tri and Co-Gen plants because most are using natural gas as the primary energy source, the engineering in these systems is complex and developing field, possibly the important criteria to understand is the possibility of an abundant source of waste heat.

Few on site generation plants are totally reliant on the onsite plant, some will provide partial power to reduce shoulder loads, and others may have an emergency backup from the electrical grid.

9.107 TRIPLEX BOILERS

Triplex plant for a boiler or heat exchange design can be a cost effective option if each unit is 50% of the peak load .this gives a reasonable redundancy, with such systems eccentric running controls are preferred because it gives a pre-warning of probable plant life.

In a boiler only installation it is often the case that three boilers will be a feature of the design .two at 50% peak load and one at the summer running load which may comprise Domestic hot water ,Kitchen hot water. Steam generation for sterilising. Marginal weather condition comfort heating, and preheat for humidification.

Boilers for mechanical services systems may be linked to primary circulation pumps that allows control over the heat input ,the duty boiler will carry the thermal load initially ,when the flow temperature drops it indicates that the duty boiler has insufficient capacity to meet the thermal load and the second boiler and pump will cut in ,the control system will then rationalise the load as an even distribution between both boilers running ,should there be a third boiler this will have a similar control arrangement . The duty boiler and stand by boiler roles will be alternated by the control system.

9.108 CONTROL OF MULTIPLE HEATING UNITS

Where multiple water heating units are used in Plumbing Projects the control systems lack the sophistication of the mechanical services systems .Three gas heaters will join a manifold and there will be one circulating pump ,on temperature drop ALL three heaters will activate ,the only delay will be the thermostat tolerance differences of one or two degrees

The plausible explanation is that Plumbing designers are using domestic scale appliances which the manufacturers have not developed sufficiently to meet the requirements of industrial and Institutional hot water design, also there is no coordination or facilities in the hardware to accommodate reasonably simple fuel saving controls?

In recent discussions with Mr. Brian Dolly of Rinnai in respect to the recently released HEX250 combination unit of instant heaters coupled to a 250 litre thermal exchange vessel the writer was advised the in the Rinnai systems.

"Multiple *gas continuous flow water heaters are controlled in various ways, dependent on the application and design.*

Manifolded heaters on a deadleg system incorporate either a mechanical or electronic staging system so that only the required numbers of heaters are operated to match the required combined fixture flow rate. This is required as a low flow rate creates insufficient flow to start each heater and / or starting each heater will result in too high an outlet temperature. Staging stops the operation of heaters that are not required to match the load. As more fixtures open, more heaters fire up and vice versa.

When a bank of manifolded heaters are joined to a storage tank, there is usually one primary circuit circulating pump. In this case the pump is of sufficient flow rate capacity to operate all heaters simultaneously. To prevent an excessive input of energy into the tank whenever the tank mounted thermostat activates the primary pump, each and every heater will modulate its gas firing rate in proportion to the inlet temperature from the tank to the heater. Colder inlet water from the tank to the gas heater results in a higher gas input rate. This load matches the heaters to the hot water demand and prevents excessive cycling of the pump and heaters.

Both designs reduce the unnecessary starting and stopping of gas continuous flow water heaters and therefore maintain highest possible efficiency.

Note: large scale closed circuit heating circuits without a tank to store energy will incorporate a solenoid valve and / or primary pump per heater so that only the required number of heaters operate in proportion to the heating load. This is usually controlled from the mechanical services control system".

It is noted that in addition to the above, the secondary hot water supply of the HEX250 system is not exposed to an interaction with copper or mild steel, this is of considerable interest where polymer pipes are used in the secondary system reticulation, those of us interested in this phenomena will be watching the long term performance of systems with this combination.

9.109 BOILER CONTROL

As noted previously, there exists a subtle and regrettable design difference between the Mechanical engineering and Hydraulic services engineering approach to the way boilers are piped and valved to modulate on, or off line, as the thermal demand requires.

Domestic Hot water should not be piped through all (and cold) boilers or heaters simultaneously regardless of the thermal load, as is the case with most hydraulic domestic hot water system designs where typically three or more heaters will activate near simultaneously regardless of the load . A midnight baby bottle or coffee may well trigger a 200kW system in a remote plant room.

In such systems the heaters integral heat modulation is the only control modulation capacity provided at the gas burners; most domestic style gas storage heaters have atmospheric gas burners which have a limited turn down capacity. The gas heater (or boiler) should run at its most efficient thermal performance point, running three heaters simultaneously every time there is a load means that in many instances of low load, the metal content and thermal inertia, and thermal loss of all activated heaters then contributes to the inefficiency of the system.

The training of hydraulic engineers does not appear to extend to a modular andmulti (50kW) heater control systems using motorised valves and individual heater circulation pumps that are all control linked to activate and bring the system on line progressively with a modulated heat input. Presumably the philosophy is that the consumers accept a 10 year plant life and the crude status quoi design works fine. Why change it?

9.110 LARGE DIRECT HEATING POTABLE WATER BOILERS

Boilers which produce high kW outputs and utilise potable water and copper core heat exchangers have overcome the corrosion issues of a steel or cast iron boiler, but copper core boilers have the potential of releasing trace copper as a result of erosion corrosion and of melting the convoluted copper heat exchange element if the water flow through the boiler heat exchanger is not sufficient.

The Teledyne Laars “C” series offers an optional Cupro-nickel heat exchanger to prevent erosion.

To avoid the overheating problem noted, a minimum boiler work load and minimum water flow rate through the heat exchanger is essential, high flow rates compliment high-water velocity and high heat exchange rates, the high water velocity breaks down the film coefficient of the water flow within the heat exchanger which gives efficient heat transfer of heat.

The copper exchanger tube area has fined convolutions which maximises the water to copper to flame interface area and heat transfer over a minimised length, the possibility of high temperature and high velocity corrosion and the de-composition of the copper as trace metal in the water system is a matter of concern in health care .particularly where infants are the patients.

Where boilers of this design are used they often require a minimum thermal load in adjacent storage to compensate for the lack of water content in the heat exchange component of the boiler ,where the storage is provided by storage cylinders these should be stainless steel ,where vitreous (Glass coated) mild steel storage cylinders are used it is probable that the cylinders will contain zinc /aluminium sacrificial anodes that will extend the life expectancy of the vitreous protected mild steel ,in the process of corroding as the sacrifice the anode will release zinc and aluminium into the potable water flow.

The health effect of such metals in drinking water at the levels involved is not known .the sediment can be sufficient to lodge in thermostatic mixing valves and disrupt the function of the valve.

Where copper core boilers and mild steel storage with catholicprotection sacrificial anodes are used it is recommended that for health care installations, the boiler pipe circuit is disconnected by a stainless steel plate heat exchanger, this arrangement should prevent the transfer of corrosion by-products and increase the life expectancy of the boiler plant and storage units by reducing the oxidisation content of the closed circuit water.

The Chart below draws attention to Raypak models 2214-2634-3164-3694 which have constant rate pumped water velocities that are compliant with, but very near, the maximum velocities allowed by the current version of AS/NZS 3500.

1 1	992	1182	1292	1412	1722	1922	2214	2634	3164	3694	**Raypak Model**

22	65	65	65	65	65	65	80	80	80	80	Pipe Size mm
33	5.38	6.31	6.31	6.31	6.31	6.31	12.06	12.62	12.62	12.62	L/s
44	1.84	2.151	2.151	2.151	2.151	2.151	**2.872**	**2.991**	**2.991**	**2.991**	m.V/s
55	63.5	63.5	63.5	63.5	63.5	63.5	76.20	76.20	76.20	76.20	Pipe I.D mm

9.111 THE HEAT PUMP

The heat pump is a device that uses the vapour compression system that relocates heat, and amplifies low grade heat to high grade heat. Essentially using the thermal properties of phase change and the energy release as heat when a liquid evapourates into a gas or vapour (Cooling Tower) .or the energy required to change a gas / vapour into a liquid by compression. In respect to these notes the hydraulics designer does not really need to understand more than the basics of the Heat pump, Should the reader feel inclined to research more it is a subject well covered by Wikipedia ,

The heat pump used for heating requires a source of low grade heat, this can be warm air above 5°C below this temperature the COP (Coefficient of Performance is poor), or low grade waste hot water, the heat pump transport medium is for most smaller systems a refrigerant gas (These changed composition in 1990) The gas as a heat carrier has an upper limit of 60°C which means in health care some topping up to 65°C.

The waste heat can originate at the condenser water system return to the cooling tower which runs at 28/30°C A single stage compressor –condenser- liquid expansion valve –evapourator circuit will have a COP of 4.5 to 5, possibly 6 for a very good machine, this means that for every $ that is spent driving the compressor the machine will deliver $4-50 to $5.00 of heat.

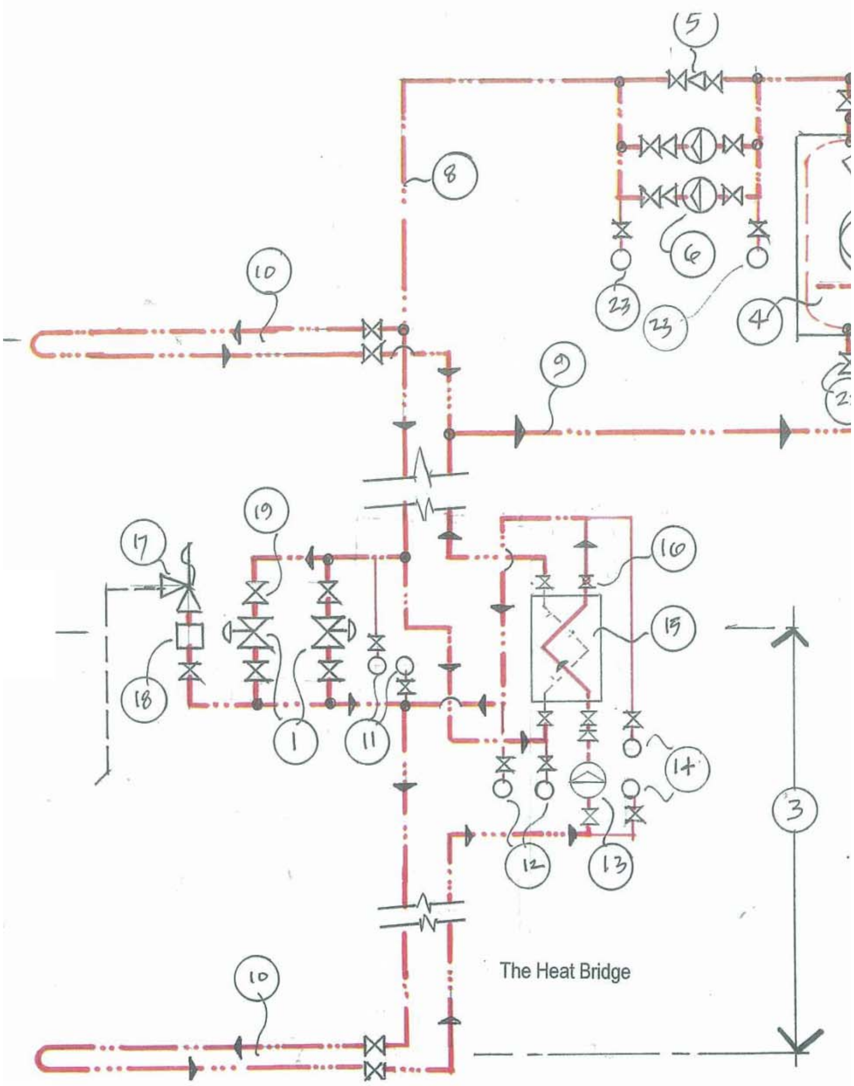
The AC Chiller is a massive heat pump that extracts heat ***(only a reduction of heat is possible)***,the machine will have a hot gas line which could with a gas to water heat exchanger (SWEP) produce high grade hot water (Supermarket chains use their chilled food cabinets to provide food prep hot water) The manufacturers of AC Chillers are very reluctant to provide this facility because it may compromise the machines warranty ,this being a penalty of not manufacturing Chillers in Australia.

Water to water heat pumps have been linked to solar hot water collection systems and geothermal systems, however most extract heat from the air, the logic of incorporating added moving parts to a simplistic solar collector, would not seem a viable proposition.

With most waste heat systems ,and solar systems ,the peak heat supply may not be available in sufficient quantities in the peak demand period ,the obvious problem with a solar contribution and night time heating peaks, the heat pump drawing from the air minimises this peak supply / demand problem ,however some hot water storage will be required . The hot water storage efficiency will be dependent upon the temperature of the stored water ,its volume ,the temperature of the water to be heated (The highest temperature difference is achieved by a cold feed pre-heat)

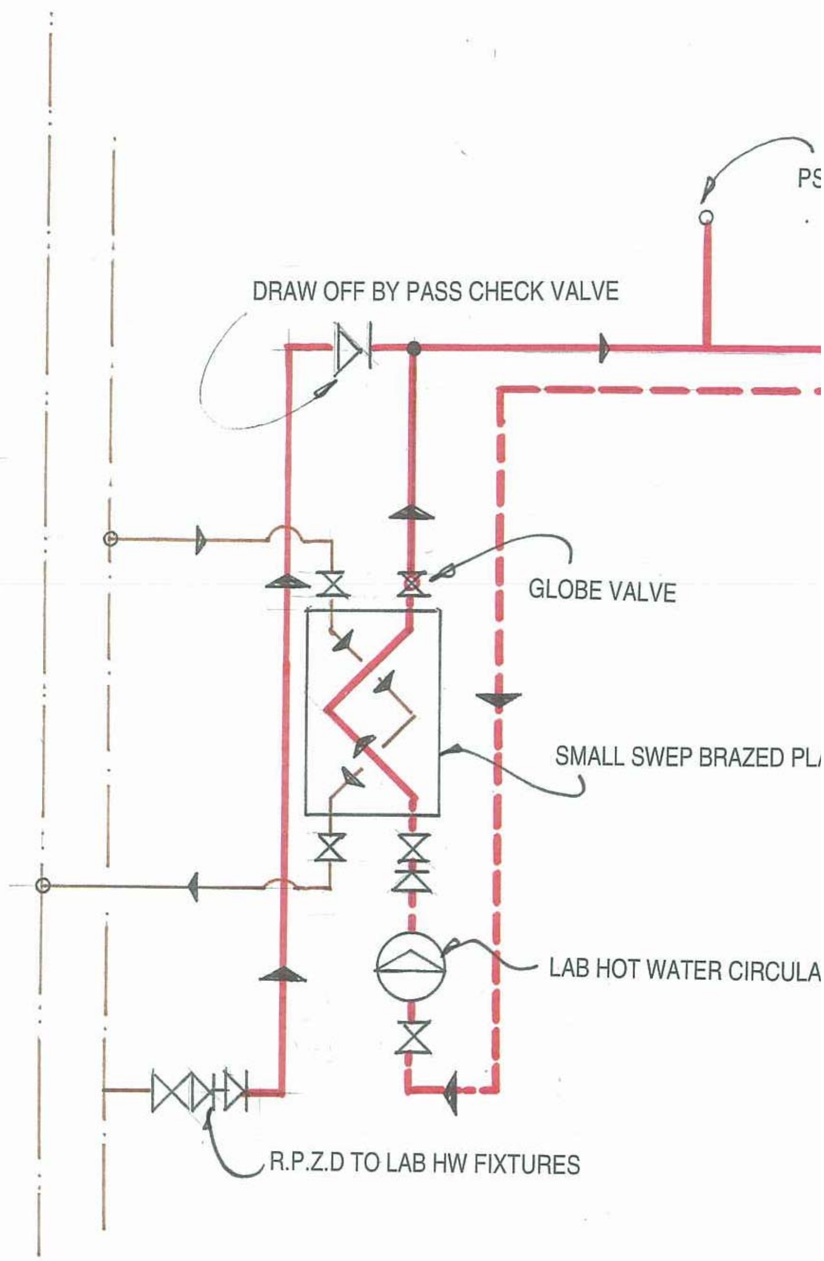
The Heated water storage for pre heat must be cost effective ,the stored water need not be potable if a pre-heat exchanger is used, the stored water can be low pressure (A tank) ,the stored water vessel must be well insulated ,include the prevention of surface evaporation by means of floating insulation.

The storage volume can be increased by the use of Phase Change Materials such as Eutectic salts which when heated change from a crystallised solid into a liquid , the system is dated ,it has been experimented with by ROTEX but to date the system is not offered for storage of heat for domestic hot water systems by any Australian manufacturer.

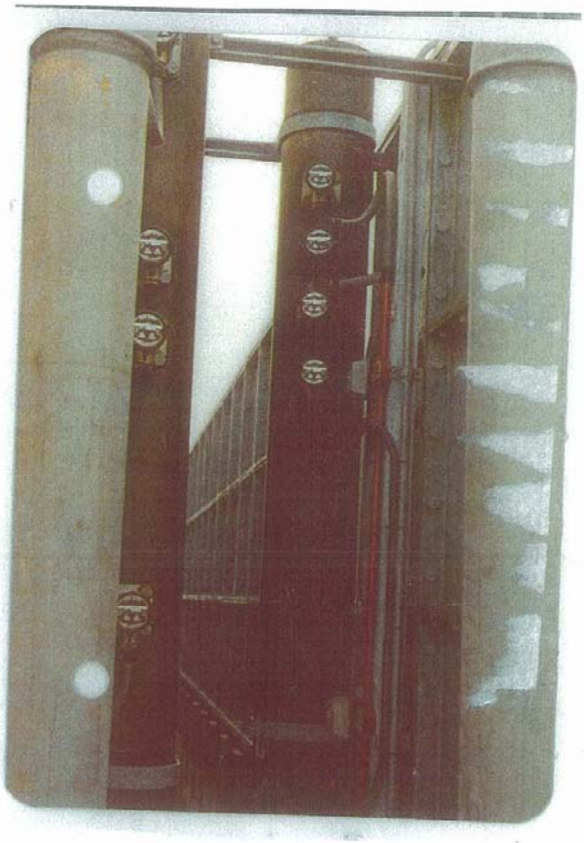


The Heat Bridge Legend

Item	Description	Notes
1	Pressure reduction valves	Duty standby suitable for Hot V
2	Upper pressure zone	
3	Lower Pressure zone	
4	Hot water Storage	
5	Draw Off by pass check valve	
6	Duty Standby circulation pumps	
7	Cold Feed	
8	Hot water flow	
9	Hot water return	
10	Branch circulating loop	
11	Pressure gauges	PRV controlled pressure zone
12	Pressure drop through heat exchange	Primary side
13	Circulating pump	Could be duty standby
14	Pressure drop through heat exchange	Secondary side
15	SWEP Heat exchanger	Pressure rated
16	Return globe valve	
17	Relief valve	
18	Pressure switch alarm	To BMS
19	Isolation valves	
20	Check Valves	
21	HW Secondary return to storage	
22	Cylinder Drain	
23	Pressure gauges	



THERMAL BRIDGE FOR THE TRANSFER OF CENTRAL SOURCE HE
AT RPZD VALVES AND PRESSURE REDUCTION VALVE



Water storage tank float switch vessel

Overflow activation alarm

Both pumps, Off control

Pump 1 On control

Pump 2 On Control and peak load alert

Low alarm shut down pumps to avoid motor burn out

9.112 HYDRONIC OR SHARED DOMESTIC HOT WATER AND COMFORT HEATING SYSTEMS

The writer has included this system with a fair amount of trepidation having argued the case for the systems more general use in Australia for over 30 years with only a few successful results mainly due to the support of enlightened clients and Roger Hurley then of Mechanical services Consultants (TWA).

9.113 THE HYDRONIC CONCEPT

The concept of a shared domestic hot water system is not new, and is not an invention claimed by the author, it is practiced more in cooler temperate climates where central heating for smaller projects is common place and is within the scope of plumbers work and education. The design approach is the subject of a paper Potable Water Space Heating Systems .The Economic Story by J Grenader (USA) who notes that in 1971 the Pacific Coast Builders Association 13 Annual Conference in San Francisco presented a creative plaque award to the " series loop" system as an entirely new concept (Series loop is understood to be the American term for such combined systems)

9.114 IN AUSTRALIA THE FOLLOWING PROJECTS HAVE USED THIS SYSTEM

The Cox Richardson Observatory Hotel. In the Rocks Sydney (The largest system but not health care)

A Catholic Retirement home in Garden Street Kogarah,

The now demolished Royal Women's Hospital Paddington Sydney.

The brain injury unit Ryde Rehabilitation Hospital.

One remote building at Westmead Hospital that could not be serviced from the central plant.

9.115 HISTORIC IMPLICATIONS

The separation of domestic hot water services from comfort heating system probably originated in the hard water areas of the UK in particular the London basin with its population of 12 million people .It is unwise to use hard water in heating systems because in a short time frame the pipes will be coated with a layer of calcium which as the changing water is heated will grow until the pipes ,boilers radiators are completely blocked ,it is/was also cost effective to use black mild steel pipe for heating systems ,much the same as sprinkler systems ,once the free oxygen content of the water is exhausted ,corrosion all but ceases .

9.116 ADVANTAGES AND LIMITATIONS

The shared system saves the capital cost of a complete system of pipe work. The shared system saves the thermal loss from a complete system of pipe work, it is therefore environmentally responsible and might in the broadest sense of the word be claimed Innovative.

The shared system saves boiler duplication for heating and domestic water

The shared system serves two differing load profiles; the load is not the sum of both.

The shared system means that comfort heating is available in marginal weather conditions.

The shared system requires an increase in the return service and pumping rates.

The shared system can operate at 75°C Flow 60 return, the instant kill temperature for Legionella the desirable supply temperature for commercial kitchens, and the efficient delta T for air heating coils.

The Shared system must use thermostatic mixing valves that will accept 75º C (Mattsson).

The shared system must use copper core radiators with Aluminium decorative convection box covers.

Manufacturer;- Hydrothermal Australia Pty Ltd 65 Northern Road West Heidelberg Victoria 3081 T 4575141

The shared system must serve air heating coils constructed of copper or aluminium. (Note water velocity in such coils may be an erosion issue)

9.117 CONTROL AND RUNNING ECONOMY

The shared Hydronic system has one circulation system serving however many circuits are required to provide comfort heat and domestic hot water ,the most efficient use is in ward block configurations with an en-suite toilet in which there is a service duct for soil and vent ,cold water and the insulated shared heating domestic hot water service flow and return pipes ,at the upper level the heating mains will serve the bulk head located ,copper coil ,fan coil unit ,it will be provided with a flow regulation return valve ,and a flow isolation valve strainer and low voltage soft close solenoid valve . The fan coil unit heat input will be controlled by a local room thermostat. In addition to the copper air heating coil the fan coil unit may contain a chilled water coil for cooling, both control solenoid valves to heating or cooling coils can be linked to magnetic reed switches embedded in windows and doors, this will allow shut down of heating and cooling when doors or windows to outside air are open.

9.118 EL AND K

The content of these notes has assumed that the reader is an above average competent hydraulic services designer, familiar with most aspects of the industry ,but disposed to being open minded and interested in how others see the design process .

One of the significant changes in the design industry that the writer has witnessed has been the overwhelming impact of the computer, coming from trade beginnings that were hand crafted, the transfer to computers experience was not without trauma, and a residual mistrust of programs that spit out, at lightning speed, the answer to complex calculations, without much back ground on how the result was achieved, tends to feed this lingering doubt.

In pipe sizing there are two differing systems to consider

- Those systems dealing primarily with conveying water to the consumer and other notes herein deal with the human factor of usage diversity, its history, and the mathematics of it.

- Those systems which convey known loads, with no diversity to consider, an exercise limited to determining the energy required for this transport of liquid to overcome resistance and gravity.

The second system involves Equivalent Length and K. Factors, the nomenclature may change to Velocity Head VEL HD or C.V Value ,depending on the origin and the units used ,most relate to resistance that may be hidden away in your favourite computer software programme. It is an advantage to know how the programme evolved and the origins of the calculations'

The resistance of fittings such as bends ,tees ,valves ,tank openings were resolved by testing much of this being undertaken by Crane Co America Technical Paper 410M. Interesting data regarding this work is presented in Australian Pump Manufacturers Association Ltd Pipe Friction Handbook which a comprehensive reference is highly recommended to reside in any self-respecting Hydraulic Consultants Library.

More recent work is available in the Toyo Valve Co Ltd Technical Data 804 Flow Characteristics and Flow Pressure Drop Charts ,an equally valued reference which deals mainly with all types of valves and the flow characteristic open to closed ,these charts use EL and the American Cv system to show valve capacity in the fully open position ,the formula and the charts are used under turbulent flow conditions such that the Reynolds number of the given fluid is more than 3000

In an application where the fluid is not water ,the flow or pressure drop can be obtained using the following

Liquid $Q = Cv \sqrt{\frac{\Delta P}{G}}$

Where Q = Flow in US Gallons per minute

G = Specific Gravity

ΔP = Pressure drop (psi)

Gas Q = 42.2Cv √ ΔP (P1 + P2)

G

Where Q = Flow in cubic feet per hour

G = Specific gravity

P1 = Inlet pressure (psi)

P2 = Outlet pressure (psi)

ΔP = Pressure drop (P1 – P2)

Saturated Steam W = 2.1 Cv√ ΔP (P1 + P2)

Where W = Flow in pounds /hour

P1 = Inlet pressure (psi)

P2 = Outlet pressure (psi)

ΔP = Pressure drop (P1 – P2)

Apologies are given for the imperial and American units

The Cv system used by Toyo Valve Co Ltd is the flow rate of the valve represented by

US Gallons per minute at 60 ºF when the pressure difference across the valve is 1 psi

Whichever system you prefer to use ,the origins are from experiments and the results should be similar ,well within the engineering tolerances that prevail in the Hydraulic Services Consulting industry , the criteria that is important is Temperature of the Fluid and the condition and resistance of the pipe material .

9.119 PIPE SIZING TABLES AND DATA *(COMMENT FROM ROGER GIBSON)*

Historically pipe sizing tables and charts were, and still are, to be found in the guide and data books published by the hydraulic and engineering institutes and the large pipe and fittings manufacturers. It was always the hope of the designers that suitable data could be found covering the materials, sizes and conditions appropriate to the design. Engineers would jealously guard personal files of data collected over many years in a similar manner to the way the site tradesman cared for his tools.

The advent of personal computers, laptops, notepads and the like has now made it much simpler for designers to generate their own data from freely available formulae and incorporate it into programs to make the whole pipe sizing exercise less tedious.

The relationships below have been taken from the C.I.B.S.E Guide and used to generate the tables that follow.

FLOW IN STRAIGHT PIPES

Q = -4 (N3.Δp1.d^5)^0.5 log (ks/3.7d +N4.d/(N3.Δp1.d^5)^0.5

N3 = π^2/(32.ρ)

N4 = 1.255πμ/(4ρ)

V = Q/A = Q πd^2/4

where

Q = volume flow rate (m3/s)

V = velocity (m/s)

A = cross sectional area of pipe (m2)

Δp1 = per unit length pressure drop (Pa/m)

d = internal pipe diameter (m)

ks = absolute roughness (m)

π = 3.1416

ρ = density (kg/m3)

μ = dynamic viscosity (Pa.s)

PRESSURE LOSS IN VALVES AND FITTINGS

The pressure loss in fittings and valves is calculated by multiplying a factor obtained from tables by a length of pipe which will produce a pressure loss equivalent to one velocity head. This length of pipe is referred to as the equivalent length and calculated from the following:

Elf = EL.ζ

EL = equivalent length equal to one velocity head (m) = 0.81ρ.Q^2/(Δp1.d^4)

ζ = pressure loss factor

Elf = equivalent length of fitting (m)

DATA

Data covering all of the variables in the equations above are readily available from guide and data books, manufacturers and the internet. The sample tables that follow use the following data.

Absolute roughness ks	0.0015mm
Density of Water 10˚C	999.73kg/m3
Density of Water 75˚C	974.85kg/m3
Dynamic viscosity 10˚C	1.306mPa.s
Dynamic viscosity 75˚C	0.378mPa s

PIPE DATA AS 1432

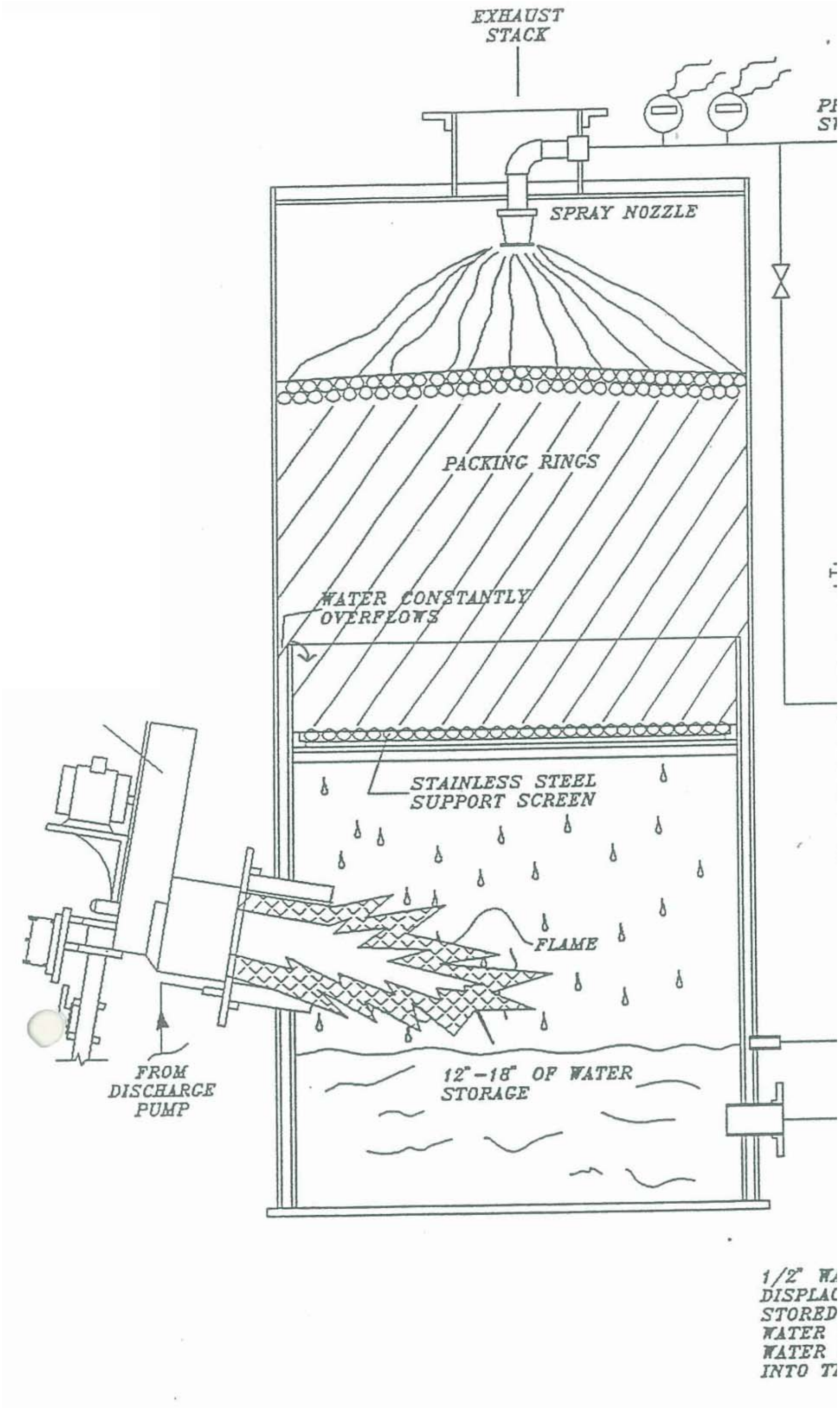
Nom Size	Internal diameter
dia mm	dia mm
10	7.7
15	10.9
20	17.1

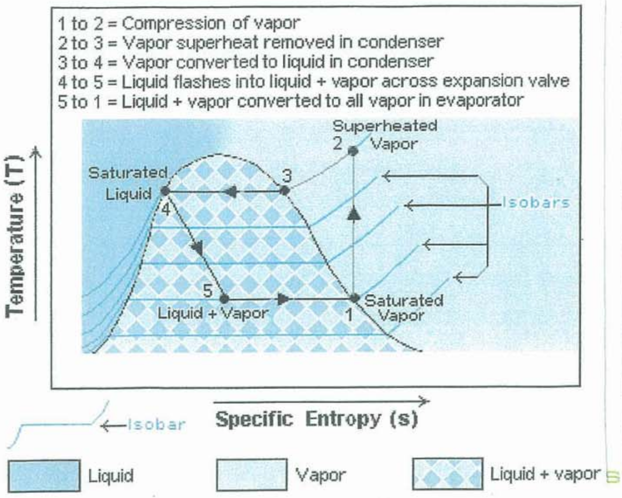
25	23
32	29.4
40	35.7
50	48.4
65	61.1
80	73
100	98.4
125	123.8
150	148.4

TYPICAL PRESSURE LOSS FACTOR Z FOR FITTINGS

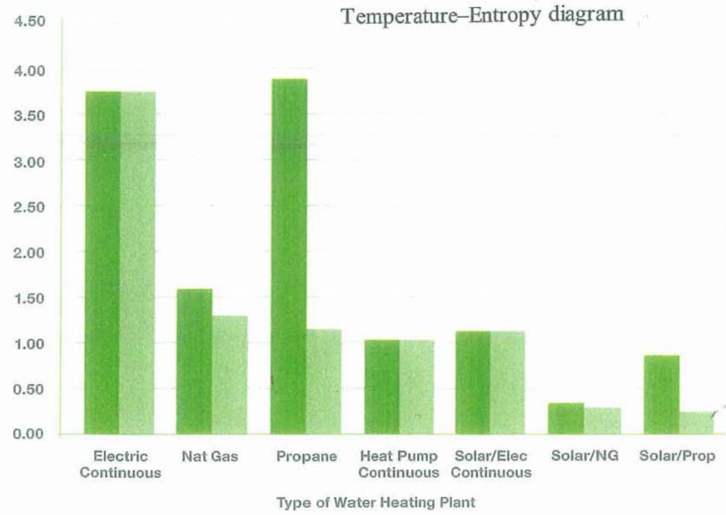
	15dia	25dia	50dia	65+dia
Elbow	1	1	0.8	0.5
Bend	0.4	0.4	0.3	0.2
Tap	10	10	-	-
Gate Valve	0.5	0.3	0.2	0.1
Non Return Valve	2	2	2	2
Globe Valve	15	10	7	6
Tee*	0.5 plus bend or reduction factor			

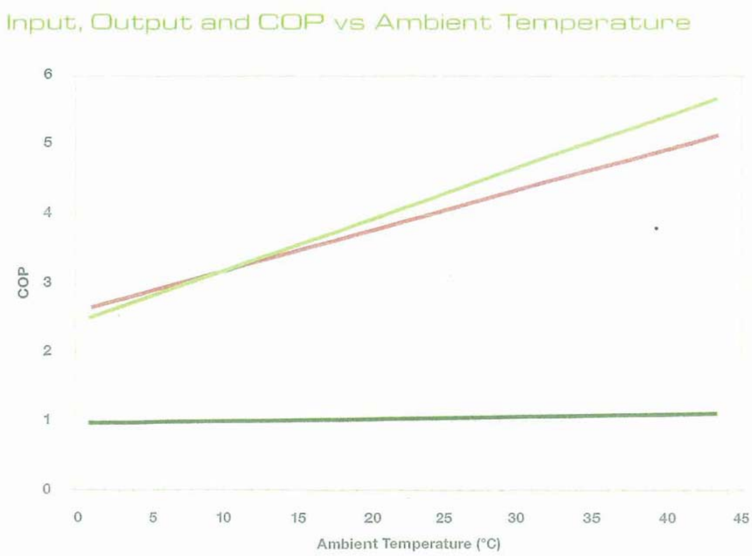
More comprehensive tables of pressure loss factors are available from Australian Pump Manufacturers handbook. C.I.B.S.E. and A.S.H.R.A.E Guides and Handbooks, various hydraulic handbooks and fitting and valve manufacturers' data sheets and literature.


EXHAUST STACK
SPRAY NOZZLE
PACKING RINGS
WATER CONSTANTLY OVERFLOWS
STAINLESS STEEL SUPPORT SCREEN
FLAME
FROM DISCHARGE PUMP
12"-18" OF WATER STORAGE



Temperature–Entropy diagram





CHAPTER 10. THE NOTIONAL HOSPITAL

10.1 CONCEPT OF THE NOTIONAL HOSPITAL

The Concept of the Notional Hospital is a means to provide the author with a demonstration vehicle that incorporates some of the more radical ideas.

In practice a Tri-Gen system would seem to negate solar viability because Tri-Gen would have sufficient waste heat to service most domestic hot water needs, these impacts on the commercial viability of a solar contribution, similarly heat pumps which draw heat from the air, are in effect solar heaters, also in the broad view are wood burners being a result of photo synthesis. Wood burning in some countries is considered carbon neutral providing replacement trees are planted. The core issue is to save energy where possible, and the energy cost account should debit the manufacturing cost over its Life Cycle of any device seen to be green.

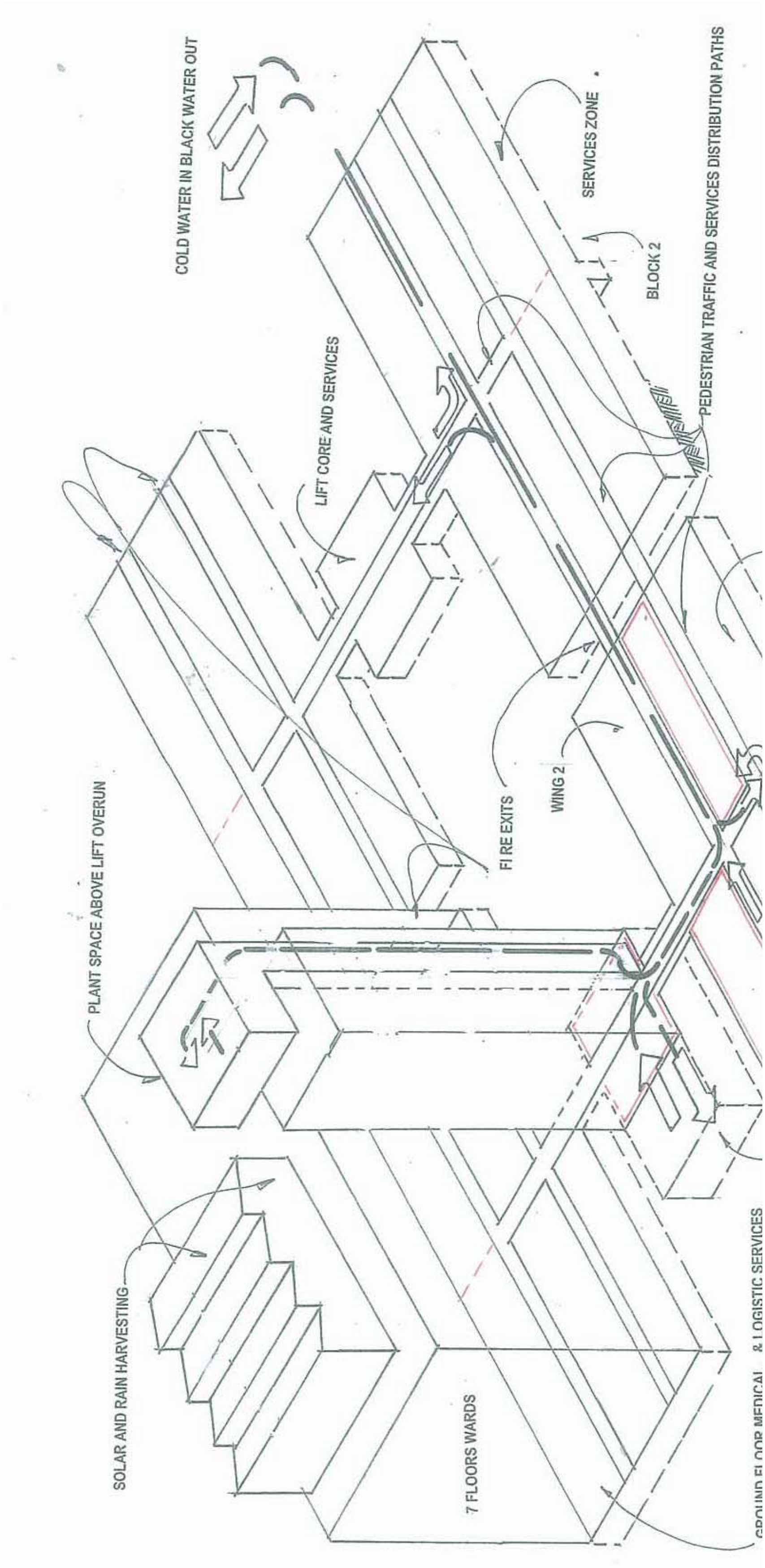
The interesting philosophical dichotomy about the current Health Care policy for hospital design is a much more basic issue and not within the writer’s qualified scope.

Is the “Health Care Battleship” (Quoting Doctor Burnie Amos) The big Teaching Hospital going to survive?

Or will health care become a more budget flexible “Frigate Class operation” with specialised local to the problem care centres with all the high tech plant and staff required. Cardiac Care. Cancer Care. Obesity .Drug rehabilitation. Age Issues Mental Health etc.etc.

This might be a means to minimise the problem of acquired infection, and the resistant bacteria that seem to develop in the multiple treatment environment. There might also be a planning advantage in placing the appropriate specialist facility where most needed ,or increasing the availability of health centres to deal with health problems that are seen to be increasing ,such as ageing related problems.

To the construction industry building a new Frigate might be a more economical proposition, as would be expanding the facility, or up grading, or relocating, or replacing in a new population centre.



10.2 THE NOTIONAL HOSPITAL SITE SERVICES

The Notional Hospital is a traditional "*Health Care Battle Ship*", it is located at the centre of population gravity in a city of three million people, it is a teaching hospital affiliated to a Notional University .The Hospital has extensive Clinical and Biological research facilitates and it has good access to the suburban rail system and also a civil airport is available for helicopter traffic.

Within its catchment area of population there is significant light industry and manufacturing .The notional hospital is classified as a Disaster Centre with facilities for decontamination of staff and vehicles that may attend chemical fires at local factories.

The architectural configuration of the Notional Hospital has a maximum height above ground of 25 metres giving Ground level plus 7 floor levels, the lower floors are patient care and logistic support, the upper levels comprises two 370 patient blocks with four wing per floor 20 or more patient / rooms, average per wing.

Services to the Notional Hospital comprise a sewer connection that is at a level that will allow all floor levels to be gravity drained. However the concept of using a pneumatic or vacuum assisted drainage system where the maximisation of flexibility or the transport of trade waste is required should be an option open for consideration, also where animal cage cleaning is required. The option of central vacuum cleaning and removal of bedding material from pathogen free animal cage rooms is an established proposition ,such systems should preferably not rise immediately ,rising air assisted vacuum pipes compete with gravity and the contest is less significant when the material being transported is more diffused in the system and amenable to air assisted transport .

The writer cannot provide useful comment in respect to wet central vacuum assisted drainage systems, but such a system constructed of chemically and heat resistant plastic would appear to have the potential for application in some health care services applications.

Radio Active waste water from the I131 Nuclear Medicine unit will be subject to half-life delay detention and pumping to the confluence prior to the sewer connection and downstream of the black water treatment plant.

Re-cycled water will be available from Black water re-cycling plant.

Rainwater harvesting, which will augment the flushing and other industrial type water use .The Public Utility supply coming from existing interconnected mains network serving streets on all four sides of the site, the mains are medium to high pressure and historically are not considered adequate to meet extreme peak loads, or the long term population predictions loads of the hospital population catchment, The water augmentation plant will be sufficient to service the hospitals immediate demands and for the planned final capacity 50 years hence.

At the rear boundary of the Notional hospital there is a pristine natural water course for the disposal of storm water by the Civil Engineer.

On Site detention will not be a feature of the project and surface water drainage is within the scope of Civil Engineering.

10.3 NOTIONAL HOSPITAL DESIGN DEVELOPMENT OVERVIEW

The Consultants and the Notional Hospital User Groups have agreed a concept design for further development; the concept design will incorporate many new, possibly radical design features that enhance environmental conservation, reject wasteful design. The team have undertaken not to resist departures from the conventions of the last century in those cases where a departure can be supported with good engineering and an advantage that can be demonstrated.

10.4 KEY ENVIRONMENTAL SUSTAINABLE PLANT

The Notional hospital will include the following.

- Heat recovery from grease traps,
- Heat recovery from shower waste flows
- Heat recovery from Animal cage washing machines
- A Primary rotating disc biological sewerage treatment plant
- Rain harvesting system
- A Solar Contribution.
- A Reverse Osmosis membrane technology black water treatment plant.
- Low thermal loss pipe systems for heated water.
- Low waste small bore dead leg pipe systems to sanitary fixtures.

10.5 DESCRIPTION OF KEY ENERGY PLANT

Comfort heating and power generation will be Natural gas driven with a stand-by heating gas boiler and a Tri-Generation system within the Mechanical Services scope of work, this thermal station will provide intermittent waste heat for domestic hot water, and electrical energy to the hospital.

The significant issue to hydraulic services is that the Tri Gen thermal plant will be, with minor exceptions, central, and the distribution system of comfort and primary heating hot water will be by the mechanical services engineer who will provide duplicate stainless steel plate heat exchangers with three way valve thermostatic temperature modulation at the main hydraulic load points in the notional hospital campus.

The concept design for water services will establish arterial pipe route system that are, where practical, repetitive and that also compliments, load points and plant locations, flexibility, maintenance and expansion work access, co-ordination with other services..

Energy conservation will be a feature of the design ,this will include a solar contribution, heat recovery from animal house cage washing ,Grease trap cooling and heat harvesting .En-suite shower waste water heat exchange tempering .Small bore hot and cold water distribution (7.5mm distribution)

The exception to the domestic hot water service design dogma will be the remote and independent free standing facilities such as Drug Rehabilitation Centre and Brain Injury Unit which will be provide with a local Natural Gas Boiler system and hydronic heating system within the hydraulic services scope of works and design.

10.6 DOMESTIC HOT AND COLD WATER SERVICE CONCEPTS

The Notional Hospital design of hydraulic services will originate from a main central riser in each of the two ward blocks; the vertical risers will accommodate the rising main, hot and cold water, sanitary and trade waste plumbing and natural gas.

The water supply for the building will be metered by the public utility and filtered at source prior to discharging to a low level bulk potable water storage system.

All potable and laboratory services will be filtered and UV sterilized.

The hospitals Cooling Tower WC Flush and Bed pan washer flushing system will be harvested rain supplied, with dry weather make up from the Potable supply and from the Reverse Osmosis black water treatment system, the potable water quality from this system will also augment domestic supplies should this become necessary in an Emergency situation.

The domestic hot water thermal storage will comprise a storage volume of 10,000 litres accommodated in three modular insulated atmospheric tanks and supplied from an adjacent solar energy pre-heated cold feed tank.

Heating to the secondary hot water system will be from local high velocity plate heat exchangers heating the thermal storage tanks with 70° C heating water.

The secondary system will comprise a lateral piping geometry ring main at each ward wing at each level, the flow and return connections being at the central riser.

Branch Small Pipe System (7.5mm dia) Hot and cold water services will supply fixtures from local load point manifolds which will incorporate pressure balanced thermostatic mixing valves and serve up to 5 points with warm and hot water as required.

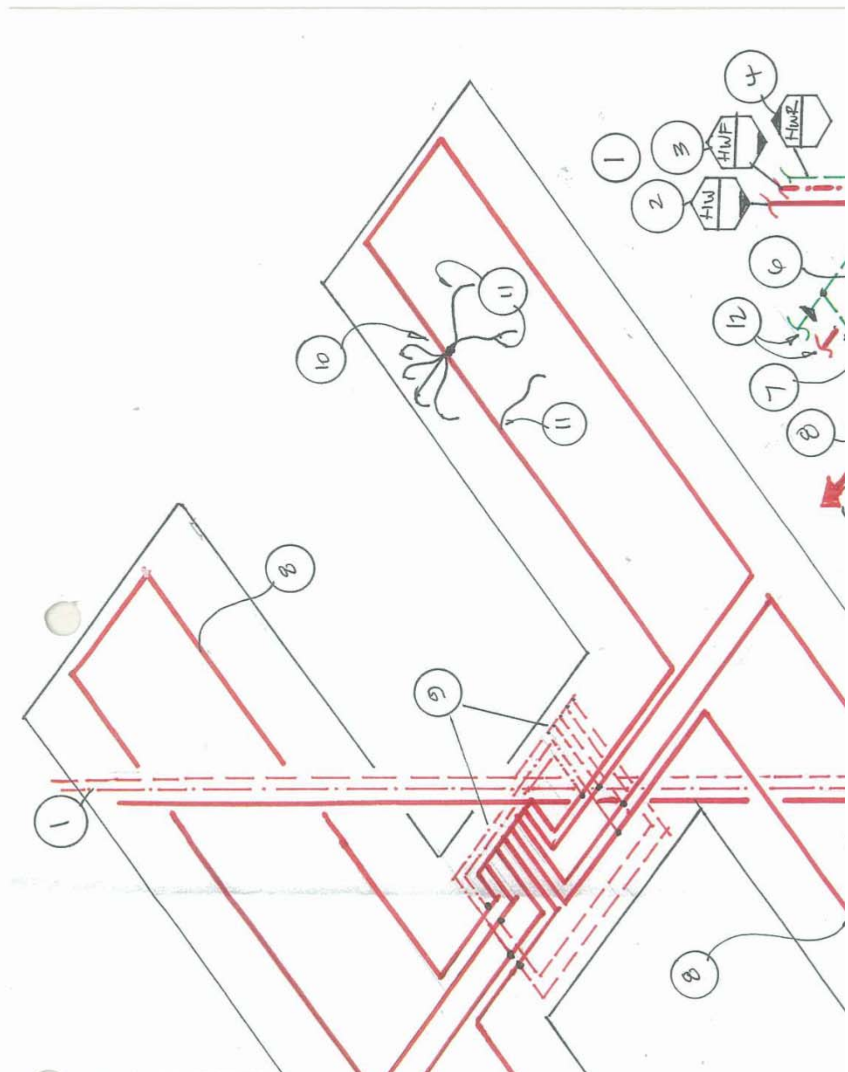


Diagram of Typical Domestic Hot Water Distribution Ring Mains for wards

Item	Description	Notes
1	Hot water services	These may be located in different risers
2	Draw off distribution	The draw off allows flow each way for economic sizes
3	Circulation flow	Circulation may be negated by draw off
4	Circulation return	Check valves prevent short circuits
5	Distribution Ring main branch with check valve	
6	Flow input to ring main	
7	Return output from ring main	
8	Ring mains	
9	Flow regulation globe valve and check valve	
10	Small bore TMV pod	Refer to the case for small bore pipes
11	Hot water to support system sinks	RPZD test stations can be centralised
12	To other fixtures	

10.7 PLUMBING AND DRAINAGE SYSTEMS

Plumbing will join a dual (Separated ground level) back bone drainage system serving sanitary plumbing, the domestic drainage outflow water will be processed by a low energy enclosed biological filter rotating cylinder system followed by membrane reverse osmosis technology to produce drinkable standard water, the plant will operate at a duty point of 135.000 litres per day, or 20% of full capacity, and will supply the flushing system and cooling towers in conjunction with harvested rain water.

The trade waste from the Notional Hospital kitchens and I131 Nuclear Medicine unit will be pre-treated and discharge to sewer with other drainage not processed by the black water reverse osmosis treatment plant

Building Plumbing will be predominantly 100 mm dia meter to all fixtures terminating at a universal connection fixture interface modem that will accept the connecting of any above floor fixture used in the project.

Sanitary Plumbing and Venting will be dual centrifugal fan assisted and UV Irradiated at the designated release point at roof level.

10.8 ASSUMED FIXTURE USE CHARACTERISTICS IN HEALTH CARE INSTALLATIONS

Staff showers and surgeons operating theatre scrub sinks. 100% demand.

Infection control basins will have a steady intermittent use in the working day.

Patient en-suites are going to have a well defused demand resulting in a low proportion in use at the same time, particularly where staff assistance is needed.

Wet research laboratories and P.C Labs (Physical Containment) will have a load consistent with staff numbers and lab fixtures available to use.

Wet teaching laboratories can generate 100% loads.

Standard procedure laboratories also have high and repetitive loads.

10.9 NOTIONAL HOSPITAL SANITARY FIXTURE SCHEDULE

Fitting	Use	No	Peak use	Typical demand expectation	
Basin	Toilets	45	High	Staff shift change use	P
Basin	En-suite	740	Low	Patients	P
Basin	Dirty utility	40	Low	Infection control	P
Basin	Kitchen	4	High	Peak load meal preparation	P
Basin	Laboratory	10	High	Infection control	P

Basin	Infection control	740	Low	Nurse Patient Doctor in ward	P
Basin	Infection control	80	Low	2 per ward corridor	P
WC	Toilets	139	Low	Staff visitors 1-20 ratio	H
WC	En-suite	740	Low	Not a critical hydraulic load	H
WC	Assisted b/room	40	Low	One assisted bathroom per ward	H
Showers	Patient	740	Low	Use period estimated 8 minutes	P
Showers	Staff	20	High	Peak use at shift change	P
Deluge shower	Emergency	15	V/Low	Very low use emergency provision	P
Sink	Laboratory	150	Low	Teaching labs high Procedure low	NP
Sink	Fume cupboard	20	Low	Teaching labs high Testing low	NP
Sink	Cleaner	10	Low	Out of peak use	P
Sink	Kitchen	20	medium	Peaks prior to meals	P
Sink	Dirty utility	40	medium	Peak use	NP
Sink	Clean utility	40	medium	Peak use	P
Sink	Scrub	12	High	12 OR rooms each with 3 man scrub	P

Sink	Specialised	10		Specialised lab gear cleaning and mortuary	NP
B/P washer	Dirty utility	40	High	Or flushing sink	H
Feeder	Animal house	20	constant	Ultra-pure water	U
Cage washer	Animal house	2	constant	Manufacturers data	P
RO Point	Dialysis clinic	20	constant	0.33 l/s Or as advised	U

NOTE:-

P Hot and Cold services potable water

H Harvested rain flushing Non-potable water

NP Non-potable water with backflow protection incorporated

PC2 laboratory areas will be backflow isolated from each other.

U Ultra-pure water membrane filtration by reverse osmosis

10.10 NOTIONAL HOSPITALS WATER CONSUMPTION

The notional hospital has 740 beds, (based actual similar installation consumption as measured) the probable water consumption will be between 780 and 1045 litres per bed per day.

The Notional Hospital is designated a Disaster Hospital, must have a minimum 24 hours water storage, the local water services do have a record of failure.

Over 24 hours of consumption the average draw off of cold water will be 32500 litres /hour 541 litres a minute 9.027 litres a second. The water storage tank will buffer loads on the incoming mains supply .However two pumps are consider the minimum duty standby arrangement ,in this case 5 litres per second per pump with a control system that cuts in the standby pump on level drop ,and alternates the duty pump at each cycle .

10.11 SIZING OF WATER SERVICES PIPE RETICULATIONS

CONTRIBUTED BY ROGER GIBSON M.I.E.A

To size a domestic supply distribution piping system the designer must
evaluate both the system flow and pressure requirements at each point in the system. The maximum flow is the sum of the flow requirements of the fixtures downstream of the point under consideration; this is modified by a factor that accounts for the probability of the number of those fixtures that may in a peak load situation operate simultaneously.

The pressure available at each point in the system is the static pressure available from any elevated storage tank, plus the head imposed onto the system by circulating or pressurising pumps, less pressure loses due to friction between the source tank and the point being considered at the calculated flow rate.

Each factor will be considered in some detail in the following, the cold water service for the Notional Hospital will be sized by a number of methods to demonstrate the general sizing methodology and the affects and sensitively of the results to the source data used. The method for sizing hot and heated water piping reticulations is identical but care must be taken to ensure that the correct pipe sizing charts are being used for each service as friction losses vary with water temperature.

10.12 SIMULTANEOUSDEMAND, A BRIEF HISTORY

It has long been appreciated that the maximum simultaneous demand from a number of draw-off points is seldom the sum of the flows with all points operating together.

The full demand event can occur, for instance within a shower facility in the player's changing rooms of a sporting arena, for all players come off the field together, and an increase in load can be anticipated at shift changes ,or where contamination is involved in the work undertaken . Another example where diversity is easily predicted is in the en-suite of a hospital ward. The en-suite is specifically designed for the use of one person at a time, thus only one of the draw-off points provided will be in use at a time.

These are however special cases with the general case being some diversity existing between the uses of fixtures that involve a level of uncertainty.

Since the 1930s several attempts have been made and methods developed to provide a realistic estimate of this diversity. Each has advantages and weaknesses and each requires some level of intelligent application.

Those of British background or training are probably most familiar with the method developed by L.C.Bull in the 1950's and published in early I.H.V.E Guides, (Now CIBSE). This used the probability concept to develop a distribution that could be evaluated within a given level of accuracy. The result was the following expression;

$$m \approx n (t/T) + 1.8 \sqrt{2n(t/T)(1 - t/T)}$$

Where;-

m = number of draw off points simultaneously discharging, taken to the nearest whole number.

n = total number of draw off points

t = average time draw off point discharges for each time used

T = average time between occasions of use.

At the time of publication it was suggested that for baths, hand basins and sinks the probability t/T could be taken as 0.2 reducing the above equation to:

$m \approx 0.2n + \sqrt{n}$

It was however recognised that the use of a "fixed probability" was very limited in its application and methods were developed to combine systems containing a mixture of points with different probabilities. These methods were cumbersome, involved determining equivalent points of common probability and were seldom used. Engineers and plumbers alike often applied the simplified formula, the results of which were produced in table form, irrespective of accuracy, and generally achieved working but greatly oversized systems.

The 1959 I.H.V.E. Guide was the last time that that body or C.I.B.S.E that followed, promoted the use of a fixed probability for determining the simultaneous demand in hot or cold water systems.

The 1965 I.H.V.E Guide noted the considerable variation in the probability t/T for normal domestic equipment and provided a method of assessment based on 'demand units' that effectively allowed the mixing of fixtures of different probability and flow rates by establishing a comparative scale for fixtures against that of a basin.

Tables were provided that converted the sum of demand units on a system directly back to flow units.

It should be noted that the I.H.V.E. did not recommend the use of a fixed probability or a demand unit system for evaluating and sizing water systems for hospital ward units. These were seen as a special case and particular advice was offered based on a study by the Hospital Engineering Research Unit, University of Glasgow, 1964.

Considering the age of the research, the differences between UK and Australian practice and the advances made in the design of ward units since that time then this work is considered to be of little value today.

The conclusions reached by the I.H.V.E in the 1960's appear to have been reached earlier by the Americans. In the 1940's Dr R.B.Hunter published a series of papers estimating the diversity between the uses of fixtures to establish simultaneous demand.

His work was based on residential buildings and used a fixture unit weighting system similar to that eventually used by I.H.V.E

1979 saw the publication of 'Selection and Sizing of Copper Tubes for Water Piping Systems by the Institute of Plumbing, Australia'. This publication maintained the use of a demand unit system, re-labelled as loading units (L.U) and was probably based on the earlier American or British work.

10.13 COMPARISONS

In this Chapter we size the Notional hospital cold water system to the typical floors using four sets of data that are currently available .However the general methodology remains the same.

OPTION A – PROBABILITY RELATIONSHIP M = 0.2N + √N

This would have been the relationship used most historically. It is the easiest to apply and most familiar to those who have designed plumbing systems since the 1980's and before.

OPTION B – ASHRAE

Data probably seldom used in Australia but forms the basis of much of the data later developed and the demand unit methodology.

OPTION C – INSTITUTE OF PLUMBING AUSTRALIA

A demand or load unit method published by the Institute of Plumbing, Australian dating back to 1976 and the work of Barrie Smith.

OPTION D – AS/NZS 3500 PLUMBING AND DRAINAGE

The Australian Standard is the reference most likely to be referred to in design specifications and designers likely to be required to comply with as a minimum.

The table below shows the data extracted from the reference sources and used in the calculations.

Data		All	Option B	Option C	Option D
Fixture		**AS3500**	**ASHRAE**	**AIP**	**AS3500**
		L/s	**FU**	**DU**	**LU**
Hand Basin	**Public**	0.1	1	1	1
	En suite	0.1	1	1	1

	Staff	0.1	1	1	1
Shower	**En suite**	0.1	2	3	2
	Staff	0.1	4	3	2
Bath Patient	**Patient**	0.3	6	8	8
Sink	**Kitchen**(aerated tap)	0.1	10	3	3
Sink	**Lab/Utility**(aerated tap)	0.1	5	3	3
Maximum velocity*	**3 metres/second**				

ASHRAE.The American Society for Heating Refrigeration and Air Conditioning Engineers

AIP Australian Institute of Plumbing

FU Fixture Units

DU Demand Unit

LU Loading Unit

t/T Probability function - time in use/time between uses

Identifiers to indicate pipe sections are shown on the attached diagrams.

In each instance it has been assumed that as the en-suites are designed for a single user then only the shower is in use and the en-suite can be classified as having only one fixture available for simultaneous use.

The index or least favoured circuit has been taken to be that serving the top floor of the most distant en-suite shower.

The Maximum AS/NZS 3500 Water flow velocities is relatively high by comparison to velocities generally required for acoustic noise levels in the order of 1200 -0.900 metres per second .

It will be found that many existing hospital systems operate well below the maximum recommended velocity of 3 m/s

AS/NZS 3500 and IPA data appears to originate from a common source, but there are differences, particularly with reference to hospital plumbing, that make it necessary to look at both. AS/NZS 3500 requires a lower flow rate from showers than that recommended by IPA which is significant for ward applications but the general loading unit table is specifically for residential use and cuts off at only 60 units. The conversion however into flow units is very similar to IPA tables. The assessment based on AS/NZS3500 has used AS/NZS3500 data where available and all AS/NZS3500 basic fitting flows but the IPA table has been used to convert higher loading unit sums back to flow units.

The IPA assessment has been true to the loading unit data which produces an idiosyncrasy with relation to a single shower requiring a flow of 0.1 L/s according to AS/NZS 3500 and 0.22 L/s according to IPA. The respective loading units are 2 and 3 resulting in required flows of 0.12 and 0.15 respectively. Clearly political nonsense in both instances. 0.1 and 0.15 were used respectively to give some vent to the preference of these bodies.

A.S.H.R.A.E charts to convert from fixture units to flow units were found difficult to read as the bias was towards very large numbers of fixture units and the research was based on residential use.

OPTION A (UNDIVERSIFIED FLOW TAKEN FROM THE AS 3500)

Probability Relationship m = 0.2n + √n													
Identifier	**No Fix. Con'd**	**Undiv. Flow**	**Diversity**	**Max. Demand**	**Pipe Size**	**Vel.**	**DP**	**Len.**	**EL**	**Elf**	**Equ.Len.Fitting**	**Total Len.**	**Total DP**
		L/s	%	L/s	dia mm	m/s	Pa/m	m	m		m	m	Pa
Shower	1	0.1	100%										100000
ak - aj	1	0.1	100%	0.1	**15**	1.04	1700	1.2	0.3	1	0.3	1.5	2550
tap	1	0.1	100%	0.1	**15**	1.04	1700		0.3	10	3	3	5100
aj - header	1	0.1	100%	0.1	**7.5**	2.15	8800	1.5	0.3	11	3.3	4.8	42240
Mixer*	4	0.4	70%	0.28	**20**						0	0	28000
ai - ah	4	0.4	70%	0.28	**20**	1.22	1200	0.2	0.6	10	6	6.2	7440
ah - ae	4	0.4	70%	0.28	**20**	1.22	1200	3.5	0.7	2.5	1.75	5.25	6300
ae - ad	5	0.5	65%	0.33	**25**	0.81	400	2.5	0.8	0.2	0.16	2.66	1064
ad - ac	7	0.72	58%	0.42			80	1.5	1.2	0.2	0.24	1.74	139.2
ac - ab	8	0.82	55%	0.45			82	3.5	1.2	0.2	0.24	3.74	306.68
ab - aa	12	1.22	49%	0.6			140	2.5	1.3	0.2	0.26	2.76	386.4
aa - z	14	1.44	47%	0.68			175	1.5	1.3	0.2	0.26	1.76	308
z - y	15	1.54	46%	0.71			180	3.5	1.4	0.2	0.28	3.78	680.4
y - x	19	1.94	43%	0.83	40		240	12	1.4	2.2	3.08	15.08	3619.2
x - w	23	2.34	41%	0.96	Ring		320	3.5	1.5	0.2	0.3	3.8	1216
w - v	24	2.44	40%	0.98			340	1.5	1.5	0.2	0.3	1.8	612
v - u	26	2.84	40%	1.14			455	2.5	1.5	0.2	0.3	2.8	1274
u - t	30	3.24	38%	1.23			500	3.5	1.6	0.2	0.32	3.82	1910
t - s	31	3.34	38%	1.27			510	4	1.6	0.2	0.32	4.32	2203.2
s - r	35	3.74	37%	1.38			600	0.5	1.6	0.2	0.32	0.82	492
r - q	36	3.84	37%	1.42		1.42	620	14.5	1.6	1.2	1.92	16.42	10180.4
q - p	144	15.36	28%	4.3	65	1.48	350	3.5	3.1	1.7	5.27	8.77	3069.5
p - o	288	30.72	26%	7.99	80	1.92	450	3.5	4.1	0.2	0.82	4.32	1944
o - n	432	46.08	25%	11.52	100	1.52	210	3.5	5.6	0.2	1.12	4.62	970.2
n - m	576	61.44	24%	14.75	100	1.8	270	3.5	6	0.2	1.2	4.7	1269
m - l	720	76.8	24%	18.43	100	2.29	420	3.5	6.8	0.2	1.36	4.86	2041.2
l - k	864	92.16	23%	21.2	125	1.8	210	3.5	7.6	0.2	1.52	5.02	1054.2
k - j	1008	107.52	23%	24.73	150	1.43	113	50	9.1	1.6	14.56	64.56	7295.28
TOTALs		107.52	**23.00%**	24.73				134.4			48.5		**233665**

OPTION B

ASHRAE

Identifier	No Fix. Con'd***	Undiv. Flow	ASHRAE FU	Max. Demand a		Pipe Size	Vel.	DP	Len.	EL	Elf	Equ. Len Fitting	Total Len.	Total DP
		L/s	No	L/s		dia mm	m/s	Pa/m	m	m		m	m	Pa
Shower	1	0.1	2											100000
ak - aj	1	0.1	2	0.1		15	1.04	1700	1.2	0.3	1	0.3	1.5	2550
tap	1	0.1	2	0.1		15	1.04	1700		0.3	10	3	3	5100
aj - header	1	0.1	2	0.1		7.5	2.15	8800	1.5	0.3	11	3.3	4.8	42240
Mixer*	4	0.4	6	0.3		20						0	0	16000
ai - ah	4	0.4	6	0.3		20	1.28	1300	0.2	0.6	10	6	6.2	8060
ah - ae	4	0.4	6	0.3		20	1.28	1300	3.5	0.6	2.5	1.5	5	6500
ae - ad	5	0.5	7	0.3		20	1.28	1300	2.5	0.6	0.2	0.12	2.62	3406
ad - ac	7	0.72	13	0.5				100	1.5	1.3	0.2	0.26	1.76	176
ac - ab	8	0.82	14	0.5				100	3.5	1.3	0.2	0.26	3.76	376
ab - aa	12	1.22	20	0.7				180	2.5	1.4	0.2	0.28	2.78	500.4
aa - z	14	1.44	26	0.8				240	1.5	1.4	0.2	0.28	1.78	427.2
z - y	15	1.54	27	0.8				240	3.5	1.4	0.2	0.28	3.78	907.2
y - x	19	1.94	33	0.95		40		310	12	1.5	2.2	3.3	15.3	4743
x - w	23	2.34	39	1.2		RIng		460	3.5	1.6	0.2	0.32	3.82	1757.2
w - v	24	2.44	40	1.2				460	1.5	1.6	0.2	0.32	1.82	837.2
v - u	26	2.84	47	1.35				590	2.5	1.6	0.2	0.32	2.82	1663.8
u - t	30	3.24	53	1.4				610	3.5	1.6	0.2	0.32	3.82	2330.2
t - s	31	3.34	54	1.4				610	4	1.6	0.2	0.32	4.32	2635.2
s - r	35	3.74	60	1.55				750	0.5	1.6	0.2	0.32	0.82	615
r - q	36	3.84	70	1.7			1.65	820	14.5	1.7	1.2	2.04	16.54	13562.8
q - p	144	15.36	280	3.75		50	2.02	820	3.5	2.5	1.7	4.25	7.75	6355
p - o	288	30.72	560	5.6		65	1.9	560	3.5	3.3	0.2	0.66	4.16	2329.6
o - n	432	46.08	840	9		80	2.15	550	3.5	4.2	0.2	0.84	4.34	2387
n - m	576	61.44	1120	10.2		80	2.45	700	3.5	4.3	0.2	0.86	4.36	3052
m - l	720	76.8	1400	12.6		100	1.65	240	3.5	5.7	0.2	1.14	4.64	1113.6
l - k	864	92.16	1680	13.5		100	1.8	275	3.5	5.8	0.2	1.16	4.66	1281.5
k - j	1008	107.52	1960	15.7		100	2.1	360	50	5.9	1.7	10.03	60.03	21610.8
TOTAL	1008	107.52	1960	15.7	14.60%				134.4			41.78	176.2	**252517**

OPTION C

INSTITUTE OF PLUMBING AUSTRALIA

Identifier	No Fix. Con'd***	Undiv. Flow	LU	Max. Demand	Pipe Size	Vel.	DP	Len.	EL	Elf	Equ.Len Fitting	Total Len.	Total DP
		L/s	No	L/s	dia mm	m/s	Pa/m	m	m		m	m	Pa
Shower	1	0.1	3										100000
ak - aj	1	0.1	3	0.15	15	1.6	3400	1.2	0.3	1	0.3	1.5	5100
tap	1	0.1	3	0.15	15	1.6	3400		0.3	10	3	3	10200
aj- header	1	0.1	3	0.15	15	1.6	3400	1.5	0.3	11	3.3	4.8	16320
Mixer*	4	0.4	8	0.25	20						0	0	20000
ai - ah	4	0.4	8	0.25	20	1	850	0.2	0.6	10	6	6.2	5270
ah - ae	4	0.4	8	0.25	20	1	850	3.5	0.6	2.5	1.5	5	4250
ae - ad	5	0.5	9	0.26	20	1.1	1000	2.5	0.6	0.2	0.12	2.62	2620
ad - ac	7	0.72	13	0.3			330	1.5	0.8	0.2	0.16	1.66	547.8
ac - ab	8	0.82	14	0.31			350	3.5	0.8	0.2	0.16	3.66	1281
ab - aa	12	1.22	22	0.38			500	2.5	0.8	0.2	0.16	2.66	1330
aa - z	14	1.44	26	0.39			530	1.5	0.8	0.2	0.16	1.66	879.8
z - y	15	1.54	27	0.41			570	3.5	0.9	0.2	0.18	3.68	2097.6
y - x	19	1.94	35	0.43	25		620	12	0.9	2.2	1.98	13.98	8667.6
x - w	23	2.34	43	0.46	Ring		700	3.5	0.9	0.2	0.18	3.68	2576
w - v	24	2.44	44	0.47			725	1.5	0.9	0.2	0.18	1.68	1218
v - u	26	2.84	53	0.54			930	2.5	0.9	0.2	0.18	2.68	2492.4
u - t	30	3.24	61	0.64			1280	3.5	1	0.2	0.2	3.7	4736
t - s	31	3.34	62	0.65			1300	4	1	0.2	0.2	4.2	5460
s - r	35	3.74	70	0.73			1600	0.5	1	0.2	0.2	0.7	1120
r - q	36	3.84	73	0.76		1.8	1700	14.5	1	1.2	1.2	15.7	26690
q - p	144	15.36	292	2.26	50	1.1	320	3.5	2.2	1.7	3.74	7.24	2316.8
p - o	288	30.72	584	3.44	50	1.86	700	3.5	2.5	0.2	0.5	4	2800
o - n	432	46.08	876	4.3	65	1.48	350	3.5	3.1	0.2	0.62	4.12	1442
n - m	576	61.44	1168	4.74	65	1.6	420	3.5	3.2	0.2	0.64	4.14	1738.8
m - l	720	76.8	1460	5.64	65	1.95	570	3.5	3.3	0.2	0.66	4.16	2371.2
l - k	864	92.16	1752	6.3	65	2.15	700	3.5	3.4	0.2	0.68	4.18	2926
k - j	1008	107.52	2044	7.05	80	1.7	355	50	4	1.7	6.8	56.8	20164
TOTAL	1008	107.52	2044	7.05				134.4			33	167.4	**256615**

OPTION D

AS 3500	

Identifier	No Fix. Con'd***	Undiv. Flow	LU	Max. Demand	Pipe Size	Vel.	DP	Len.	EL	Elf	Equ.Len Fitting	Total Len.	Total DP
		L/s	No	L/s	dia mm	m/s	Pa/m	m	m		m	m	Pa
Shower	1	0.1	2										100000
ak - aj	1	0.1	2	0.1	15	1.04	1700	1.2	0.3	1	0.3	1.5	2550
tap	1	0.1	2	0.1	15	1.04	1700		0.3	10	3	3	5100
aj - header	1	0.1	2	0.1	7.5	2.15	8800	1.5	0.3	11	3.3	4.8	42240
Mixer*	4	0.4	6	0.23	20						0	0	16000
ai - ah	4	0.4	6	0.23	20	1	850	0.2	0.6	10	6	6.2	5270
ah - ae	4	0.4	6	0.23	20	1	850	3.5	0.6	2.5	1.5	5	4250
ae - ad	5	0.5	7	0.24	20	1.04	900	2.5	0.6	0.2	0.12	2.62	1441
ad - ac	7	0.72	11	0.28			300	1.5	0.8	0.2	0.16	1.66	498
ac - ab	8	0.82	12	0.29			320	3.5	0.8	0.2	0.16	3.66	1171.2
ab - aa	12	1.22	18	0.38			500	2.5	0.8	0.2	0.16	2.66	1330
aa - z	14	1.44	22	0.39			520	1.5	0.8	0.2	0.16	1.66	863.2
z - y	15	1.54	23	0.41			550	3.5	0.8	0.2	0.16	3.66	2013
y - x	19	1.94	29	0.42	25		600	12	0.9	2.2	1.98	13.98	8388
x - w	23	2.34	35	0.44	Ring		650	3.5	0.9	0.2	0.18	3.68	2392
w - v	24	2.44	36	0.44			650	1.5	0.9	0.2	0.18	1.68	1092
v - u	26	2.84	45	0.49			800	2.5	0.9	0.2	0.18	2.68	2144
u - t	30	3.24	51	0.52			850	3.5	0.9	0.2	0.18	3.68	3128
t - s	31	3.34	52	0.54			940	4	0.9	0.2	0.18	4.18	3929.2
s - r	35	3.74	58	0.64			1200	0.5	1	0.2	0.2	0.7	840
r - q	36	3.84	61	0.65		1.58	1300	14.5	1	1.2	1.2	15.7	20410
q - p	144	15.36	244	1.98	50	1.1	278	3.5	2.2	1.7	3.74	7.24	2012.72
p - o	288	30.72	488	3.13	50	1.7	600	3.5	2.4	0.2	0.48	3.98	2388
o - n	432	46.08	732	3.9	65	1.36	300	3.5	3.1	0.2	0.62	4.12	1236
n - m	576	61.44	976	4.5	65	1.5	370	3.5	3.2	0.2	0.64	4.14	1531.8
m - l	720	76.8	1220	5.11	65	1.8	480	3.5	3.3	0.2	0.66	4.16	1996.8
l - k	864	92.16	1464	5.64	65	1.96	580	3.5	3.3	0.2	0.66	4.16	2412.8
k - j	1008	107.52	1708	6.23	80	1.5	290	50	3.9	1.7	6.63	56.63	16422.7
TOTAL	1008	107.52	1708	6.23				134.4			32.73	167.1	**253967**

The following summaries the resulting design flows from the assessment of simultaneous demand via the various methods and data:

Option	**A (IHVE)**	**B (ASHRAE)**	**C (IPA)**	**D (AS 3500)**

Design Flow L/s	24.73	15.70	7.05	6.23
% of Undiversified L/s	23	15	6.6	5.8
Equivalent t/T	0.2	0.12	0.048	0.042

10.14 CONCLUSION

OPTION A

Results in an assessment of required flow are 3 to 4 times greater than that which results from using IPA/AS3500 load units.

There has been a clear perception for many years that water services reticulating systems have been grossly oversized. (As indicated by some of the site measurements referred to herein).

Consumption data for hospitals generally indicates average water demand at well below 10% of design flow and the commonly held view among experienced plumbers is that the maximum demand on a water systems generally lies in the order of three times its average consumption.

The historical use of Option A is undoubtedly the cause, but the solution does not lie in simply substituting a lower usage ratio (t/T) back into Bull's original equation.

The initial assumption that a fixed usage ratio could be used across the system as a whole has proved incorrect requiring a system to give weight to both flow requirements and variable usage ratios.

This weighting method was pioneered by Hunter and the A.S.H.R.A.E. result shows a considerable reduction in predicted maximum flow from that resulting from Bull. Further improvement to the data is evident from the IPA and AS3500 results.

There being no hue and cry of under-sizing since the IPA publication in the 1970's and the introduction of the Australian Standard then the use of AS3500 data, supplemented where required by the IPA tables definitely appear to provide the more realistic estimate of the maximum flow requirements of the system.

In short AS3500/IPA loading unit system of assessment should always be used as a basic system, modified as required for the obvious peak load fixture groups such as showers.

It should be born in mind that what we have endeavoured to calculate is the MAXIMUM SIMULTANEOUS DEMAND, or peak flow of each section of piping from the source tank to the least favoured fixture. The designer must now size all the rest of the branches and calculate the system pressure losses.

10.15 SYSTEM PRESSURE LOSSES

As water travels through the system under the pressure provided by the static head (Or pump) and the pressure is reduced due to friction in the pipes, fittings and equipment resulting in less pressure being available at more distant points that are at the same height.

The theoretically ideally sized system would maintain the same pressure throughout via the selection of pipe sizes alone resulting in the regulation required from all flow regulating devices being the same in all instances. Each tap, flow regulator and mixing value mixing value would behave in an identical way having exactly the same pressure available to it. An Ideal world indeed but in practice a design overkills.

We should attempt, as far as possible, to make the system self-balancing and within a desirable water velocity range, when selecting pipe sizes to compensate for the natural variations that are occurring due to friction and elevation, the result generally being a more economical and functionally superior system.

To calculate the pressure loss due to friction tabular or chart information showing for each size pipe the flow (L/s), velocity (m/s) and equivalent length (m) over a wide range of pressure drop (Pa/m) rates is used. The flow rate is the maximum demand resulting from the simultaneous demand assessment detailed above; the velocity and pressure drop are read from the table for the selected pipe size while keeping the velocity below the reasonable m/s limit and noise generation. Also keeping an eye on the pressure drop rate.

The equivalent length comes from the table and is used to calculate the pressure loss in fittings. Separate tables are provided (e.g. A.S.H.R.AE., C.I.B.S.E. Pump Manufacturers Handbook) for factors to be multiplied by equivalent lengths (EL) for each type of fitting.

The product is the straight length of pipe that would result in the same pressure drop as the fitting.

The equivalent length for fittings can be added to the straight measured length of pipe from the drawings to produce a total effective length for the section. The effective length then multiplied by the pressure drop rate will give the pressure drop in that section of pipe.

This may sound complex but reference to the sizing option tables completed above demonstrate it to be a simple procedure in reality, being eminently adaptable to spread sheet management.

When deciding on the maximum pressure drop rate to use when sizing the pipes the designer has to be aware of the pressure rating of the tubing to be used and the height of the building. If for instance we are using tubing with a maximum safe working pressure of 950kPa in the larger sizes and decide to restrict ourselves to imposing 600kPa onto any part of the system we should deduct from our limit the pressure that would be imposed by the height of the building before deciding the maximum pressure any roof top pumps could be allowed to impose on the system.

For a 25m (250kPa in terms of water) building it may be concluded that pumping 350kPa (600 – 250) would be the maximum that could be imposed by the pumps and we should try to size our system to require no more than a 300 kPa pressure drop. Allowing a minimum of 100 kPa for legislated flow restrictors on outlets and 25 kPa for the pressure drop in thermostatic mixer valves then for a most disadvantaged, highest shower 3 meters (30 kPa) below the source tank the following would be the maximum pressure drop available for the pipe system.

Pump 300 kPa + Static 30 kPa – Flow restrictor 100 kPa – Mixer 25 kPa

Available for piping system = 205 kPa

If the index run is 135 m long and allowing 25% for fittings then the effective length of the index run is 169 m

And indicative pressure drop rate = 205/169 = 1.2 kPa/m or 1200 Pa/m

We now have a guide as to maximum velocity and upper limit for the average pressure drop rate to use when sizing the pipes.

10.16 SUB-CIRCUITS

We cannot, or at least should not, assume that having sized the index circuit we can apply the sizes established for the typical, but index floor to the remaining floors or even the other sections of the same floor.

For the index floor repeat the exercise for another wing fed from the opposite direction to ensure that the correct index route was chosen. For the remaining floors be mindful of the fact that a greater pressure is available for friction loss due to the combined factors of shorter path and increased static head. If for our example we go down five floors at 3.5 m floor height for Option D and our AS3500 assessment we find that pipe sections l to q no longer are in our path saving a total of 9165Pa of pressure drop. Additionally we have 5 floors at 3.5 m or 17.5 m extra head available. This translates to 18.41 m or 184 kPa of extra pressure from that which was available on the top floor. This large increase in pressure available should be sufficient to stimulate us to investigate the effects of reducing the size of our ring main on the lower floors.

The following table repeats the Option D sizing procedure for the typical floor ring main alone using a 20 mm dia. pipe as opposed to the 25 mm pipe proposed for the index floor.

Identifier	**No Fix. Con'd*** **	**Undiv Flow**	**LU**	**Max. Demand**	**Pipe Size**	**Vel.**	**DP**	**Len.**	**EL**	**Elf**	**Equ.Len. Fitting**	**Total Len.**	**Total DP**
		L/s	No	L/s	dia mm	m/s	Pa/m	m	m		m	m	Pa
ad - ac	7	0.72	11	0.28		1.22	1200	1.5	0.6	0.2	0.12	1.62	1944
ac - ab	8	0.82	12	0.29		1.27	1300	3.5	0.6	0.2	0.12	3.62	4706
ab - aa	12	1.22	18	0.38		1.65	2000	2.5	0.7	0.2	0.14	2.64	5280
aa - z	14	1.44	22	0.39		1.72	2200	1.5	0.7	0.2	0.14	1.64	3608
z - y	15	1.54	23	0.41		1.8	2390	3.5	0.7	0.2	0.14	3.64	8699.6
y - x	19	1.94	29	0.42	20	1.81	2400	12	0.7	2.2	1.54	13.54	32496
x - w	23	2.34	35	0.44	Ring	1.9	2650	3.5	0.7	0.2	0.14	3.64	9646
w - v	24	2.44	36	0.44		1.9	2650	1.5	0.7	0.2	0.14	1.64	4346
v - u	26	2.84	45	0.49		21.3	3200	2.5	0.7	0.2	0.14	2.64	8448
u - t	30	3.24	51	0.52		2.3	3600	3.5	0.7	0.2	0.14	3.64	13104
t - s	31	3.34	52	0.54		2.35	3800	4	0.7	0.2	0.14	4.14	15732
s - r	35	3.74	58	0.64		2.8	5200	0.5	0.8	0.2	0.16	0.66	3432

r - q	36	3.84	61	0.65	2.83	5300	14.5	0.8	1.2	0.96	15.46	81938
												193379.6
												48198.6

The resulting pressure drop on the ring from entry to the most distant shower is 193.38 kPa as opposed to 48.2 kPa with a 25 mm pipe. An increase of 145.18 kPa against 184 kPa extra pressure available.

With maximum velocity below the setlimit and bearing in mind it is based on a maximum simultaneous water flow that may seldom if ever occur then we would be justified in adopting a 20 mm ring main size on the lower floors.

If we need any further justification we could look at our assumption of flow path around the ring main. We have assumed a path from entry to the most distant point in one direction because we cannot reasonably predict in which direction and in what proportions the water will be flowing. We could however have taken the total number of fixtures and loading units on the ring and applied the greater diversity associated with the larger numbers. There are in this instant 122 (2 x 61) demand units on the ring that are subject to simultaneous use and the resulting flow could be conceived to be a half of what 122 translates to in flow units, that is 0.61 L/s. It may not seem like much reduction from the 0.65 L/s but the pressure loss rate reduces from 5300 Pa/m to 4700 Pa/m giving a reduction of over 9 kPa in pipe section q to r alone.

10.17 REVIEW DISCUSSION

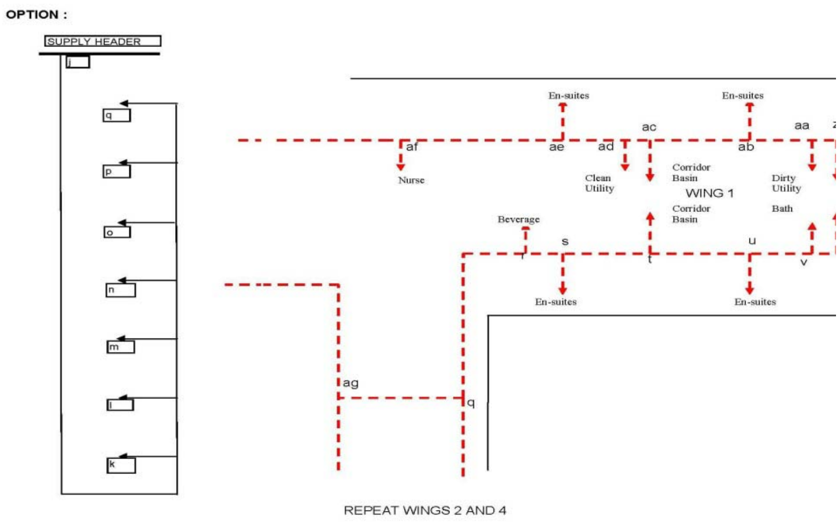
We have considered in these notes the probable maximum demand of a water service system, its pressure requirements and the method by which the pipes should be sized.

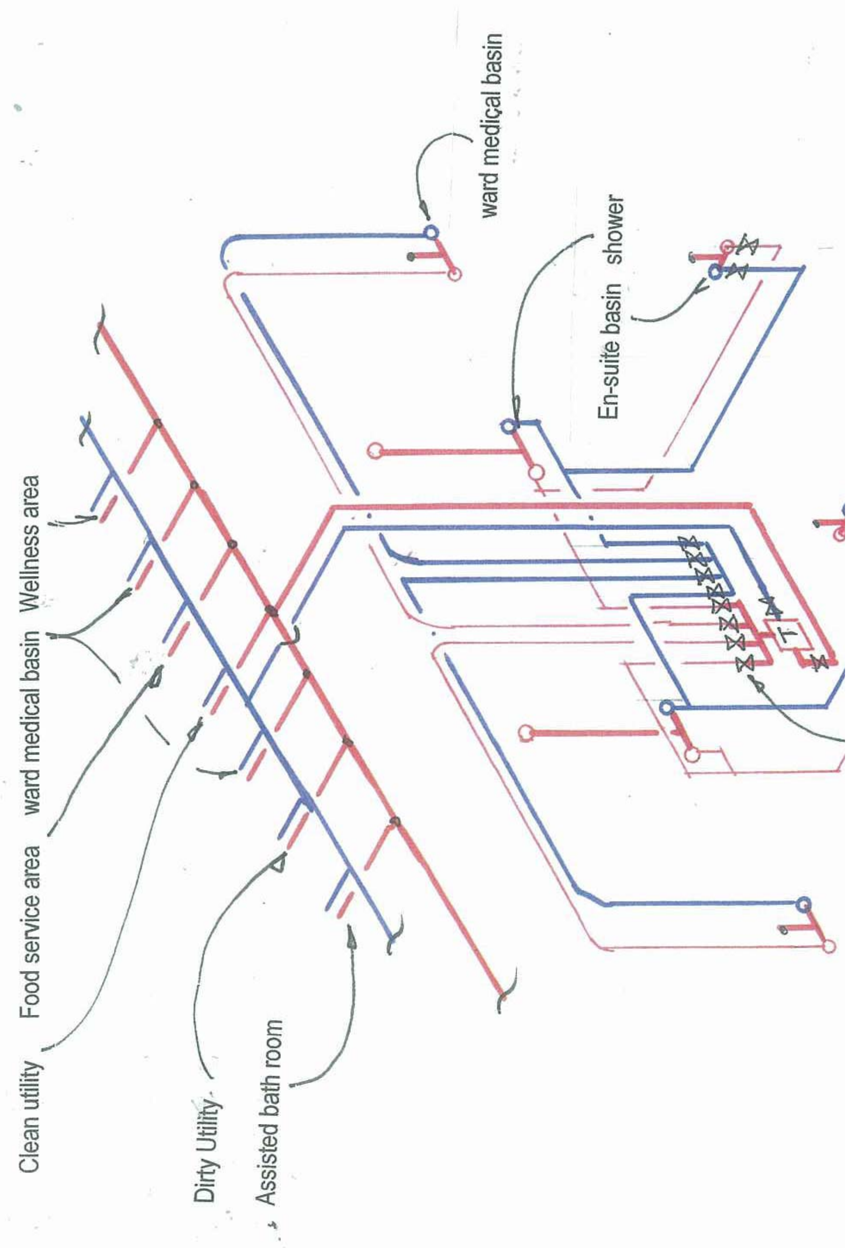
It is perhaps also worth noting that the advent of flow restrictors to showers and the introduction of thermostatic mixers to prevent scolding has resulted in some older systems that were designed to operate from gravity tanks to now being pump assisted.

When pumps are added design criteria changes with a large increase in pressure becoming available throughout the system.

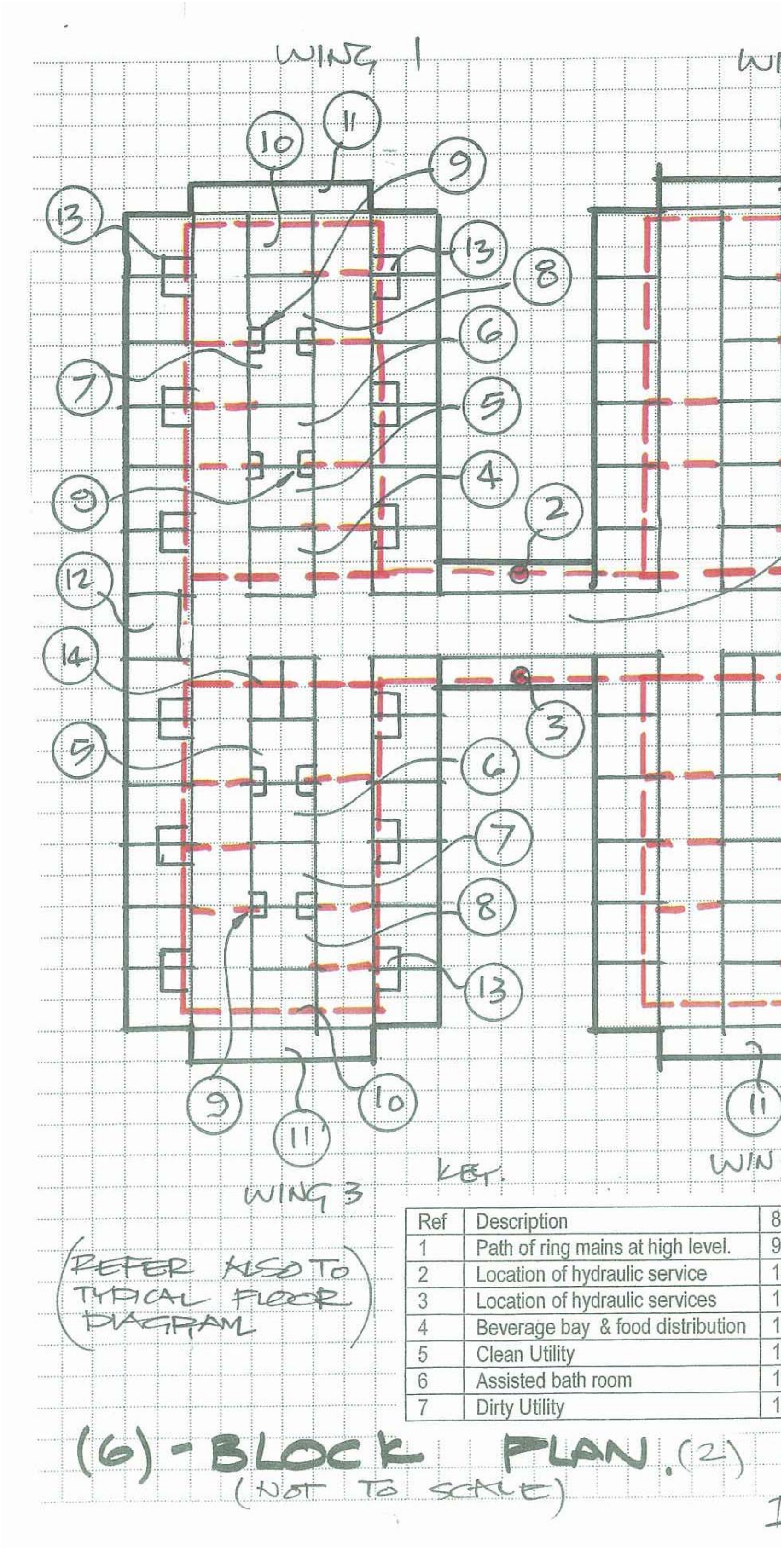
Sluggish index circuits can be made to work well even under the highest conceivable demand and the remainder of the system needs flow control restriction and regulation to cope with the excess pressure.

Under average or low flow periods the velocities in the pipes are so low as to be hard to measure and under low flow periods the pipes behave as tanks. This was always the case but the pipes were sized for the very low pressure drop rates that were available to gravity systems compounded by many designers over estimating the maximum demand flow by using Bull's fixed usage ratio of 0.2.

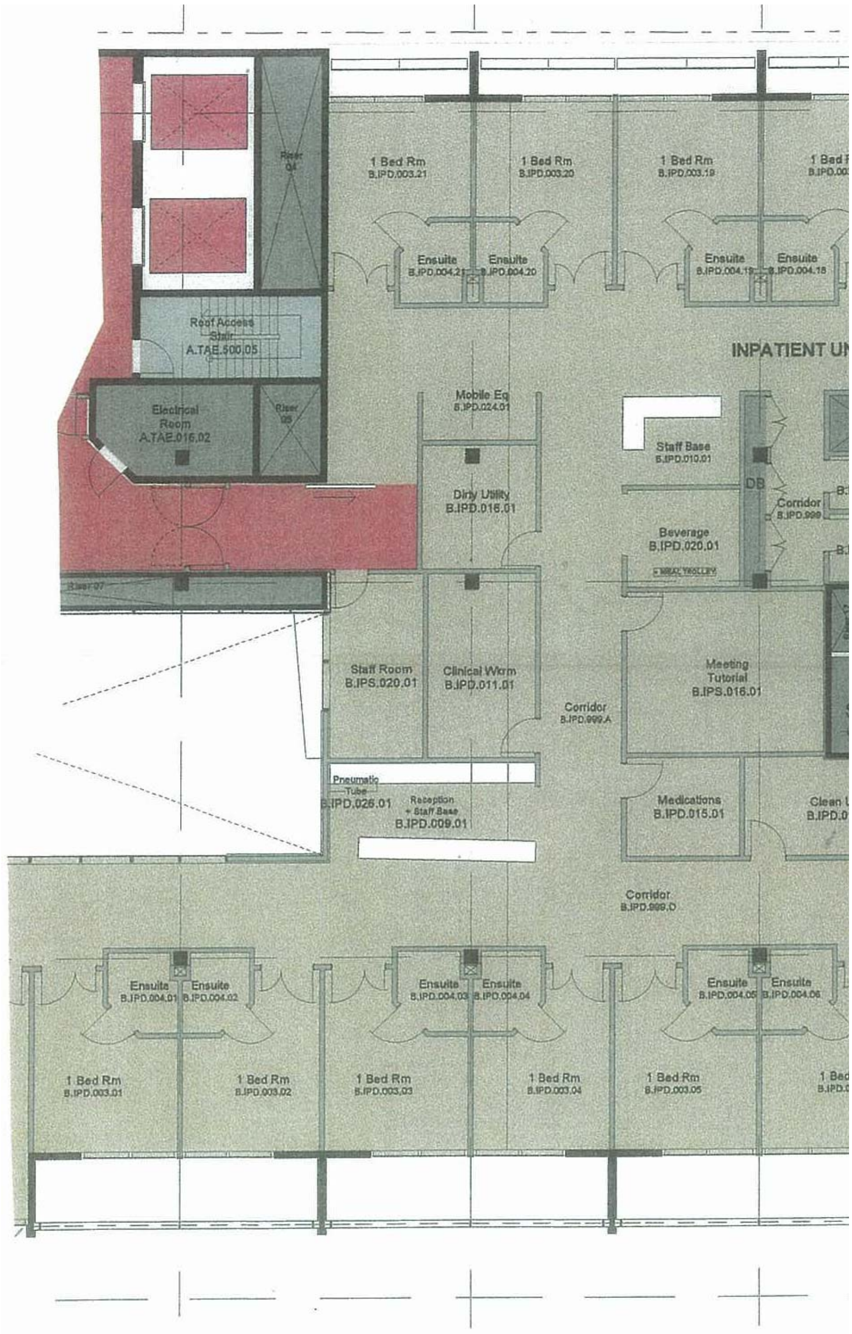

OPTION :
SUPPLY HEADER
En-suites
En-suites
af
ae
ad
ac
ab
aa
Nurse
Clean Utility
Corridor Basin
WING 1
Corridor Basin
Dirty Utility
Bath
Beverage
s
u
v
En-suites
En-suites
ag
q
REPEAT WINGS 2 AND 4



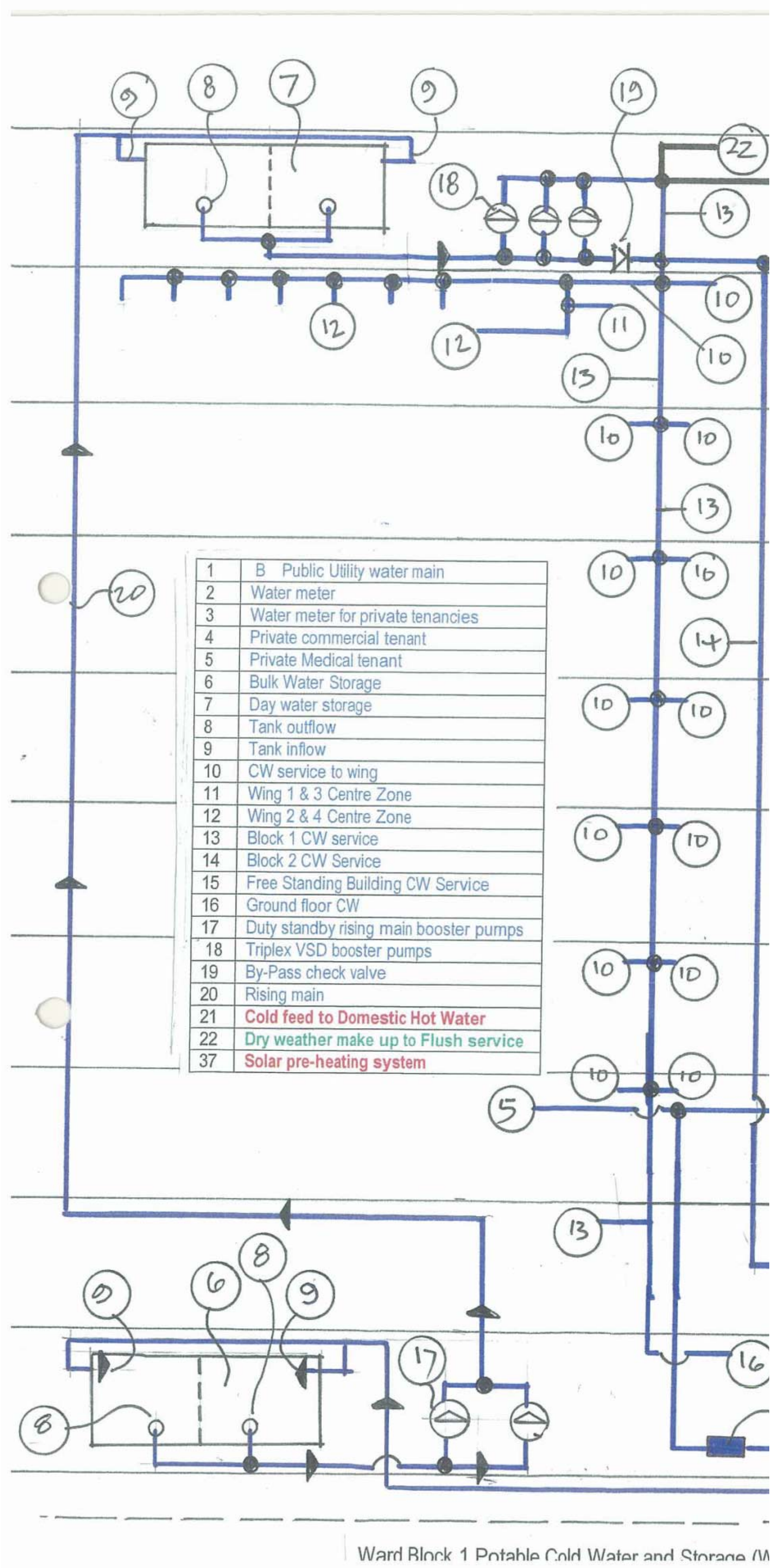
Notional Hospital En-suites
Adjacent en-suites with a single TMV ,four way 7.5 mm Pl
services based on a maximum of two fixtures operating at

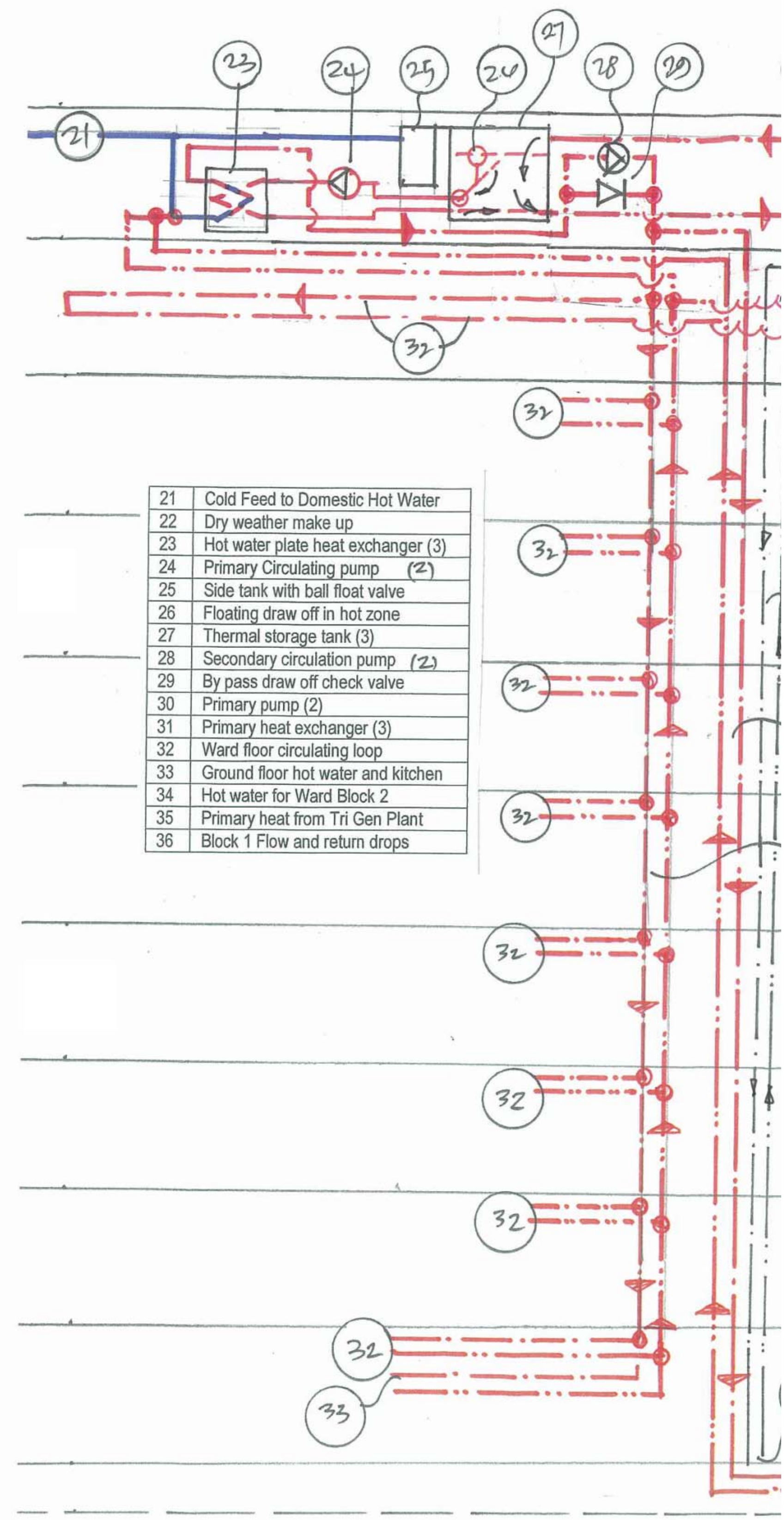


Ref	Description	8
1	Path of ring mains at high level.	9
2	Location of hydraulic service	1
3	Location of hydraulic services	1
4	Beverage bay & food distribution	1
5	Clean Utility	1
6	Assisted bath room	1
7	Dirty Utility	1

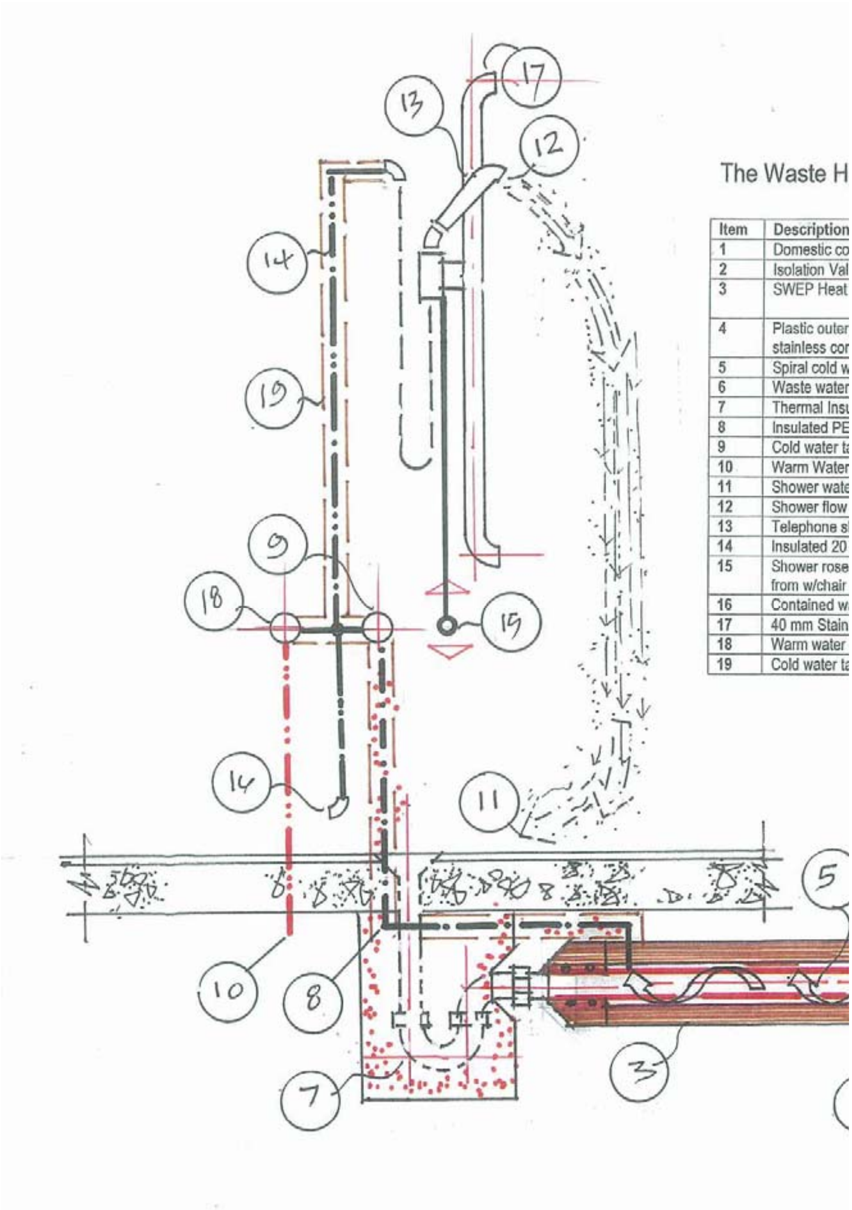


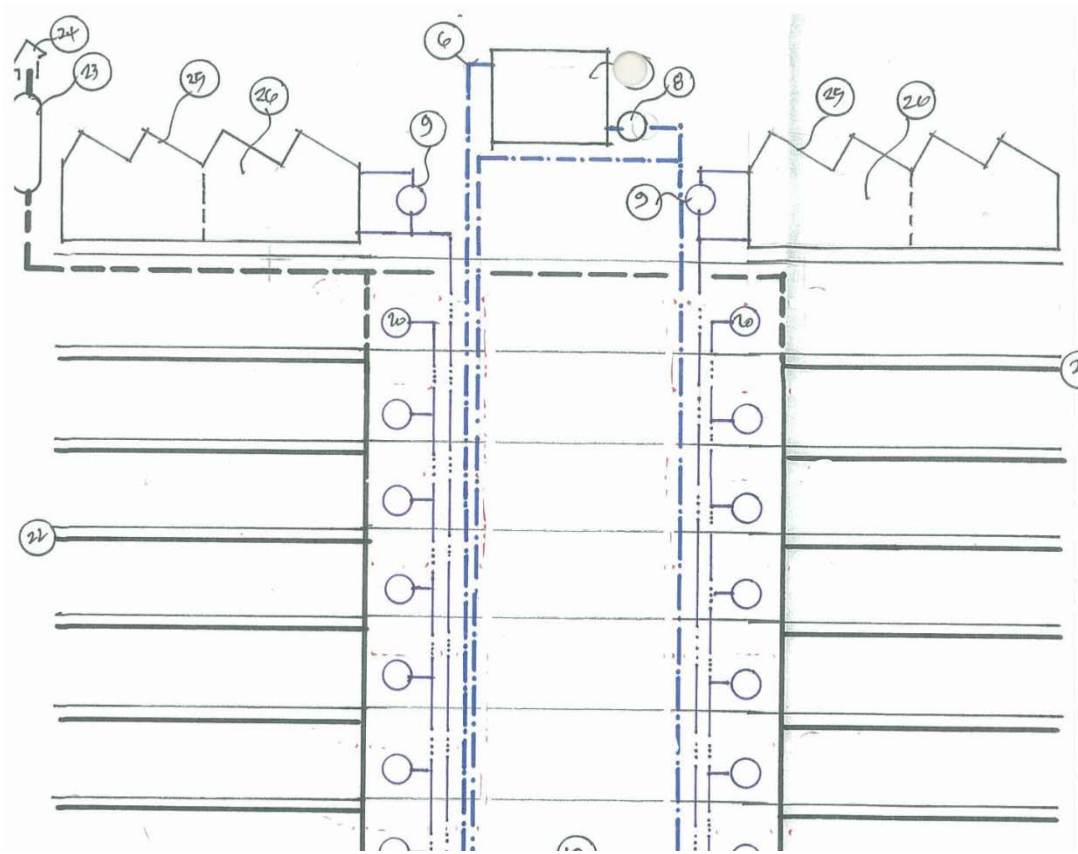
Typical Health Care Architectural plan showing ward
Sanitary service ducts .The centre core with lifts and
The back of house centre zone supporting areas wh
case included a harvesting tank for roof rainwater


1 B Public Utility water main
2 Water meter
3 Water meter for private tenancies
4 Private commercial tenant
5 Private Medical tenant
6 Bulk Water Storage
7 Day water storage
8 Tank outflow
9 Tank inflow
10 CW service to wing
11 Wing 1 & 3 Centre Zone
12 Wing 2 & 4 Centre Zone
13 Block 1 CW service
14 Block 2 CW Service
15 Free Standing Building CW Service
16 Ground floor CW
17 Duty standby rising main booster pumps
18 Triplex VSD booster pumps
19 By-Pass check valve
20 Rising main
21 Cold feed to Domestic Hot Water
22 Dry weather make up to Flush service
37 Solar pre-heating system
Ward Block 1 Potable Cold Water and Storage



Ward Block 1 Potable Hot Water and Storage (Ward block


The Waste H
Item
Description
1
Domestic co
2
Isolation Val
3
SWEP Heat
4
Plastic outer
stainless cor
5
Spiral cold w
6
Waste water
7
Thermal Insu
8
Insulated PE
9
Cold water t
10
Warm Water
11
Shower wate
12
Shower flow
13
Telephone s
14
Insulated 20
15
Shower rose
from w/chair
16
Contained w
17
40 mm Stain
18
Warm water
19
Cold water t



Notional Hospital Waste and Water Concept

No	Description
1	Public Utility water supply
2	Grade 2 water Dual RPZD
3	Low level water storage tank 24 hours storage volume
4	Triplex booster pumps to tanks (7)
5	Filtration and UV sterilisation
6	Rising main Grade 316 stainless steel
7	High level potable water storage tank
8	High level triplex VSD pump booster set 250 min 500 max
9	Harvested rain filtration system
10	Harvested rain gravity balance pipe between all storage tanks
11	Harvested rain pressurisation and UV Sterilization
12	Emergency diversion valve for black water treatment
13	Bio-disc extended aeration treatment system
14	Humus tank
15	Modular membrane water treatment
16	Chlorination and distribution pressurisation pump
17	Public Utility sewer
18	Emergency Black water treated water supply
19	Potable water to fixtures other than flushing
20	Flushing supply
21	Emergency black water treated water
22	Sanitary Plumbing and Drainage
23	Fan assisted UV treated Sanitary vent discharge to the atmosphere
24	Discharge point
25	Solar collectors
26	High level rainwater storage tanks

Emergency
Victoria base
purification fi
is offering dis
communities,
ultrafiltration
ultra violet lig
emergency dr
supplies from
floodwater.
On a helico
pallet, these
Australian ma
units with the
engines, kill b
viruses and r
and other impurities to make any water
Models with different capacities can be
likely flood scenarios.
Drawing on rivers, dams, lakes or floo
are available with the ability to produce
of drinking water. Optionally they can be
ultrafiltration and UV systems are bypas
used to initially pump out flooded areas
to 45,000L/h.

Emergency Black Water Treatment

It is not hard to visualise a Disaster Hospital water treatment syste
modules of this innovative package that has the advantage of port
transported to disaster areas, providing the operation was subject
and the other logistics for transport, power/ fuel and connections t
infrastructure were in place and could be activated efficiently at ve
stressful conditions .Sounds like an expansion of the Engineering

10.18 NOTIONAL HOSPITAL STAFF SHIFT CHANGES

Based on the hospital data available this Notional hospital will have a staff to bed ratio of 2.5 giving an estimated 740 x 2.5 = 1850 staff plus 740 patients' total 2590 persons.

Considering some staff are shift workers the actual total on site will be reduced by the off duty staff assumed to be 33% thus reducing the total on duty staff who work 9 am to 5 pm by 33% of 1850 = 616

1850 Total (less shift 616) = 1234 on site (staff Nurses doctors clerical maintenance).

At shift changes the staff population may have a short term and peak load demand rise of 15% increasing the total to 15% of 1234 = 185 giving an estimated 1419 staff at the shift interchange.

Patient visitors are not known (Visitors will have access to public toilets and ward en-suites) and an allowance of 1 visitor per bed for 30% of patients is estimated = 222 of which 10% may use the public facilities of the hospital = 22 persons.

Staff for franchised food, flowers and gift shops is estimated to be 100

Volunteers estimated to be 100

Bringing the estimated maximum site population to be:-

740 Patients + 1419 Shift change + 22 visitors + Franchise staff 100 + Volunteers 100 = 2381

10.19 WC PROVISIONS BASED ON BCA FACILITIES

Toilets required for an estimated 2381 persons peak population for toilet accommodation. The gender balance of the female and male population can change in respect to all segments of the population count ,assuming 50% of each gender, the facilities are required to serve other than the 740 patients who will have an en-suite facility 50% of (2381 – 740) = 821 50% males and 50% females . The 1641 users based on a WC to 20 persons results in 40 Urinals 82 WC pans and a similar amount of basins, distributed in the hospital for the ablution convenience of staff and visitors.

The provision of En-suite WC pans for patients is a move away from the historic data used to determine the diversity of flushing systems , the ratio of WC to patients has altered significantly from early hospitals with shared facilities and a more frequent use of bed pans.

10.20 TABLE OF THE FLUSHING FIXTURES IN THE NOTIONAL HOSPITAL

	Staff and Visitors WC	**Patients En-Suite WC**	**Dirty Utility**	**Male Staff & Public use Urinals**	**Assisted Bathroom WC**	**Totals**	1
Fixture number	82	740	40	40 (20 flush)	40	922	**2**
Population total served	1234	740	111	821	111	2590 day	**3**
Est. Shift on	1419	740		200		2381 estimated	**4**

site maximum						persons on site	
Use per person						Based on 2590	
% on site as shift and other	54%	29%	5%	7%	5%	100%	**5**
% Litres Used over 24h	83516	44851	7733	10826	7733	154660 litres100%	**6**
9 Litre actions 24h	9279	4983	859	1202	859	154660 litres	**7**
6 Litre flushing consumption	55674	29898	5154	7212	1145	102075 litres	**8**
Ref	**A**	**B**	**C**	**D**	**E**	**F**	

The average healthy human being visits the toilet about 5 times a day (24 hours) .

From the table above of the 922 (F2) Flushing valves are presumed to use (F6) 20% of the buildings total daily water consumption, that total being between 780 /1045 litres of water per bed per day.

The Notional Hospital has 740 beds which mean that it will consume between 577200 and 773300 litres per day of potable water. Based on the measured flushing valve consumption of 20% for 9 litre flush valves, the 6 litre cistern flush should change this water consumption to 102075 litres /day.

The average flow rate into the building is going to be between 6.68 and 8.950 litres per second .Conventional wisdom and industry practice estimates that peaks require 3 x average flow.

Based on 3 x Average the peak demand for cold water is between 20.04 and 26.85 l/s requiring three cold water VSD drive booster pumps each one will have a duty of 8.95 l/s

10.21 NOTIONAL HOSPITAL FLUSH VALVE SYSTEM SIZING

AS/NZS 3500:1 Provides a Limited Building size (250 valves) Tank fed flush valve table (Very similar to the National Plumbing Code Handbook by Manus 1957)

No table is provided for 25 NB Mains pressure flushing valves, or the more recent dedicated harvested rain or black water treated cistern flushing systems.

Blue Table AS/NZS 3500:1 Table 190.2 2003 and By-Law 14 Break tanks to Flushing Valve Sizing

Red Table added data including flow at low noise velocities in AS 1432 Table B Copper Tube

Available Head in metres of Water	**Maximum number of flush valves That may be served**	**NB Pipe Size**	mm² of tube Area	Area per valve	mm²Tube to max valves served	M/S"V"	Pressure Drop m/100	Velocity m/second
3 to 6 m	**1 to 2**	**40**	**999**	**999/2**	**499.5**	**1.50**	**6.926**	**1.502**
	3 to 15	**50**	**1837**	**1837/15**	**122**	**2.90**	**2.929**	**1.143**
	16 to 50	**65**	**2928**	**2928/50**	**58.56**	**4.50**	**3.594**	**1.503**
	51 to 150	**80**	**4179**	**4179/150**	**27.86**	**6.50**	**3.085**	**1.556**
6 to 9 m	**1 to 3**	**40**	**999**	**999/3**	**333**	**1.50**	**6.926**	**1.502**
	4 to 30	**50**	**1837**	**1837/30**	**61.23**	**2.90**	**2.929**	**1.143**
	31 to 150	**65**	**2928**	**2928/150**	**19.52**	**4.50**	**3.594**	**1.503**
	151 to 200	**80**	**4179**	**4179/200**	**20.89**	**6.50**	**3.085**	**1.556**
9 to12m	**1 to 4**	**40**	**999**	**999/4**	**249**	**1.50**	**6.926**	**1.502**
	5 to 50	**50**	**1837**	**1837/50**	**36.74**	**2.90**	**2.929**	**1.143**
	51 to 200	**65**	**2928**	**2928/200**	**14.64**	**4.50**	**3.594**	**1.503**
Over 12m	**1 to 6**	**40**	**999**	**999/6**	**166.5**	**1.50**	**6.926**	**1.502**
	7 to 100	**50**	**1837**	**1837/100**	**18.37**	**2.90**	**4.899**	**1.524**
	101 to 250	**65**	**2928**	**2928/250**	**11.71**	**4.50**	**3.594**	**1.503**
	250 to 350	**80**	**4179**	**4179/350**	**11.94**	**6.50**	**3.085**	**1.556**
	351 to 640	**100**	**7595**	**7595/640**	**11.86**	**11.50**	**2.048**	**1.514**
	641 to 1500	**150**	**17283**	**17283/1500**	**11.52**	**26.00**	**1.235**	**1.504**

Available Head in metres of Water	Maximum number of flush valves That may be served	NB Pipe Size	mm² of tube Area	Area per valve	mm²Tube to max valves served	Pressure Drop m/100	Velocity m/second

The data provided in AS/NZS 3500:1 2003 is much the same as the 1960 By-Law 14 table (Blue as shown above), As with the Notional Hospital (922 flushing points, in this case cisterns) Westmead hospital was (and is) a much larger central flushing valve system than the By Law 14 table size range covers.

The Westmead system was sized on a pro-rata to pipe area table, resolved with the then Sydney Water Board Chief Inspector R Allerton. The Flushing valve guide gives no background data as to the origins of the table ,the breakdown of the table sheds little light onto the diversity method employed ,most data of the 1950s came from the USA National Plumbing Code by Vincent Manus as described in his Handbook 24-7 (2) Application of the theory of Probability to a Simple System (A system of a single kind for flushing) As discussed by Roger Gibson the system was abandoned for mixed fixture systems many years ago .

Manus maintains that for compliant single kind systems: - $p = t/T$ and that 9/300 seconds = 0.03 is appropriate for flush valves.

The Manus Handbook also presents a curve (ref 24-4) In Gallons per minute (I US GPM = 3.785 litres) The 922 cisterns (Full flow 922 x 6 l/m = 5532 l/m = 92.2 l/s) of the Notional Hospital , according to this curve require 200 US GPM = 757 l/m 12.6 l/s.

COMPARISONS OF FLUSHING SYSTEM PIPE SIZING

System	Cisterns	Load Units	Litres/sec
AS/NZS 3500	922 (n dwellings	$Q=0.03n+\sqrt{n}$	41.48*
Vincent Manus	922 Flush valves	Refer to Manus	12.6 l/s
Institute of Plumbers	922 Flush valves	2 = 1844 LU	6.51 l/s

***The only equation data given in AS/NZS 3500:1**

Table 3.2 Applies to dwellings which has in all probability inflated this calculation

10.22 NOTIONAL HARVESTED RAIN WATER SYSTEM

The harvested rain water system will originate at a roof level plant space immediately below the catchment. Rain water will discharge via screened inlets to 50% of the tank capacity immediately below the roof.

From the initial 50% tank volume a pump assisted filtration system will draw
from the tank and discharge to the remaining 50% compartment of the tank which forms the storage service tank and the suction point for pumps UV irradiation and service reticulation to the WC cisterns and designated discharge points in the building.

The filtration will process rain at an average rate to rationalize pumps and filterduty, should high intensity storms exceed the capacity of the filter the tank will overflow unfiltered flow for use because in the circumstances the water quality will be considered adequate

The Harvested rain storage tank shall have roof geometry that provides the surface area for a solar collection system.

10.23 NOTIONAL HOSPITAL MATERIAL SELECTION

The Notional Hospitals user group has directed that within the scope of hydraulic services, no potable or non-potable water system pipe work, or fittings, shall be in direct contact with material that may by erosion or corrosion; contribute trace elements of any concentration to the water content.

The Client considers that adding any un-regulated trace metal or other chemical content to the drinking water of debilitated persons, without a full understanding of the long term effect on health, could constitute risk, liability and possible future litigation.

The hydraulic services Water treatment and water transport systems, tanks and components will be constructed of Grade 316 Stainless steel. Polypropylene, Polybutylene and Polyethylene. Drainage and plumbing systems will be PVC HDPE Polypropylene with particular attention being directed at High waste water temperatures and PVC

10.24 NOTIONAL HOSPITAL SOLAR SYSTEM

As noted the Notional Hospital has a central based Thermal and Energy Station which coordinates the distribution and use of natural gas, cooling water, heating water for comfort and for domestic hot water use, the thermal station comprises a natural gas fired internal combustion engine drivers for electrical energy and cooling refrigeration chiller compressors, the gas supply being augmented with a small proportion of methane gas the by-product of the black water treatment plant.

The Tri-Generation plant delivers significant but variable to load waste heat, therelease of waste heat and the cooling load profile is buffered by the storage of ice for cooling loads to rationalize plant size, but there remains a surplus of waste heat in summer conditions which correspond seasonally to the best time frame for the harvesting of solar energy.

The abundance of heat in summer conditions tends to negate the commercial advantages of the solar contribution which has relatively poor returns in winter months ,compounding the commercial disadvantage is the recurrent costs of solar ,these being maintenance of clean collector surfaces in an area where moderate industrial air pollution fallout is expected , overheating is considered a significant issue of solar design and requires complex control systems to regulate the input of solar heat in extreme weather conditions that coincide with low load levels for the consumption of domestic hot water ,public holidays and the like where patient treatment numbers do reduce.

In extreme weather conditions the precautionary release of very hot water to reduce temperature has a cost , also there is a cost for the provisions that are associated with this, and the cost of pumping the solar circulation, a small but constant cost.

Bearing in mind that in summer the solar system is competing with a free to very low cost waste energy supply, justifying the capital cost of solar becomes much more of a problem, the investment is supported more by the desire to provide the “Disaster classified hospital” with systems that can back up public utilities that may have failed.

Based on the domestic hot water use of 35 l/bed day x 740 beds = 25900 litres of hot water day.

Based on an average draw off load over 16 hours = 1618 litres an hour

Based on a peak draw off of 3 x Average = 4856 litres is considered probable upper limit

Based on probable peak load period of 1 hour = 4856 litres/kg x 4.186 kj/kg x (15°- 70°C) = 310kW input would replace hot water at the calculated maximum rate of use, bearing in mind 25900 litres is not considered large storage for a disaster hospital, the system will be provided with four thermal storage tanks each 5000 litres 20.000 litres total plus 5000 litres solar storage contribution to be heated over a 10 hours solar day at 6 kW yield per m² solar collection area . The 5000 litres solar pre heat thermal storage will be provided with eutectic salts phase change thermal modules giving the tank an effective heat storage capacity of x 2

The thermal storage tank vessels will be constructed of steel, with a polypropylene floating bead blanket to prevent evaporative thermal loss.

The solar contribution to the Domestic Hot water system will be transferred by high velocity plate heat exchangers.

The final heating input will come from the central energy tri-generation gas driven plant, as waste heat or direct heat. The introduction of heat to water will be by means of high velocity stainless steel plate heat exchangers which will modulate to provide 70°C Domestic Hot Water Flow, this will be temperature reduced at user point pods and distributed to consumer points by 7.5 mm semi flexible polyethylene pipe with compression or grabber fittings. All dead leg branch pipes will be limited to a 2 litres volumetric capacity and a 12 second maximum delivery time.

10.25 SOLAR ARRAY

10,000kg x 4.186kj/kg x (15 - 55°ΔC)/3600 =465 kW /hour

Based on a 10 hour input at 6kW/m²/ solar collection area yield77m² collection area approximately will be provided .

The Solar Constant :- recent satellite probes confirm that the hourly suns energy at the outer layer of the earth’s atmosphere is 4.860 +/- 3.5% MJ/M² Of this about 30% is lost passing through the atmosphere and by radiation back into space so that the maximum that can reach the earth’s surface is approximately 3.406 MJ/M² on a horizontal plane At any one time this will vary considerably from place to place depending on local climate and latitude .For practical purposes an average hourly insolation in the 2.271 to 2.498 MJ/M² range (6kW/day m²)

The solar array is to form the roof located above the harvested rain tank and solar storage tank the area will probably be 17 m x 20 metres allowing for supporting fabric and shadow effect.

The harvesting rain tank is facilitating the structural supporting system for solar ,and is contributing as a roof membrane for its area ,also the tank location reduces the pumping load required for water because it is located at high level 7 ,these advantages point to a commercially viable proposition.

10.26 NOTIONAL HOSPITALS PLUMBING AND DRAINAGE

The Notional Hospital will comprise separate and distinct plumbing and drainage waste water collection systems for the following.

Domestic Sanitary Plumbing and Drainage above ground floor level.

Domestic Sanitary Plumbing and Drainage at ground level shall be protected from surcharge from upper level discharges

Trade waste comprising Isolation Ward waste .Kitchen Grease.Animal husbandry Facilities .Thermal, chemical, biological, nuclear waste levels that require pre-treatment before discharge to the Public Utility.

Trade waste subsequent to pre-treatmentwill not be treated by the site black water treatment plant.

Waste water from isolation and PC3 Laboratories will have provisions to engage heat sterilisation prior to discharge as waste products.

All vents from trade waste shall be separate and distinct from Domestic Vents.

Both systems of venting will be provided with a fan assisted system incorporating UV Sterilisation, Activated Carbon filtration, Hepa filtration where it is considered desirable as a permanent feature before releasing the vented air to the atmosphere.

Waste heat recovery shall be a design feature of waste systems serving .Grease traps .Cage washing machines Patient and Staff showers, excluding Nuclear medicine treatment areas.

10.27 WASTE WATER TREATMENT

As previously noted, the Notional Hospital is classified as a Disaster Hospital.

The term disaster hospital is open ended, it can be applied to a wide range of circumstances the will have the effect of stimulating large sections of the local population to seek help from the hospital to overcome health problems that have exceeded the communities capacity to deal with.

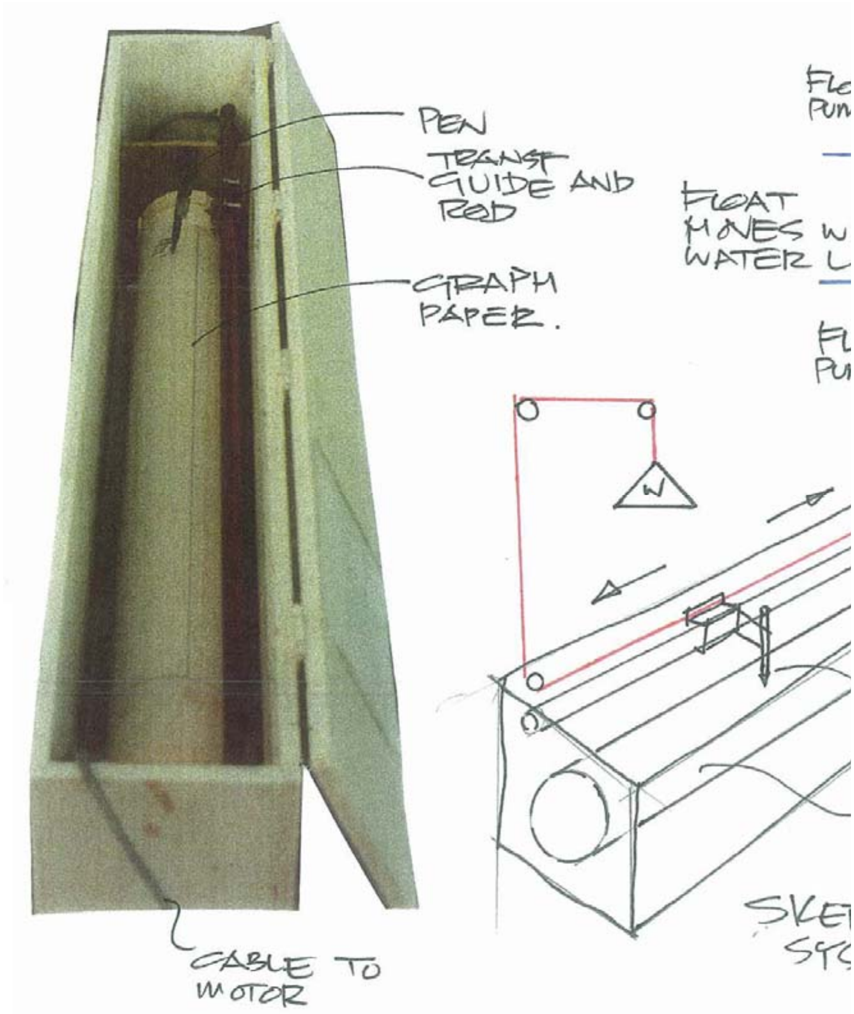
The range of disasters can vary in type and magnitude, the key design issue is that the hospital retains the capacity to function whilst normal public utility services cannot.

Storage of water will overcome a 24 hour interruption of supply.

Water storage is seen as a limited provision to give an engineering management the time frame to undertake a seamless transfer to a water supply from Black water treatment and rain water harvesting .The normal priorities will change, harvested rain will become the first choice for potable drinking water when storage is exhausted , it will be supported by the black water treatment system serving flushing and non-potable water systems ,as currently determined in NSW by the Department of Health Deviations from the NSW Health Guidelines being

determined as a decision relevant to the prevailing emergency conditions
and the health risk as determined by the Hospital laboratories water analysis capability.

The Treatment systems provided as part of the onsite plant will comprise a number of stages to produce a 30 mg/l suspended solids 20 mg/l biochemical oxygen demand (BOD) .This will be achieved by screening, Primary settlement and biological treatment by means of a low energy Bio-Disc or Bio-roller system, subsequent to this treatment maturation lagoons will provide added natural UV and oxygen, followed by Reverse osmosis membrane treatment and final chlorination to provide a chlorine residual of 0.5 mg/l through the entire system in accordance with Health Department Guidelines of Final water quality criteria and Permissible Uses It is noted that this work may not be included in the “Hydraulic Designers scope”.



Measuring Flow

In 1970 the writer constructed the above magic box to measu
pumps operating between flow switches. The very simple sys
attached, the roller and graph moved by a small motor at 1rev
rev per hour. The pen moved by a float in the tank and counte
according to the water drop in actual depth, there is a near ve
slope of the line drawn for outflow determines the rate of flow
The writer tested The State Office Building, The Reserve Ban
Ward and Theatre Block. The flow rates consistently measure
calculation, more recently at Mount Druitt Hospital a more mo
maximum 0.6 l/sec in the cold feed to the HW Calorifier, and
no problems.
The question is do we? As a Professional Group ignore this k

Table 1

Number of Draw-offs in Use (m)*

Flow/draw-off =

Total Ensuits (n)	0	50	100	150	200	250	300	350	400	450	500	550	600
0	0	12	20	28	35	43	50	57	64	70	77	84	91
1	1	12	21	28	36	43	50	57	64	71	77	84	91
2	2	12	21	28	36	43	50	57	64	71	77	84	91
3	2	13	21	28	36	43	50	57	64	71	78	84	91
4	3	13	21	29	36	43	50	57	64	71	78	84	91
5	3	13	21	29	36	43	50	57	64	71	78	85	91
6	3	13	21	29	36	43	51	58	64	71	78	85	91
7	3	13	21	29	36	44	51	58	65	71	78	85	92
8	4	14	22	29	37	44	51	58	65	71	78	85	92
9	4	14	22	29	37	44	51	58	65	72	78	85	92
10	4	14	22	30	37	44	51	58	65	72	79	85	92
11	4	14	22	30	37	44	51	58	65	72	79	85	92
12	5	14	22	30	37	44	51	58	65	72	79	86	92
13	5	14	22	30	37	44	52	58	65	72	79	86	92
14	5	15	23	30	37	45	52	59	65	72	79	86	92
15	5	15	23	30	38	45	52	59	66	72	79	86	93
16	6	15	23	30	38	45	52	59	66	73	79	86	93
17	6	15	23	31	38	45	52	59	66	73	79	86	93
18	6	15	23	31	38	45	52	59	66	73	80	86	93
19	6	15	23	31	38	45	52	59	66	73	80	86	93
20	6	16	23	31	38	45	53	59	66	73	80	87	93
21	7	16	24	31	38	46	53	60	66	73	80	87	93
22	7	16	24	31	39	46	53	60	67	73	80	87	94
23	7	16	24	31	39	46	53	60	67	74	80	87	94
24	7	16	24	32	39	46	53	60	67	74	80	87	94
25	8	16	24	32	39	46	53	60	67	74	81	87	94
26	8	17	24	32	39	46	53	60	67	74	81	87	94
27	8	17	25	32	39	46	53	60	67	74	81	88	94
28	8	17	25	32	39	47	54	61	67	74	81	88	94
29	8	17	25	32	40	47	54	61	68	74	81	88	94
30	8	17	25	32	40	47	54	61	68	74	81	88	95
31	9	17	25	33	40	47	54	61	68	75	81	88	95
32	9	17	25	33	40	47	54	61	68	75	81	88	95
33	9	18	25	33	40	47	54	61	68	75	82	88	95
34	9	18	26	33	40	47	54	61	68	75	82	88	95
35	9	18	26	33	40	48	55	62	68	75	82	89	95
36	10	18	26	33	41	48	55	62	68	75	82	89	95
37	10	18	26	34	41	48	55	62	69	75	82	89	96
38	10	18	26	34	41	48	55	62	69	76	82	89	96
39	10	19	26	34	41	48	55	62	69	76	82	89	96
40	10	19	27	34	41	48	55	62	69	76	83	89	96
41	11	19	27	34	41	48	55	62	69	76	83	89	96
42	11	19	27	34	41	49	56	62	69	76	83	90	96
43	11	19	27	34	42	49	56	63	69	76	83	90	96
44	11	19	27	35	42	49	56	63	70	76	83	90	96
45	11	20	27	35	42	49	56	63	70	77	83	90	97
46	11	20	27	35	42	49	56	63	70	77	83	90	97
47	12	20	28	35	42	49	56	63	70	77	84	90	97
48	12	20	28	35	42	49	56	63	70	77	84	90	97
49	12	20	28	35	42	50	57	63	70	77	84	90	97

Table 2

Percent of Draw-offs in Use

Total Points (n) ↓ / →	0	50	100	150	200	250	300	350	400	450	500	550	600
0	0%	24%	20%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%
1	100%	24%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%
2	####	23%	21%	18%	18%	17%	17%	16%	16%	16%	15%	15%	15%
3	67%	25%	20%	18%	18%	17%	17%	16%	16%	16%	16%	15%	15%
4	75%	24%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%
5	60%	24%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%
6	50%	23%	20%	19%	17%	17%	17%	16%	16%	16%	15%	15%	15%
7	43%	23%	20%	18%	17%	17%	17%	16%	16%	16%	15%	15%	15%
8	50%	24%	20%	18%	18%	17%	17%	16%	16%	16%	15%	15%	15%
9	44%	24%	20%	18%	18%	17%	17%	16%	16%	16%	15%	15%	15%
10	40%	23%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%
11	36%	23%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%
12	42%	23%	20%	19%	17%	17%	16%	16%	16%	16%	15%	15%	15%
13	38%	22%	19%	18%	17%	17%	17%	16%	16%	16%	15%	15%	15%
14	36%	23%	20%	18%	17%	17%	17%	16%	16%	16%	15%	15%	15%
15	33%	23%	20%	18%	18%	17%	17%	16%	16%	15%	15%	15%	15%
16	38%	23%	20%	18%	18%	17%	16%	16%	16%	16%	15%	15%	15%
17	35%	22%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%
18	33%	22%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
19	32%	22%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
20	30%	23%	19%	18%	17%	17%	17%	16%	16%	16%	15%	15%	15%
21	33%	23%	20%	18%	17%	17%	17%	16%	16%	15%	15%	15%	15%
22	32%	22%	20%	18%	18%	17%	16%	16%	16%	15%	15%	15%	15%
23	30%	22%	20%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
24	29%	22%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
25	32%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
26	31%	22%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
27	30%	22%	20%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
28	29%	22%	20%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
29	28%	22%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
30	27%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
31	29%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
32	28%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
33	27%	22%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
34	26%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
35	26%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
36	28%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
37	27%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
38	26%	20%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
39	26%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
40	25%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
41	27%	21%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%	15%
42	26%	21%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
43	26%	20%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
44	25%	20%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%
45	24%	21%	19%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
46	24%	21%	18%	18%	17%	17%	16%	16%	16%	16%	15%	15%	15%
47	26%	21%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%	15%
48	25%	20%	19%	18%	17%	16%	16%	16%	16%	15%	15%	15%	15%
49	24%	20%	19%	18%	17%	17%	16%	16%	16%	15%	15%	15%	15%

Table 3

Flow From Draw-offs - Hot or Cold Water (L/s)

Total Points (n)	0	50	100	150	200	250	300	350	400	450	500	550	600
0	0.00	1.20	2.00	2.80	3.50	4.30	5.00	5.70	6.40	7.00	7.70	8.40	9.10
1	0.10	1.20	2.10	2.80	3.60	4.30	5.00	5.70	6.40	7.10	7.70	8.40	9.10
2	0.20	1.20	2.10	2.80	3.60	4.30	5.00	5.70	6.40	7.10	7.70	8.40	9.10
3	0.20	1.30	2.10	2.80	3.60	4.30	5.00	5.70	6.40	7.10	7.80	8.40	9.10
4	0.30	1.30	2.10	2.90	3.60	4.30	5.00	5.70	6.40	7.10	7.80	8.40	9.10
5	0.30	1.30	2.10	2.90	3.60	4.30	5.00	5.70	6.40	7.10	7.80	8.50	9.10
6	0.30	1.30	2.10	2.90	3.60	4.30	5.10	5.80	6.40	7.10	7.80	8.50	9.10
7	0.30	1.30	2.10	2.90	3.60	4.40	5.10	5.80	6.50	7.10	7.80	8.50	9.20
8	0.40	1.40	2.20	2.90	3.70	4.40	5.10	5.80	6.50	7.10	7.80	8.50	9.20
9	0.40	1.40	2.20	2.90	3.70	4.40	5.10	5.80	6.50	7.20	7.80	8.50	9.20
10	0.40	1.40	2.20	3.00	3.70	4.40	5.10	5.80	6.50	7.20	7.90	8.50	9.20
11	0.40	1.40	2.20	3.00	3.70	4.40	5.10	5.80	6.50	7.20	7.90	8.50	9.20
12	0.50	1.40	2.20	3.00	3.70	4.40	5.10	5.80	6.50	7.20	7.90	8.60	9.20
13	0.50	1.40	2.20	3.00	3.70	4.40	5.20	5.80	6.50	7.20	7.90	8.60	9.20
14	0.50	1.50	2.30	3.00	3.70	4.50	5.20	5.90	6.50	7.20	7.90	8.60	9.20
15	0.50	1.50	2.30	3.00	3.80	4.50	5.20	5.90	6.60	7.20	7.90	8.60	9.30
16	0.60	1.50	2.30	3.00	3.80	4.50	5.20	5.90	6.60	7.30	7.90	8.60	9.30
17	0.60	1.50	2.30	3.10	3.80	4.50	5.20	5.90	6.60	7.30	7.90	8.60	9.30
18	0.60	1.50	2.30	3.10	3.80	4.50	5.20	5.90	6.60	7.30	8.00	8.60	9.30
19	0.60	1.50	2.30	3.10	3.80	4.50	5.20	5.90	6.60	7.30	8.00	8.60	9.30
20	0.60	1.60	2.30	3.10	3.80	4.50	5.30	5.90	6.60	7.30	8.00	8.70	9.30
21	0.70	1.60	2.40	3.10	3.80	4.60	5.30	6.00	6.60	7.30	8.00	8.70	9.30
22	0.70	1.60	2.40	3.10	3.90	4.60	5.30	6.00	6.70	7.30	8.00	8.70	9.40
23	0.70	1.60	2.40	3.10	3.90	4.60	5.30	6.00	6.70	7.40	8.00	8.70	9.40
24	0.70	1.60	2.40	3.20	3.90	4.60	5.30	6.00	6.70	7.40	8.00	8.70	9.40
25	0.80	1.60	2.40	3.20	3.90	4.60	5.30	6.00	6.70	7.40	8.10	8.70	9.40
26	0.80	1.70	2.40	3.20	3.90	4.60	5.30	6.00	6.70	7.40	8.10	8.70	9.40
27	0.80	1.70	2.50	3.20	3.90	4.60	5.30	6.00	6.70	7.40	8.10	8.80	9.40
28	0.80	1.70	2.50	3.20	3.90	4.70	5.40	6.10	6.70	7.40	8.10	8.80	9.40
29	0.80	1.70	2.50	3.20	4.00	4.70	5.40	6.10	6.80	7.40	8.10	8.80	9.40
30	0.80	1.70	2.50	3.20	4.00	4.70	5.40	6.10	6.80	7.40	8.10	8.80	9.50
31	0.90	1.70	2.50	3.30	4.00	4.70	5.40	6.10	6.80	7.50	8.10	8.80	9.50
32	0.90	1.70	2.50	3.30	4.00	4.70	5.40	6.10	6.80	7.50	8.10	8.80	9.50
33	0.90	1.80	2.50	3.30	4.00	4.70	5.40	6.10	6.80	7.50	8.20	8.80	9.50
34	0.90	1.80	2.60	3.30	4.00	4.70	5.40	6.10	6.80	7.50	8.20	8.80	9.50
35	0.90	1.80	2.60	3.30	4.00	4.80	5.50	6.20	6.80	7.50	8.20	8.90	9.50
36	1.00	1.80	2.60	3.30	4.10	4.80	5.50	6.20	6.80	7.50	8.20	8.90	9.50
37	1.00	1.80	2.60	3.40	4.10	4.80	5.50	6.20	6.90	7.50	8.20	8.90	9.60
38	1.00	1.80	2.60	3.40	4.10	4.80	5.50	6.20	6.90	7.60	8.20	8.90	9.60
39	1.00	1.90	2.60	3.40	4.10	4.80	5.50	6.20	6.90	7.60	8.20	8.90	9.60
40	1.00	1.90	2.70	3.40	4.10	4.80	5.50	6.20	6.90	7.60	8.30	8.90	9.60
41	1.10	1.90	2.70	3.40	4.10	4.80	5.50	6.20	6.90	7.60	8.30	8.90	9.60
42	1.10	1.90	2.70	3.40	4.10	4.90	5.60	6.20	6.90	7.60	8.30	9.00	9.60
43	1.10	1.90	2.70	3.40	4.20	4.90	5.60	6.30	6.90	7.60	8.30	9.00	9.60
44	1.10	1.90	2.70	3.50	4.20	4.90	5.60	6.30	7.00	7.60	8.30	9.00	9.60
45	1.10	2.00	2.70	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.30	9.00	9.70
46	1.10	2.00	2.70	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.30	9.00	9.70
47	1.20	2.00	2.80	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.00	9.70
48	1.20	2.00	2.80	3.50	4.20	4.90	5.60	6.30	7.00	7.70	8.40	9.00	9.70
49	1.20	2.00	2.80	3.50	4.20	5.00	5.70	6.30	7.00	7.70	8.40	9.00	9.70

Table 4

Total Maximum Flow from Hot and Cold Services including

Beds	0	50	100	150	200	250	300	350	400	450	500	550	600	
0	0.00	2.70	4.50	6.30	7.88	9.68	11.25	12.83	14.40	15.75	17.33	18.90	20.48	2
1	0.23	2.70	4.73	6.30	8.10	9.68	11.25	12.83	14.40	15.98	17.33	18.90	20.48	2
2	0.45	2.70	4.73	6.30	8.10	9.68	11.25	12.83	14.40	15.98	17.33	18.90	20.48	2
3	0.45	2.93	4.73	6.30	8.10	9.68	11.25	12.83	14.40	15.98	17.55	18.90	20.48	2
4	0.68	2.93	4.73	6.53	8.10	9.68	11.25	12.83	14.40	15.98	17.55	18.90	20.48	2
5	0.68	2.93	4.73	6.53	8.10	9.68	11.25	12.83	14.40	15.98	17.55	19.13	20.48	2
6	0.68	2.93	4.73	6.53	8.10	9.68	11.48	13.05	14.40	15.98	17.55	19.13	20.48	2
7	0.68	2.93	4.73	6.53	8.10	9.90	11.48	13.05	14.63	15.98	17.55	19.13	20.70	2
8	0.90	3.15	4.95	6.53	8.33	9.90	11.48	13.05	14.63	15.98	17.55	19.13	20.70	2
9	0.90	3.15	4.95	6.53	8.33	9.90	11.48	13.05	14.63	16.20	17.55	19.13	20.70	2
10	0.90	3.15	4.95	6.75	8.33	9.90	11.48	13.05	14.63	16.20	17.78	19.13	20.70	2
11	0.90	3.15	4.95	6.75	8.33	9.90	11.48	13.05	14.63	16.20	17.78	19.13	20.70	2
12	1.13	3.15	4.95	6.75	8.33	9.90	11.48	13.05	14.63	16.20	17.78	19.35	20.70	2
13	1.13	3.15	4.95	6.75	8.33	9.90	11.70	13.05	14.63	16.20	17.78	19.35	20.70	2
14	1.13	3.38	5.18	6.75	8.33	10.13	11.70	13.28	14.63	16.20	17.78	19.35	20.70	2
15	1.13	3.38	5.18	6.75	8.55	10.13	11.70	13.28	14.85	16.20	17.78	19.35	20.93	2
16	1.35	3.38	5.18	6.75	8.55	10.13	11.70	13.28	14.85	16.43	17.78	19.35	20.93	2
17	1.35	3.38	5.18	6.98	8.55	10.13	11.70	13.28	14.85	16.43	17.78	19.35	20.93	2
18	1.35	3.38	5.18	6.98	8.55	10.13	11.70	13.28	14.85	16.43	18.00	19.35	20.93	2
19	1.35	3.38	5.18	6.98	8.55	10.13	11.70	13.28	14.85	16.43	18.00	19.35	20.93	2
20	1.35	3.60	5.18	6.98	8.55	10.13	11.93	13.28	14.85	16.43	18.00	19.58	20.93	2
21	1.58	3.60	5.40	6.98	8.55	10.35	11.93	13.50	14.85	16.43	18.00	19.58	20.93	2
22	1.58	3.60	5.40	6.98	8.78	10.35	11.93	13.50	15.08	16.43	18.00	19.58	21.15	2
23	1.58	3.60	5.40	6.98	8.78	10.35	11.93	13.50	15.08	16.65	18.00	19.58	21.15	2
24	1.58	3.60	5.40	7.20	8.78	10.35	11.93	13.50	15.08	16.65	18.00	19.58	21.15	2
25	1.80	3.60	5.40	7.20	8.78	10.35	11.93	13.50	15.08	16.65	18.23	19.58	21.15	2
26	1.80	3.83	5.40	7.20	8.78	10.35	11.93	13.50	15.08	16.65	18.23	19.58	21.15	2
27	1.80	3.83	5.63	7.20	8.78	10.35	11.93	13.50	15.08	16.65	18.23	19.80	21.15	22
28	1.80	3.83	5.63	7.20	8.78	10.58	12.15	13.73	15.08	16.65	18.23	19.80	21.15	22
29	1.80	3.83	5.63	7.20	9.00	10.58	12.15	13.73	15.30	16.65	18.23	19.80	21.15	22
30	1.80	3.83	5.63	7.20	9.00	10.58	12.15	13.73	15.30	16.65	18.23	19.80	21.38	22
31	2.03	3.83	5.63	7.43	9.00	10.58	12.15	13.73	15.30	16.88	18.23	19.80	21.38	22
32	2.03	3.83	5.63	7.43	9.00	10.58	12.15	13.73	15.30	16.88	18.23	19.80	21.38	22
33	2.03	4.05	5.63	7.43	9.00	10.58	12.15	13.73	15.30	16.88	18.45	19.80	21.38	22
34	2.03	4.05	5.85	7.43	9.00	10.58	12.15	13.73	15.30	16.88	18.45	19.80	21.38	22
35	2.03	4.05	5.85	7.43	9.00	10.80	12.38	13.95	15.30	16.88	18.45	20.03	21.38	22
36	2.25	4.05	5.85	7.43	9.23	10.80	12.38	13.95	15.30	16.88	18.45	20.03	21.38	22
37	2.25	4.05	5.85	7.65	9.23	10.80	12.38	13.95	15.53	16.88	18.45	20.03	21.60	22
38	2.25	4.05	5.85	7.65	9.23	10.80	12.38	13.95	15.53	17.10	18.45	20.03	21.60	22
39	2.25	4.28	5.85	7.65	9.23	10.80	12.38	13.95	15.53	17.10	18.45	20.03	21.60	22
40	2.25	4.28	6.08	7.65	9.23	10.80	12.38	13.95	15.53	17.10	18.68	20.03	21.60	23
41	2.48	4.28	6.08	7.65	9.23	10.80	12.38	13.95	15.53	17.10	18.68	20.03	21.60	23
42	2.48	4.28	6.08	7.65	9.23	11.03	12.60	13.95	15.53	17.10	18.68	20.25	21.60	23
43	2.48	4.28	6.08	7.65	9.45	11.03	12.60	14.18	15.53	17.10	18.68	20.25	21.60	23
44	2.48	4.28	6.08	7.88	9.45	11.03	12.60	14.18	15.75	17.10	18.68	20.25	21.60	23
45	2.48	4.50	6.08	7.88	9.45	11.03	12.60	14.18	15.75	17.33	18.68	20.25	21.83	23
46	2.48	4.50	6.08	7.88	9.45	11.03	12.60	14.18	15.75	17.33	18.68	20.25	21.83	23
47	2.70	4.50	6.30	7.88	9.45	11.03	12.60	14.18	15.75	17.33	18.90	20.25	21.83	23
48	2.70	4.50	6.30	7.88	9.45	11.03	12.60	14.18	15.75	17.33	18.90	20.25	21.83	23
49	2.70	4.50	6.30	7.88	9.45	11.25	12.83	14.18	15.75	17.33	18.90	20.25	21.83	23

Table 5

Total Average Flow from Hot and Cold Services including s

Beds	0	50	100	150	200	250	300	350	400	450	500	550	600
0	0.00	0.90	1.50	2.10	2.63	3.23	3.75	4.28	4.80	5.25	5.78	6.30	6.83
1	0.08	0.90	1.58	2.10	2.70	3.23	3.75	4.28	4.80	5.33	5.78	6.30	6.83
2	0.15	0.90	1.58	2.10	2.70	3.23	3.75	4.28	4.80	5.33	5.78	6.30	6.83
3	0.15	0.98	1.58	2.10	2.70	3.23	3.75	4.28	4.80	5.33	5.85	6.30	6.83
4	0.23	0.98	1.58	2.18	2.70	3.23	3.75	4.28	4.80	5.33	5.85	6.30	6.83
5	0.23	0.98	1.58	2.18	2.70	3.23	3.75	4.28	4.80	5.33	5.85	6.38	6.83
6	0.23	0.98	1.58	2.18	2.70	3.23	3.83	4.35	4.80	5.33	5.85	6.38	6.83
7	0.23	0.98	1.58	2.18	2.70	3.30	3.83	4.35	4.88	5.33	5.85	6.38	6.90
8	0.30	1.05	1.65	2.18	2.78	3.30	3.83	4.35	4.88	5.33	5.85	6.38	6.90
9	0.30	1.05	1.65	2.18	2.78	3.30	3.83	4.35	4.88	5.40	5.85	6.38	6.90
10	0.30	1.05	1.65	2.25	2.78	3.30	3.83	4.35	4.88	5.40	5.93	6.38	6.90
11	0.30	1.05	1.65	2.25	2.78	3.30	3.83	4.35	4.88	5.40	5.93	6.38	6.90
12	0.38	1.05	1.65	2.25	2.78	3.30	3.83	4.35	4.88	5.40	5.93	6.45	6.90
13	0.38	1.05	1.65	2.25	2.78	3.30	3.90	4.35	4.88	5.40	5.93	6.45	6.90
14	0.38	1.13	1.73	2.25	2.78	3.38	3.90	4.43	4.88	5.40	5.93	6.45	6.90
15	0.38	1.13	1.73	2.25	2.85	3.38	3.90	4.43	4.95	5.40	5.93	6.45	6.98
16	0.45	1.13	1.73	2.25	2.85	3.38	3.90	4.43	4.95	5.48	5.93	6.45	6.98
17	0.45	1.13	1.73	2.33	2.85	3.38	3.90	4.43	4.95	5.48	5.93	6.45	6.98
18	0.45	1.13	1.73	2.33	2.85	3.38	3.90	4.43	4.95	5.48	6.00	6.45	6.98
19	0.45	1.13	1.73	2.33	2.85	3.38	3.90	4.43	4.95	5.48	6.00	6.45	6.98
20	0.45	1.20	1.73	2.33	2.85	3.38	3.98	4.43	4.95	5.48	6.00	6.53	6.98
21	0.53	1.20	1.80	2.33	2.85	3.45	3.98	4.50	4.95	5.48	6.00	6.53	6.98
22	0.53	1.20	1.80	2.33	2.93	3.45	3.98	4.50	5.03	5.48	6.00	6.53	7.05
23	0.53	1.20	1.80	2.33	2.93	3.45	3.98	4.50	5.03	5.55	6.00	6.53	7.05
24	0.53	1.20	1.80	2.40	2.93	3.45	3.98	4.50	5.03	5.55	6.00	6.53	7.05
25	0.60	1.20	1.80	2.40	2.93	3.45	3.98	4.50	5.03	5.55	6.08	6.53	7.05
26	0.60	1.28	1.80	2.40	2.93	3.45	3.98	4.50	5.03	5.55	6.08	6.53	7.05
27	0.60	1.28	1.88	2.40	2.93	3.45	3.98	4.50	5.03	5.55	6.08	6.60	7.05
28	0.60	1.28	1.88	2.40	2.93	3.53	4.05	4.58	5.03	5.55	6.08	6.60	7.05
29	0.60	1.28	1.88	2.40	3.00	3.53	4.05	4.58	5.10	5.55	6.08	6.60	7.05
30	0.60	1.28	1.88	2.40	3.00	3.53	4.05	4.58	5.10	5.55	6.08	6.60	7.13
31	0.68	1.28	1.88	2.48	3.00	3.53	4.05	4.58	5.10	5.63	6.08	6.60	7.13
32	0.68	1.28	1.88	2.48	3.00	3.53	4.05	4.58	5.10	5.63	6.08	6.60	7.13
33	0.68	1.35	1.88	2.48	3.00	3.53	4.05	4.58	5.10	5.63	6.15	6.60	7.13
34	0.68	1.35	1.95	2.48	3.00	3.53	4.05	4.58	5.10	5.63	6.15	6.60	7.13
35	0.68	1.35	1.95	2.48	3.00	3.60	4.13	4.65	5.10	5.63	6.15	6.68	7.13
36	0.75	1.35	1.95	2.48	3.08	3.60	4.13	4.65	5.10	5.63	6.15	6.68	7.13
37	0.75	1.35	1.95	2.55	3.08	3.60	4.13	4.65	5.18	5.63	6.15	6.68	7.20
38	0.75	1.35	1.95	2.55	3.08	3.60	4.13	4.65	5.18	5.70	6.15	6.68	7.20
39	0.75	1.43	1.95	2.55	3.08	3.60	4.13	4.65	5.18	5.70	6.15	6.68	7.20
40	0.75	1.43	2.03	2.55	3.08	3.60	4.13	4.65	5.18	5.70	6.23	6.68	7.20
41	0.83	1.43	2.03	2.55	3.08	3.60	4.13	4.65	5.18	5.70	6.23	6.68	7.20
42	0.83	1.43	2.03	2.55	3.08	3.68	4.20	4.65	5.18	5.70	6.23	6.75	7.20
43	0.83	1.43	2.03	2.55	3.15	3.68	4.20	4.73	5.18	5.70	6.23	6.75	7.20
44	0.83	1.43	2.03	2.63	3.15	3.68	4.20	4.73	5.25	5.70	6.23	6.75	7.20
45	0.83	1.50	2.03	2.63	3.15	3.68	4.20	4.73	5.25	5.78	6.23	6.75	7.28
46	0.83	1.50	2.03	2.63	3.15	3.68	4.20	4.73	5.25	5.78	6.23	6.75	7.28
47	0.90	1.50	2.10	2.63	3.15	3.68	4.20	4.73	5.25	5.78	6.30	6.75	7.28
48	0.90	1.50	2.10	2.63	3.15	3.68	4.20	4.73	5.25	5.78	6.30	6.75	7.28
49	0.90	1.50	2.10	2.63	3.15	3.75	4.28	4.73	5.25	5.78	6.30	6.75	7.28

10.28 IDENTIFICATION OF PIPES

The Australian Standard for the identification of piped services. AS 1345 Identification of Piping Conduits and Ducts was reviewed for its application to the proposed services range to be installed at the Westmead Teaching Hospital in 1977. The Standard was reviewed in comparison with the existing NSW Government Public Works Departments Standard at that time EDS M101 ,all services disciplines were party to the final resolution for services identification which was published as drawing (04)-A1-TD-(H)-001 Identification of pipes. The drawing dealt with and specified the Ground colour and Supplementary Bands for 66 services which are noted herein, with some adaptations for evolutionary change added, it is not suggested that this dated system is used as a standard or reference, it predates RO systems and Harvested rainwater ,it does however show that things do not appear to have changed much in the past thirty five years since the issue of Drawing (04)-A1-TD-(H)-001

Identification of pipes ,particularly in respect to co-ordination between disciplines or the inclusion of the line type requirements of computer aided drawing technology.

10.29 A NEW APPROACH TO PIPE IDENTIFICATION

Colour coding of pipes and valves could be considered a most basic and fundamental services management facility lacking any electronic or technological supporting system such as bar coding, or impressed signals that now have the technical potential to be linked to building management systems and diagnostic programs, however basic, it is probable that because of its simplicity and tangible presence colour coding will remain a feature of services design for the foreseeable future.

Regarding the recognition and differences between the multitude of services

In much the same way as we are lacking a viable and fully comprehensive standard for all services pipe drawing identification, the legends we all use for drawings and the standards given by codes could be improved considerably in regard to a uniform and comprehensive standard for the services industry that extends into CAD / REVIT drafting technology and the Health Care Clients Assets management system.

10.30 THE NOTIONAL HOSPITAL COLOUR CODE

(1977 Version of Colour Coding for a Teaching Hospital and now considered to be very much a work in progress)

line	Service	Ground Colour AS K185 Ref Number	Supplementary bands	Notes
1	Steam	Post office red 538	Aluminium	Mechanical Service
2	Condensate	Aluminium		Mechanical Service
3	HTHW Flow	Middle blue 109		Mechanical Service hot water high medium
4	HTHW Return	Oriental blue 174		Temperature services
5	PHWF	Brilliant green 221	White	Potable hot water service flow
6	PHWR	Eau-de-nil 216	White	Potable hot water service flow
7	NPHWF	Middle Brown 411		Non-Potable hot water service flow
8	NPHWR	Golden Brown 414		Non-Potable hot water service flow
9	WWF	Brilliant Green 221	Black	Potable warm water to TS11
10	Heating water flow	Middle Brown 411		Not Hydronic system will effect potable or
11	H Water Return	Golden Brown 414		Non potable recognition.
12	Potable Cold Feed	Aircraft Grey 693	White	
13	Non Potable C F	Aircraft Grey 693	Black	
14	Soil and Waste	Black	Trade waste signage	Trade waste identification required
15	Boiler room pipe	Lacquered copper		Drains and cold feeds to

				boilers
16	Natural Gas	Primrose 310		May also be towns gas
17	LPG	Primrose 310	Black	
18	Compressed Air	Oxford blue 105		Non-medical air
19	Vacuum	Golden Yellow 356		Non-medical
20	Acetylene	Maroon 451		Seldom piped more probable a local bottle
21	Oxygen non-medical	White		
22	Carbon Dioxide	Dark Grey 632	Black	Therapy Pool pH adjustment
23	Hydrogen	Dark Grey 632	Red 537	
24	Nitrogen	Dark grey	Light Grey	
25	Helium	Dark Grey 632	Brown	
26	Other gases			As directed
27	Liquid Soap	Light buff 358		Soap for central systems
28	Harvested rain	French Blue 166	Purple	Refer recycled water code
29	Light oil	Beige 388		
30	Heavy oil; hot	Beige 388	Post office red 539	
31	Heavy oil; hot	Beige 388	White	
32	Condenser water	Sky Blue 101		
33	Cooling water	Aircraft grey 693		
34	Chilled water	Aircraft grey green283	White	Flow and return
35	Refrigerant hot gas	French Grey 630	Post office red 538	
36	Refrigerant liquid	French Grey 630	Traffic Green 267	
37	Refrig Liquid Hot	French Grey 630	Aircraft grey green 283	
38	Refrig suction	French Grey 630	Strong blue 107	
39	Control /lube oil	Lacquered copper		Boiler houses plant rooms
40	Distilled water	Sky Blue 101	Black	Point of use still probable
41	Ultra-Pure water	Sky blue 101	Traffic Green 267	Check RO specifications
42	Fire Services	Signal Red 537		
43	Electrical Services	Light orange 557		
44	Medical Oxygen	Biscuit 369	White & Golden yellow with black diagonal stripes	Refer to As 1169 for back ground combinations which are complex
45	Medical air	Artic Blue 112	French blue /yellow stripes	
46	Nitrous oxide	Biscuit 369		
47	Lab CW	French blue 166	Yellow 356	NPCW may be treated
48	Lab HW	Eau-de nil 216	Yellow 356	NPHW may be treated
49	Filtered P water	Sky Blue 101	Grey 632	Potable water
50	HW Post mortem	Brilliant green 221	Yellow 356	
51	HW Kitchen	Brilliant Green 221	Brown 414	75/80 ºC water for kitchen
52	Haemodialysis	Sky blue 101	Violet 796	Refer also to Ultra-pure

				water
53	Chemical waste	Black	Hazard symbol	Biological –Chemical-Radio active
54	Chilled Drinking	Sky blue 101	Grey 628	Seldom reticulated
55	Flushing service	French Blue 166	Black	Refer recycled water code
56	Filtered water	Sky blue 101	Yellow 356	Now NPCW or PCW
57	Bidet service cold	French blue 166	Yellow 356	Now NPCW
58	Bidet service hot	Eau-de –nil 216	Yellow 356	Now NPHW
59	Special water supply	Sky Blue 101	Violet	Now NPCW –recycled?
60	Sterilizer vent	Black	Grey 692	Older machines only
61	Rising main	Sky Blue 101	Royal Blue 105	Dedicated supplies to tanks
62	Domestic CW	Aircraft grey 693		PCW Designation
63	BMC Control air	Light buff 358		
64	Dental vacuum wet	Artic blue 112	Black band	
65	Dental vacuum dry	Artic Blue 112	White band	
66	Treated Black water	French Blue 166	Black	Refer recycled water code
67	Treated Class “A” Water			Refer NSW Health Circular

CHAPTER 11 HYDRO THERAPY POOLS

11.1 DESIGN SCOPE

The design of therapy pool waste water systems, sanitary plumbing and drainage and domestic hot cold and warm water services will be included in the hydraulic services, the design of a therapy pool water treatment system may be undertaken by a specialist consultant, or a mechanical services consultant, or the hydraulic services consultant.

The pool waste water drainage will be waste water from the pool concourse and filtration back wash water ,the back wash rate will in most systems exceed the capacity of the sanitary drainage system to accept ,a holding delay tank will be required ,some local councils allow the back wash flow that follows a first flush ,to be directed to an irrigation water holding tank .

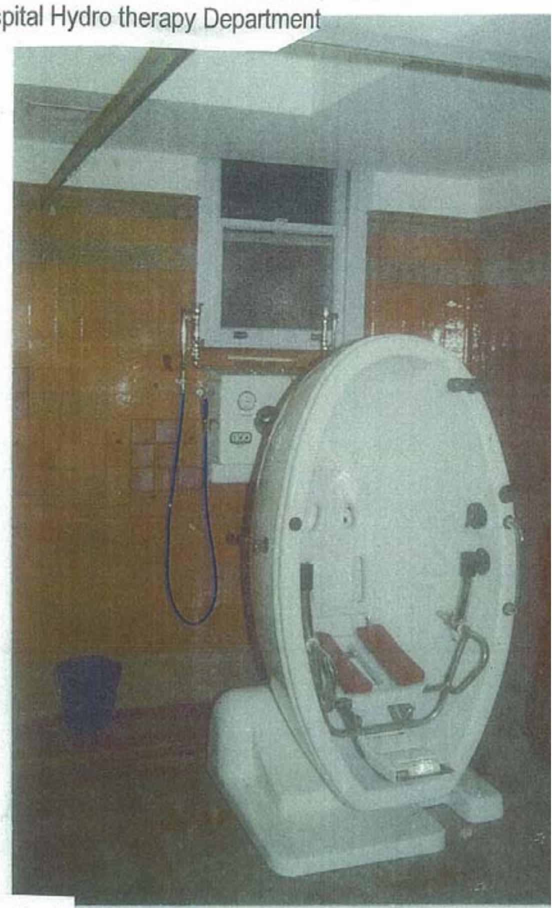
Where the hydraulic designer is undertaking the water treatment system and the concrete outline, it is cost effective design to incorporate back wash holding and possibly harvesting in the general excavation and structural outline of the pool and its surge tank.

It is considered good practice to disconnect concourse drainage inlets from the sanitary drainage by means of a disconnecting gully.

The pool showers may cater for staff activities that are not directly associated with health care therapy, it is cost affective to locate a thermostatic control switch in the mixed water pipe service from one or two of the showers, when the warm shower flow activates the thermostat this activates a circuit to bring on line additional fan ventilation to the change room.

The pool water treatment design is a co-ordination exercise between the structural engineers, the mechanical services engineer who will be attending to the environment of the space above the pool. Specialist advice will be required from the suppliers of water treatment plant.

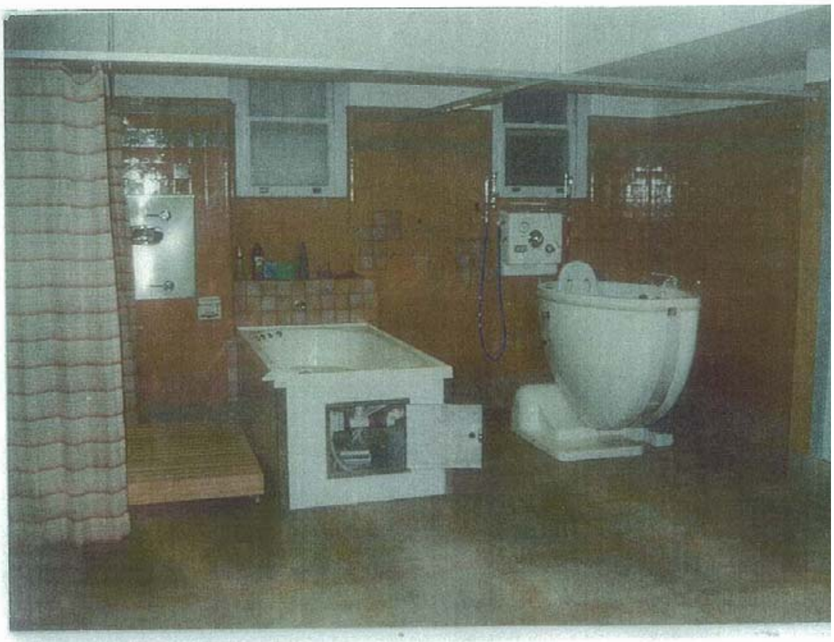
The San Hospital Hydro therapy Department

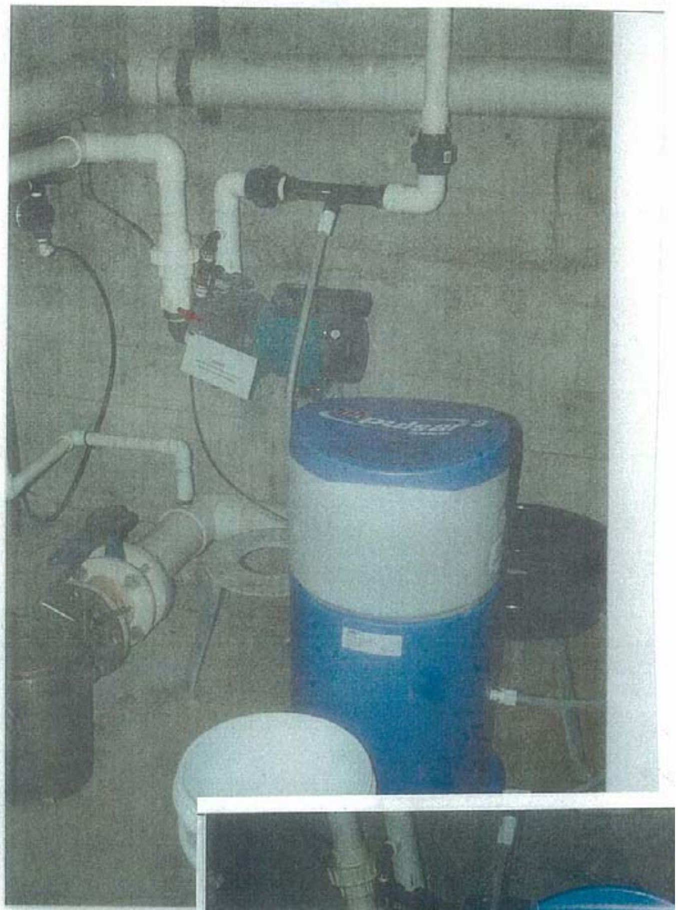


Tilting Egg bath for sitting patients

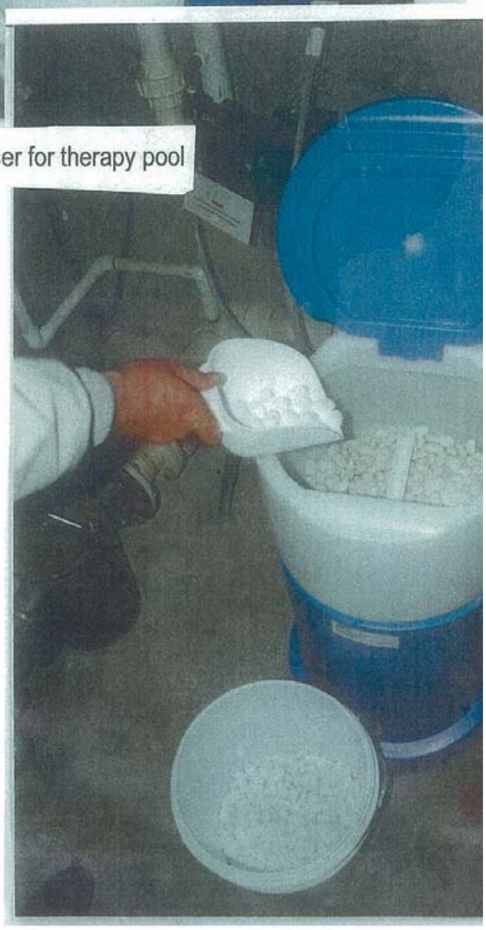
Open position for patient access

Closed position for filling





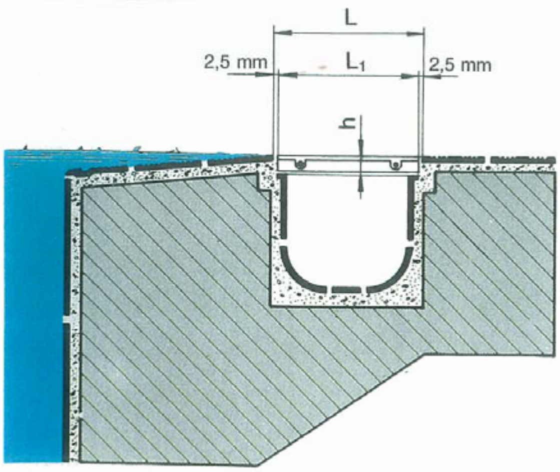
Calcium Chloride tablet dispenser for therapy pool

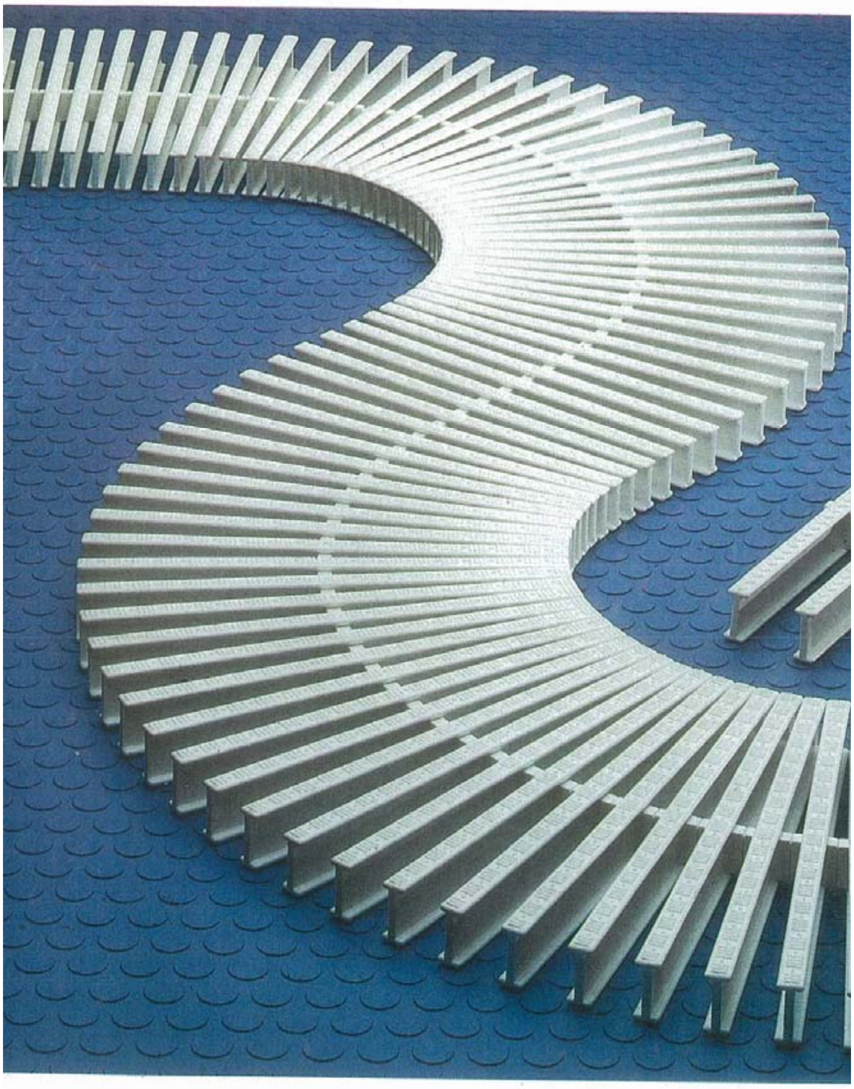


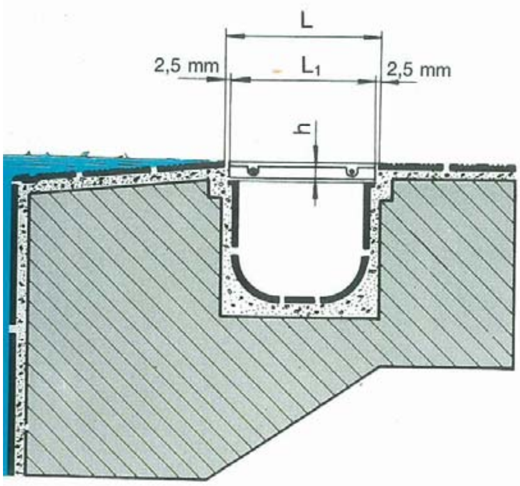
Typical Level Deck T

With patient chair lift

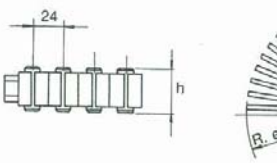
Level or Wet deck sic





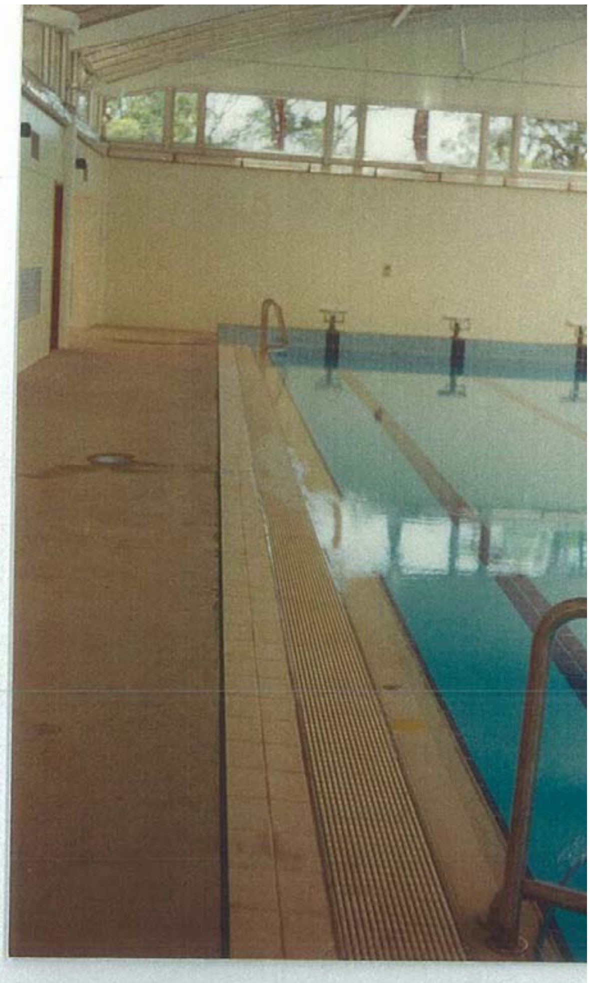


- Modular grating for bends (45
slot together to from a flexible
- Modules pour courbes (45 pa
eux par emboitement.
- Módulos para curvas (45 por m
a presión.



NEW

Model	L	L_1
11107	200	195
11108	250	245
00220	200	195
00221	250	245
00222	300	295
00223	340	335



system. ProMinent offer a wide range for the pool industry.

Concept	0 – 15 L/H
Gamma	0 – 30 L/H
Vario	0 – 120 L/H
Meta	0 – 530 L/H

These pumps can be operated independently of the control system if desired for any reason – for example to super chlorinate.

Hydro vacuum
- Bottle or Wal
- Capacities up
- Manual or Au
- Empty bottle
- Optional mult

ProMi
& Flu
Pty. L

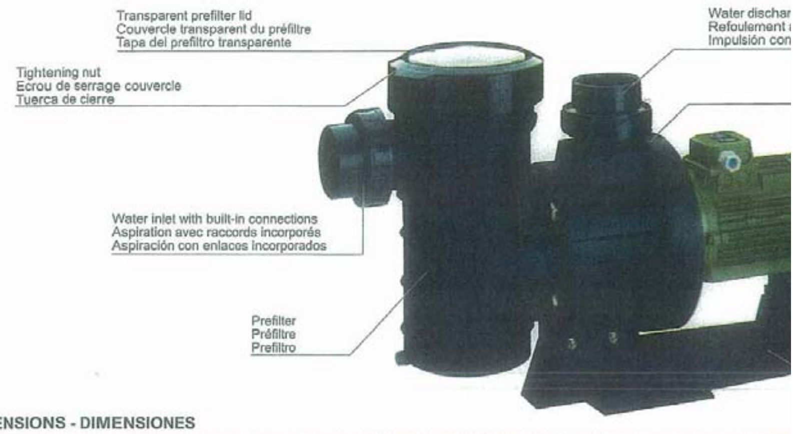
ACN: 001 4

HEAD OFF
& Pittwater
NSW 2100
Telephone

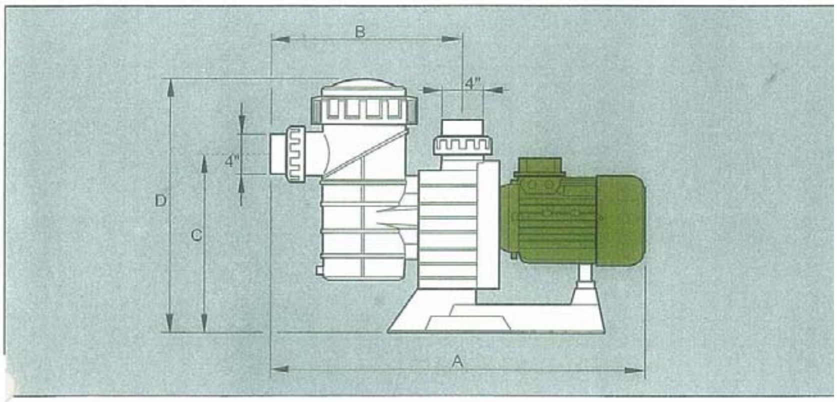
'D' Series – where installation is to be simple and quick! The controller and dosing pump are one! Ideal for small pools and spas.

Here CO
liquid chl
is fully au
retransmi

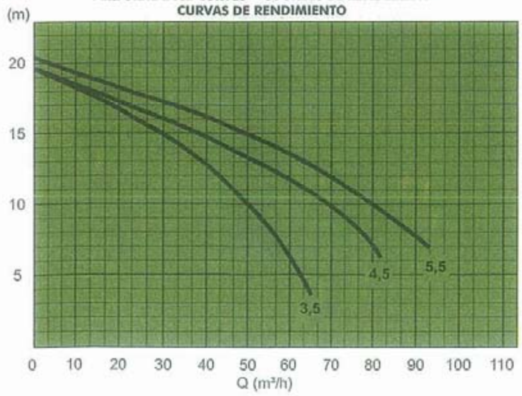
- Water inlets and outlets included.
- Replaceable prefilter.
- Transparent prefilter lid and large capacity prefilter basket (8 lts.).
- Mechanical seal in ceramic, graphite and stainless-steel.
- Double protected motor shaft.
- Threephase motors: 230/400 V. for 220/380 or 240/415 V.
- Motors are built to E.C. standards with IP-54 protection and type F insulation.
- Self-priming up to 1,7 m.



DIMENSIONS - DIMENSIONES

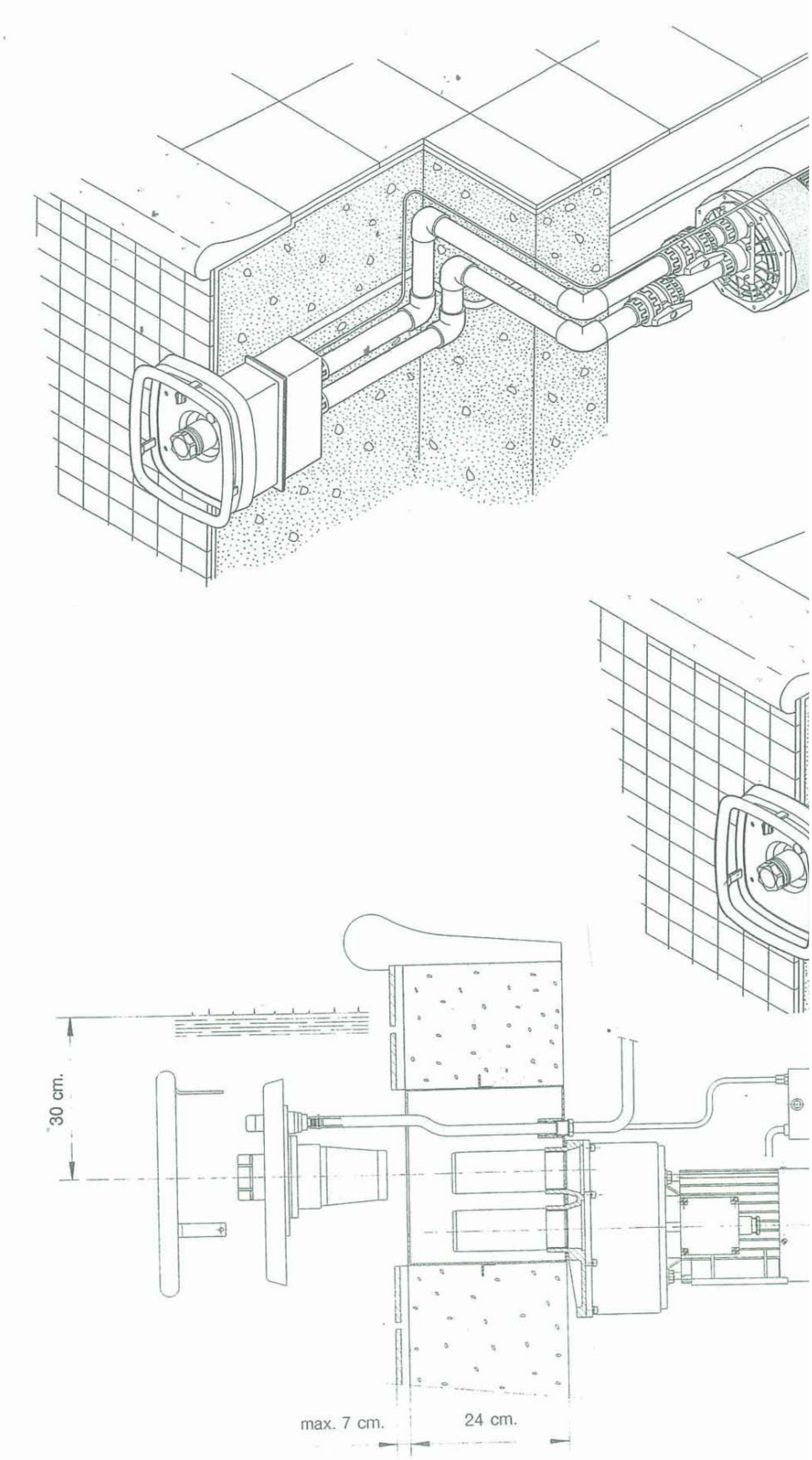


PERFORMANCE CURVES • COURBES DE RENDEMENT
CURVAS DE RENDIMIENTO



TECHNICAL CHARACTERI
CARA

Model Modèle Modelo	Type Tipe Tipo	Volts.
08003	3.5	220/380
08004	4.5	220/380
08005	5.5	220/380



The counter current swimming unit may be required in sports medicine installations, as shown in this Astral Pool drawing the pumping unit can be remote, or local to the jets., a minimum pool water level is monitored by the unit Some modification may be required for a level deck design pool, also a time limit setting is good practice, and pumps of this type can overheat if used for extended time frames.

11 2 OVERVIEW OF WET DECK POOLS

Therapy pools are invariably a level ,or wet deck configuration ,the pool water level is near the same as the concourse level at the perimeter of the pool ,the pool perimeter will comprise a grated channel drain (300mm x 300mm approx. with 1% grade to balance tank) with plastic cover having predominant longitudinal bars which intercept wave motion caused by the displacement volume of persons entering the water , the wave from swimming ,and the increase in volume of entering filtered /heated pool water .

The wet deck pool was first designed for the Munich Germany Olympic Games ,the better vision and lack of side wave reverberation from the end swimming lanes are considered an advantage to competitive swimming ,the ease of access from the water to the concourse ,and the improved observation quality for staff were also seen as significant therapy pool advantages .

The cascade of water at the pool edge gutter can be a source of considerable heat loss; (And noise) a by-pass pipe arrangement should be activated to open when the pool is not in use.

11.3 STRUCTURE

Wet deck pools need a surge, or balance tank to absorb the variations in water volume caused by patients immersion, the tank may be calculated in volume from a nomogram in DIN 19643 (Printed in English), Surge calculations are relevant to the pool length, flow into the edge gutter and pool volume factors that include potential pool population and method of entry most applicable to recreational / sporting pools.

For therapy pool budget calculations the surge is about 10% of the total pool volume, the pool volume will be in the order of 50,000 litres. The depth 1200 mm and the pool may have a wheel chair ramp entry and possibly a patient crane entry from the concourse which could feature under tile heating,

For a concrete pool the hydraulics designer should prepare the concrete profile drawings for the structural engineer to use as the basic concept design.

It is important that all of the pipe work system serving the therapy pool are technically accessible without the need to demolish or change the basic structure, all distribution pipes of treated /heated water to the pool must be housed in concrete chases and back filled with cerement mortar,. In principle .When the structure is completed, the pool pipe work installer should be able to install all of the pipe work without any concrete cutting or similar work. (Please note:-Structural engineers do not always appreciate this requirement).

11.4 MECHANICAL SERVICES ENGINEER

The mechanical services engineer makes an important contribution to the therapy pool ,as with any indoor swimming pool or large water surface ,the loss of heat from the water is for all intents and purposes from surface evaporation from the water to the air interfacing with the water surface ,as with most heat exchange interfaces the transfer of heat by evaporation is dependent upon the temperature difference between the air and the water ,this difference and the dew point of the air determine the loss rate ,theoretically if the water and the air are at the same temperature the loss will be minimal if any ,the recommended air temperature difference is 1ºC above the water ,temperature and an air RH of 60 to 70 % The ventilation rate recommended is 15l/s m^2/pool surface area .

Cold surfaces in the pool hall are vulnerable to condensation, the condensation has a high chlorine content making it very corrosive to metal, light fittings, hand rails, duct work, window frames are all vulnerable products.

Heat recovery in the air heating system and back wash pool water discharge are environmental innovations that are cost effective in maintaining the pool hall environment stable 24 hours a day, the exhausted pool air. Heated

should pass through a run around coil system to preheat in fresh air intake,
the back wash water should do a similar thing with the cold water make up through a plate heat exchanger.

11.5 WATER TREATMENT

Water treatment will involve the following processes and plant:-

10.5.1 Make up and fill

The raw domestic cold water supply at approximately 15°C should be metered and back flow protected by RPZD and be fitted with an auto back wash micro mesh strainer screen of 50 micron and soft close solenoid valve that is activated and closed by a level switch in the balance tank, with a parallel control circuit to the back wash initiation circuit.

As a heat recovery option the cold feed at 15° should pass through a plate heat exchanger, the other side of the exchange being 30 degree pool water.

The heat recovery plate heat exchanger should be valved to allow the back wash side to be flow reversed through a blow down valve to remove filtration debris from the system.

The pre strained, pre-heated cold feed make up shall enter the surge tank at very low level in close proximity to the pool pump suction point.

11.6 FILTRATION

Filtration is a mechanical straining process as compared with biological filtration which is mainly an air induced accelerated degradation process, filtration turnover rates for therapy pools should be 1 to 1.5 pool volumes through the filtration plant per hour when in use ,plant design may adjust this rate for out of use periods .Pool filters become more resistant to flow as the filter becomes dirty ,this phenomena is undesirable and tends to promote a high initial rate and a low final phase flow rate ,pumping plant prior to filters may be fitted with an automatic compensating flow resistance valve (Rubber lined diaphragm) or an energy conserving variable speed drive pump ,both systems require modulating / digital control to balance the flow to the design rate .

Filtration can be undertaken with different filtration plant types.

11.7 CARTRIDGE OR PAD FILTRATION

A low cost removable cylinder shaped fabric screen formed in a thick wall tube, which can be pressure washed out of place, or discarded and replaced, a small pool filter for filtration rates of between 1 and 25 m^3/hour the performance of these filters is variable and they are not recommended for therapy use.

10.6 1 Micro mesh screen straining to 5 micron: - Claimed to be an effective method?

10.6.2 P re-coats diatomaceous earth. Comprising a pressure cylinder with a star shaped porous fabric foundation module that is coated with a water and powdered diatoms mix that resembles white talcum powder and with water milk.

Filtration rate and back wash rate 4m^3/m^2/hour

The diatoms are the skeletal remains of prehistoric sea creatures mined in parts of Europe (Probable that synthetic substances now exist) the microscopic interlocking geometry of the diatoms form a water filter that provides exceptional water clarity. DE Backwash must capture the removed product in a bag filter, and new DE powder must be added. The water clarity is claimed to be superior to sand filtration and there are considered to be maintenance and general running advantages that some hospital engineers favour over the more common sand filter.

11.8 SAND FILTRATION

Sand filtration types:-

High Rate / Medium Rate Pressure Sand Filters

The difference in rate is relative to the rate of water processed, the construction of the media bed and the inlet and under drain pipe work design. Sand media filters are a physical screening process down to 5-10 microns, if colour Where colloidal impurities are a problem a flocculent may be added which forms a gel layer on the sand surface, filtration is carried out under pressure and rated at range of 10 to 50 m^3/m^2 performance range rates above 25 m^3 are not recommended for therapy use.

The filter size being determined by the pool contents turn over's per hour, this rate being determined by the maximum use population of the pool and its volume per person as set down in Public Health Standards and AS3979-1991

Designers must bear in mind that the patients using the pool may be severely debilitated and not have full muscular control; a method of rapidly draining the pool is desirable.

Pressure sand filtration is considered to be the most common swimming pool filtration system being compact and simple to operate or automate, whilst the water quality is not as pristine as DE the clarity difference is not considered to be an issue to most hospital engineers.

The filtration media being a 750 to 1500 mm deep graded layer of washed river sand ,preferable as a vertical cylinder ,horizontal cylinders tend to promote channeling .in some water qualities flocculants or additive gel can be used to remove colloidal substances (Such as ink) .

Filters should if practicable be duplicated, and be connected to a dedicated circulation pump; the system may then be shut down to 505 running when not in use.

Dependent upon the performance of the filter a back wash pump may be required as a separate unit. Flow reversal of sand filters to back wash creates friction and cleaning of the sand material the backwash process can be automated to function at a set pressure drop across the filter or by timer if the loads are consistent after an initial first flush subsequent flow can be directed to harvesting tanks for irrigation and similar.

11.9 POOL CIRCULATION

All areas of the pool should be subject to water change from mushroom recessed inlets in the base of the pool which do not present a hazard to foot traffic ,the pattern of distribution may vary with the pool ,for pools with a depth increase the inlets must be proportional to the increasing water volume (Note Some pool installations can serve as an after hours staff amenity) The Surflo system which is a central spine distribution to the sides is common ,all wet deck systems have an edge gutter pool return ,two types are available

The simple gutter with plastic grate and toe hold tile edge graded with the toe hold submerged about 20mm, and the concourse being the high point of the grade point which falls away from the pool to a waste drainage system.

The split channel system in cooperates two gutters below the grate, one accepts the concourse drainage, the other serves the pool. The pool concourse can be low temperature under floor heated to assist drying.

Pools may incorporate a shower to prevent hydrothermia .or a hydraulic hoist for stretcher patients.

11.10 THERAPY POOL WATER STERILISATION - CHLORINE

The most used chemical because it has residual capacity and remains in the water for a period of time until exhausted as a residual sanitising effect A Chlorine residual of 1 to 1.5 mg/l free chlorine and a pH of 7.2 -7.8 is recommended . Chlorine may be added to the pool water in the form of Sodium hypochlorite 14-15% solution or Calcium hypochlorite ,or Bromine (a Chlorine derivative that stands heated water better) and salt water conversion (Not used in Health Care) .

Chlorine is a gas that can be chemically locked into a carrier solid or liquid for ease of storage and use. On contact with water the Chlorine gas content is released into the water volume and function as a biocide killing bacteria in the water and that inhabits the micro environment in the construction materials .This residual effect of chemicals is the feature of chlorine that supports the minimum mandatory chlorine levels required by Public Health regulations.

Chlorine should be automatically added to the water by a modulating signal from a Redox or PID sensor system; this can be achieved by side streaming pool flow through a container of solid chlorine granular material or tablets, the injection of liquid chlorine, by pulse dose pump.

11.11 TRCHLOROISOCYANURIC ACID

A solid chlorine tablet form which has the advantage of minimal pH affect, is easy to handle and is a lesser OH&S issue, the disadvantage is that the tablets will break down in wet or very humid conditions and release chlorine gas, not a quick response time to sudden contamination or high peaks, Can increase the cyanuric acid content and corrosion and prevent chlorine release. Generally not used in Health Care installations for these reasons

11.12 BROMINE & BROMOCHLORODIMETHYLHDANTOIN

Very active disinfection action and resistance to heated water, involves storage and transport problems. Constant immersion may cause skin reaction.

11.13 BALANCE PH CONTROL

The control of Chlorine content is an important issue, control by a Redox or PID measurement is recommended.

The chlorine content and its effectiveness are relevant to the heat of the water and the pH (Potential hydrogen) adjustment of the tendency for the water to become alkaline.

The pH adjustment can be achieved by a Redox or PID controlled dilute hydrochloric acid dose pump, the better systems are pulse operation and a control system that anticipates the break point required and doses the water reducing the input accordingly to avoid over compensation

As a preferred alternative to liquid acid dosing which is encumbered by Occupational Health and Safety rules (As is Chlorine) Carbon Dioxide gas dosing will achieve the same result ,regular deliveries of Co2 being a part of the hospitals order for other medical gases.

Solid dolomitic media can be added to the filtration system for pH control but is not considered sufficiently flexible for health care applications.

11.14 INSTANT KILL

As the name suggests, the bacteria kill is instant at the point of exposure, but there is no residual effect, theoretically the bacteria carried into the pool by the occupants can remain active until carried into the water treatment system for exposure at the kill point. Ozone is the most effective instant kill process and is used in conjunction with chlorine in high quality installations (The Adventists Hospital Hydro Therapy Clinic) The use of Ozone improves the quality of the disinfection process serving the pool by removing a large proportion of the biological load from the chlorine content which means a lower content may be viable and it will remain active for a longer time frame.

Chlorine reduction in the water is desirable if approval can be secured from health authorities, this approval may require biological testing to confirm the low bacteria count, a process than can only be undertaken on site by suitably qualified personnel with the appropriate laboratory facilities. Chlorine content at the levels required can after constant or repeated exposure in water .affect the mucus membranes of the human anatomy, the eyes in particular are sensitive to this exposure.

Ozone O^3 is a reactive colourless odour free gas that is not sufficiently stable to contain in a compressed state in cylinders like many other gases. Ozone is toxic and dangerous, it will in sufficient quantities, attack the human nervous system.

Ozone is manufactured near the point of use by the corona discharge of an electrical current in dry air ,the delivery system shall be suction operated for safety .Pressurised systems are not recommended for safety reasons.;

The Ozone plant will produce 18 to 25 grams of ozone per cubic metre of air. The ozone is added to the water, it makes the bacteria kill and for safety purposes the ozonized water is passed through an activated carbon filter column to remove all traces of the ozone.

Ozone is subject to the Ozone Protection Act 1989 DIN 19643 also deals with this subject and is a recommended reference

Ozone dose rate are between 0.8 and 1.0 grams per cubic metre @ 28°C (Increase to 1-1.2 g /m^3 for temperatures above 28C) of circulated water with a contact time of 120 to 150 seconds

Control by PID or Redox potential sample point prior to the activated carbon column .As with most pool plant ozone manufacture, injection and control is undertaken by and manufactured by specialist companies. Prominent is recommended.

11.15 WATER HEATING

Water heating input for the therapy pool is a balance of the heat up (from cold 15º Sydney, this temperature will vary with the location) to the use temperature of 28/ 30ºC) + The constant loss at the operating temperature.

Thermal dynamics is a complex field .The input of heat to a pool will give a temperature rise graph that is curved ,the exchange rate reducing as the temperature difference between the heating source and the water being heated becomes less ,the curve can be calculated to the log base "e " ,those last few degrees take much more time than the first few degrees rise ,for practical purposes the following is expedient ,consider also ,control response time, plant cost and the infrequent heat up from cold situations ,heat availability and as noted, thermal shock.

Australian Standard 3634 1989 Appendix E Calculation of Pool Heating Load
should be referred to B2 Evaporative Heat Loss provides the equation for calculating the evaporative loss resulting from phase change ,this is considered to be the largest loss from the system ,the pool sides and base are low loss considerations ,thermal loss from pipe work must be included ,also reheating back wash water lost (with heat) and with level deck pools some added loss takes place at the air to water interface in the gutter .

Evaporation Heat Loss

$q_e = 1.41 (3.1 + 4.1v) (P_w - P_a)$

Where

q_e = Rate of heat loss by evaporation in MJ/m²day

P_w = Saturation water vapour pressure at water temperature (tw) (kPa)

P_a = Partial water vapour pressure in the air (kPa)

v = Wind velocity at a height of 300 mm above the pool water surface in m/s (In indoor pools this is not applicable)

The constant 1.41 in the equation has the dimensions K.m/s². kg resulting from the relation between the coefficients of heat and mass transfer.

P_a = Partial water vapour pressure can be calculated from the relative humidity by :-

$$P_a = \frac{P_s \times RH}{100}$$

P_s = Saturation water vapour pressure at temperature (ta) (kPa) Refer also to Fig B2 of

AS 3634

RH = % Relative Humidity

The water vapour content of the air may also be expressed in terms of wet bulb temperature which may be converted to RH by Curve Fig B2 of the Australian Standard 3634 Appendix .

The constant loss being mainly from the evaporation loss at the pool surface and some loss to the structural fabric, the average total loss for indoor air heated therapy pools is in the order of 300W/m² pool surface area. It is usual practice to maintain air and water conditions in order to avoid high humidity and condensation on cold surface interfaces.

The heat up period will also be subject the pool structural shell to expansion and contraction stress, it is important that the heat up process does not damage the pool fabric.

BS 5385 Part 4 1992 suggests a maximum rate of not more than 0.25 degrees /hour which is considered over conservative by many structural engineers, a rate of 0.5º/C hour being considered a more realistic proposition for Australian conditions.

A thermal rise from 15ºC to 30ºC would take over 30 hours not including the progressive increasing thermal loss from the surface and the flow rate through the edge channel which should be by-passed during the heat up period (And non-use periods when the pool is operational) ,also included the heat required to raise the temperature of the pool construction mass. The combined total of heat up and operational loss will provide a margin of error and heat exchanger fouling.

A 50,000 litre therapy pool would require an input of ;-

$$\frac{50{,}000 \times 4.186\text{kj/kg} \times (15^{\circ}\text{C} - 30^{\circ}\text{ C})}{3600}$$

= 872 kW for a one hour heat up = 29 kW for a heat up over 30 hours at 1ºC/hour

29. kW/hour will meet the heat up load of the water content only, to this must be added the surface loss of a water area of 41.66²/ metres.

The surface loss will add 300Wx 41.66m² = 12.498 kW total = 29 + 12.498 = 41.498 say 43.2 kW. (As noted the nature of heat transfer is to the log base "e" ,this means that the pool volume will heat more rapidly when the Δt is high and much less as the delta t reduces .

11.16 HEAT INPUT

The heating input for the pool should be processed into the pool system by means of a SWEP grade 316 stainless steel plate heat exchanger downstream of the filters in a by-pass loop pipe configuration with thermal control sensor located in the pool suction line system well clear of chemical injection, the temperature setting being adjusted to compensate for thermal loss in the system (This should be constant with an indoor system).

The heat input for the pool in a major hospital may connect to the central comfort heating system; the heat exchanger heat input control will be a three way valve located in the primary heating system.

Where the comfort heating system is not available, the heat source may be a separate boiler (Copper core boilers are not considered acceptable for direct connection or exposure to chlorinated pool water) or heat pump.

Solar collection is considered viable for pools and could be considered where energy resources are limited, solar in conjunction with a heat pump will increase the 24 hour running viability and reduce running cost significantly.

Back wash from heated pools may be a source of heat recover ,the cold inflow passing across the warm outflow in a plate exchanger ,blow down ,and flow reversal is recommended to avoid blocking heat exchanger water ways . Final back wash disposal to the Trade waste system can add useful dilution to aggressive trade waste discharges.

11.17 TYPICAL THERAPY POOL SPECIFICATION

The following is taken from a typical teaching hospital therapy pool specification .clauses dealing with peripheral subject matter such as excavation have not been included and notes in italics are added to advise the reader of that there are other options and design considerations .

General

Scope of Work

The hydrotherapy pool scope of work comprises but is not limited to the following

Preliminary and Contractual requirements

Design documentation as follows and as stated in the (Insert as appropriate)Sub-Contract

Shop drawings

Operating and maintenance instructions

Pool pumping and circulation systems

Pool filtration and sterilisation equipment

Supply of portable pool maintenance underwater cleaning equipment

Water chemistry controller system (s), pump control panels sensors and software

All reticulation pipe work, valves and automatic controllers

AMMS standard equipment marking and labeling

12 month maintenance and defects period

Testing, commissioning and compliance certification of design and installation

1 month start up quantity of all pool chemical supplies

Staff training and instruction

Cold water supply (terminated in plant room with RPZD) by plumber for extension by pool services contractor

TESTS

Supply apparatus and materials necessary for, and carry out the tests required by the Specification or Regulatory Authorities, in the presence of the Superintendent and the authorised representative of the relevant authority for the service under test. Except for site tests, have tests carried out by authorities accredited by NATA to test in the relevant field, or an organisation outside Australia recognised by NATA through a mutual recognition agreement. Cooperate as required with testing authorities. Use instruments calibrated by authorities accredited by NATA.

Chemical Quality tests

Submit for laboratory analysis water samples from four-pool location and confirm site instrument readings are correct for Free chlorine. (DPD liquid) 0.3 to 0.6 mg/L Total chlorine (Combined chlorine < 0.4 mg/L)) pH.Redox Potential.Isocyanuric Acid .Total dissolved solids trihalomethanes, as low as possible maximum of 20 ug/L

Bacteriological tests

Heterotrophic Colony Count to AS 4276.3.1-1995 100 Colony forming units (CFU) per m/l maximum count allowable Thermo tolerant coliforms to AS 4276.6 or AS 4276.7 Nil per 100 m/l, maximum count allowable Pseudomonas aeruginosa to AS 4276.12 maximum count allowable Nil per 100 m/l

Hydrostatic tests

Test drainage pipe work at gravity pressure to flood level for a minimum period of 24 hrs. Check and repair all faulty pipe work and connections

Pressure tests

Pressure tests all pressurised pipe systems in accordance with the manufacturer's recommendations. Do not exceed the maximum design working pressure of the pipe work system during any test. Generally it is sufficient to test to 2 times the working capacity of the system measured at the pump outlet. A test shall be deemed successful if no loss of pressure occurs over a 24 hr period.

Compliance to the following is a contract condition:

Author Notes that the following will require adjustment to the relevant Australian State Legislation

Regulations and Conditions governing all contractors engaged at Hospital and Community

Health AMS (Assets Management System)

Building Code of Australia

NSW Code of Practice for plumbing installations

Room user sheets

DA approval conditions

NSW Health Department – Public swimming Pool and Spa Pool Guidelines

NSW Fire Brigade or local fire service authority

CIBSE – Public Health Engineering Guide G

Department of Health TS11 Guidelines

Safety and occupational health: The requirements of the New South Wales Work Cover Regulations

New South Wales Local Government Act

Services Rules, Regulations and Requirements of the local Electrical Supply Authority

The requirements of the Sydney Water Supply Authority

New South Wales Occupational Health and Safety Act

Units of measurement: To AS ISO 1000.

Standards, Codes & Technical Publications

All works undertaken or provided as part of the contract works will comply in all respects with the materials, workmanship, installation and commissioning requirements specified or nominated in the following published and current versions of STANDARDS, CODES AND TECHNICAL PUBLICATIONS.

AS 3979	Hydrotherapy Pools
DIN 19643	Treatment and Disinfection of Swimming Pools

AS 3979	Swimming Pools
AS 9000	Quality Assurance
AS 3000	Electrical work
AS 2107-1987	Acoustics – Recommended design sound levels and reverberation times for building interiors
AS 3497-1994	Authorization requirements for plumbing products – Domestic type water treatment appliances.
AS 3500.1-1992	National Plumbing and Drainage Code Part 1: Water Supply.
AS 3500.1.1-1998	National Plumbing and Drainage Part 1.1: Water supply – Performance requirements
AS 3500.2-1990	National Plumbing and Drainage Code Part 2: Sanitary Plumbing and Sanitary Drainage.
AS 3500.2.1-1996	National Plumbing and Drainage Code Part 2.1: Sanitary Plumbing and Drainage – Performance requirements.
AS 3700-1988	SAA Masonry Code
AS 3904.2-1992	Quality management and quality system elements Part 2: Guidelines for services.
AS 1357.2 1998	Valves primarily for use in warm and hot water systems Part 2: Control valves.
AS 2845.2-1996	Water supply – Backflow prevention devices Part 2: Air gaps and break tanks.
AS 2032-1977	Installation of UPVC pipe systems.
AS 3996-1992	Metal access covers, roads grates and frames.
AS 4130 (Int)-1993	PE pipes, pressure applications.
AS 3518	ABS pipes and fittings

AS/NZS 1477-1996	UPVC pipes and fittings for pressure applications.
AS 1345-1982	Identification of the Contents of Piping, Conduits and Ducts.
AS 2033-1980	Installation of Polyethylene Pipe Systems.
AS 3855-1994	Suitability of plumbing and water distribution systems products for contact with potable water.
AS 1428.1-1993	Design for access and mobility Part 1: General requirements for access – buildings
AS-2128	Guide to Swimming Pool Safety

PIPING

Before installation, remove loose scale, burrs, fins and obstructions. During construction, prevent the entry of foreign matter into the piping system by temporarily sealing the open ends of pipes and valves with purpose-made covers of pressed steel or rigid plastic.

Install piping in straight lines at uniform grades with no sags. Arrange to prevent air locks. Provide sufficient unions, flanges and isolating valves to allow removal of piping and fittings for maintenance or replacement of plant. Arrange and support piping so that it remains free from vibrations whilst permitting necessary movements. Minimise the number of joints. Provide at least 25 mm clear between pipes and between pipes and building elements, additional to insulation. Join dissimilar metals with fittings of electrolytically compatible material.

Provide access and clearance at fittings which require maintenance or servicing, including control valves and joints intended to permit pipe removal. Arrange piping so that it does not interfere with the removal or servicing of associated equipment or valves or block access or ventilation openings.

Sheath or sleeve metal piping chased into masonry or encased in concrete so that expansion or contraction can take place without damage to the pipe or to the material or surface finish of the surrounding element.

Thermal Insulation

Thermal insulation is to be provided to all pool service reticulation pipe work

Thermal insulation will comprise of 20 mm thick fire retardant flexible closed cell polyethylene equal to Thermotec 4 zero with factory faced aluminium foil and fire performance to AS1530.3.

The insulation is to be made continuous through supports by means of plastic blocks and be continuous through floor and wall penetrations and shall be provided with a fire stop collar at fire treated perforation joints.

Flanges

Flanges will conform with AS2129 and be Table 'E' unless specified otherwise. Use stainless steel backing rings on all plastic flanges complete with stainless steel nuts, bolts and washers.

Valves

All valves are to be Standards mark approved by Standards Australia Quality Assurance Services Pty Limited. Valves used are to be 'George Fischer' manufacture or equal unless specially stated otherwise or approved. Valves shall be placed in easily accessible positions for operation and repair. All valves shall be tested to a pressure of 2,100 kPa by an approved testing Authority.

Check Valves

Low pressure pipelines under 50mm shall be George Fischer wafer check valves. Rienzi rubber diaphragm wafer type valves will be installed on services over 50mm in diameter.

Butterfly Valves

Butterfly Valves shall be equal to George Fischer 367 hand wheel operated connected with EPDM gaskets and stainless steel bolts

Spherical ball Valves

Spherical Ball valves (two or three way) shall be equal to George Fischer type 343 or 370

Pressure Gauges

Gauges are to be K.D.G. type. The faces on the gauges are to be 150mm diameter and gauges will be graduated in metres head and kilo Pascals. Gauges will register one-third kPa more than the maximum possible pressure obtainable from the system served. Each gauge will be complete with approved gunmetal stop cock and sufficient piping for connection to the pipe work gauges will be connected to the pipe work in accordance with CB 0-1968 Code for Pump Tests. Gauges are to be installed on the suction and discharge sides of pumps, filters and pressure vessels.

Polypropylene & Polyethylene Pipe & Fittings

All pipes and fittings are to be Sydney Water and Watermark approved for use on this project. Products will also conform to DIN standards 8077, 8078, 16962 and AS2642.2/AS2642.3. (PPR) polyethylene (PE) Class 12 Type 50 Polybutylene (PB) Class 16 Cross Linked Polyethylene (XLPE) Class 16

The method of jointing for the relevant pipe systems and application including the installation technique will be strictly in accordance with the manufacturer's instructions.

All tradesmen or contractors installing these pipe work systems are to be certified as competent by the manufacturer and as a minimum attend a certified training and induction course for each particular product or system. Proof of attendance and or certification must be produced by the Contractor on demand by the Principal or their Consultants. Polypropylene and Polyethylene pipe work installations are not to be exposed to direct sunlight.

Stainless Steel Pipes

Stainless steel pipes and fittings will be constructed from 316 grade stainless steel, solid drawn to AS 1769. All pipe joints will be TIG welded.

uPVC Pipes & Fittings

UPVC pipes and fittings for use in pressurised systems will comply with AS 1477 and rated at class 12 in all cases uPVC pipes shall be jointed with solvent cement joints. Cleaner preparation shall be used for all joints and applied to spigot and socket areas.

ABS Pipes and fittings

Acrylonitrile Butadiene Styrene (ABS) for use in pressurised systems will comply with AS3518 and be rated at class 12 in all cases Joints will be either solvent cement welded or fusion welded in accordance with the manufacturer's recommendations.

Vibration Couplings

Provide flanged rubber bellows type vibration couplings at equal to Mason industries downstream of all isolation valves where connected to tanks, filters or pumps.

Pump mounts

Each pool pump set is to be positioned at the site at each fixing point to the structure, onto, machinery mounts. The actual model number of the machinery mount will be selected and submitted with calculations to the Superintendent. Each machinery mount will be secured to the structure with stainless steel expansion fastenings and with stainless steel set bolts and washers. Electric Motors Supply electric motors to comply with AS 1359 and AS 1360. Motors shall be of a type suited to drive the equipment covered in this specification in a manner recommended by the manufacturers, and in particular to the development of adequate torque relative to the starting load of the driven machine. The run up to full speed should be steady, and within a time period compatible with motor winding temperatures, within the limits of the class of insulation, and within the rating of the proposed starting equipment.

Motor rating shall be continuously rated at an ambient of 40 ºC.

Motors shall comply with the following standards as appropriate:-

Motors rated 0.37 kW and above shall be three (3) phase type unless nominated otherwise in the Motors rated above 20 kW shall be fitted with embedded winding temperature thermistors complying with AS 1023 in each phase. Trip operating temperature shall be matched to motor winding insulation classification.

Motors being supplied from variable frequency drives shall be selected to provide low noise and vibration, and shall have class "F" insulation, with class "B" temperature rise or better.

Pump Design

Pool Pumps shall be manufactured from zinc free bronze (AS 1565 - Designation 906D) with phosphor bronze impeller, Grade 316 stainless steel shaft, and mechanical seals that area suitable for a heated chlorinated pool water. Alternative construction materials (eg Plastic will be considered, if provided with an unconditional five year warranty. The pump castings shall be of uniform composition and thickness to effectively withstand all normal working and surge pressure. The impeller shall be securely keyed to the motor shaft which shall be of ample diameter to avoid vibration. The rotating assembly shall be statically and dynamically balanced.

Pool Pumps

Shall be VSD and digital speed controlled from a pressure drop sensor located downstream of the filter unit and shall be selected so as not to be greater than 90% of the maximum diameter for that particular pump.

Motors shall be sized to suit the pump casing; not necessarily the selected impeller size.

Pump selections and duty points of the system speed range shall be provided with this tender

Recirculating pumps

Shall have a shut off head shall not exceed 20 metres. It is the responsibility of the contractor to correctly assess the hydraulic resistance of the system and to determine and commission the duty points accordingly.

Recirculating pumps shall be factory tested in accordance with AS-2417, Part 2, Class C. Certificates of Performance are to be provided within the Operation & Maintenance Manuals. Pumps shall be installed in accordance with the manufacturer's Instructions and shall be complete with necessary isolating valves, flexible connections, eccentric inlet connector, concentric outlet connector, vacuum gauge, pressure gauge, and (rubber in shear type) vibration pads. Pumps shall be mounted on approved concrete plinths that are provided by the Contractor.

Pump motors shall be squirrel cage induction motors with a totally enclosed fan cooled enclosure. Motors shall be insulated with Class E materials, impregnated to be suitable for "tropical" conditions. Motors shall have a maximum continuous rating in accordance with AS 1359 to develop the power required by the pump when running under any condition of discharge. For the purpose of rating the motor, the ambient temperature of the cooling air shall be taken not to exceed 40 deg cell

Pump Classification

Contractors are to confirm the hazard zone classification for pumping units and associated controls such as float switches wiring etc. All pumps installed within car park areas shall be manufactured to class one zone two specifications. Pumps shall be certified by the manufactured or supplier as meeting these conditions prior to installation.

Pool filtration pumps

Variable speed drive pool circulation pumps consisting of (2 number) pumps, , control panel and associated control wiring all mounted on common galvanised mild steel fabricated base.

The pumps are to be VSD control system pump sets fitted with motors capable of variable speed drive. The VSD pumps will be controlled to provide a constant flow rate through the filtration system regardless of pressure resistance through the filters.

Pump Duty: provided by contractor based on 90-minute pool turnover rate and system resistance

Pre pump strainers

Provided pre pump strainers. Pre-pump strainers to remove lint and other semi fine water borne obstructions are to be provided. Pre pump strainers will incorporate quick action toggle bolts and a swing davit for easy access to stainless steel perforated basket.

Pre-pump strainers will be approved products fabricated from GMS. .

Backwash holding well pump

Supply and fix a dual submersible backwash pump, level controllers, and flexible hose connectors, guide rails, control panel and associated control wiring. The pumps rotation will operate on a timed basis from within the control panel.

Pump Duty 2 l/s @ 5 m/h

Heating water circulation pump

Supply and fix heating water circulation pump on the pool return side of the plate heat exchanger Include control panel, sensors gauges, control panel and associated control wiring.

Pump Duty: provided by contractor based on? kW rating of plate heat exchanger. Parameters are as follows:

Maximum pool water temperature 40°C

Mechanical heating water temperature 65-70°C

Maximum rise per pass through the primary heat exchanger 5°C

The completed pool plant shall provide water of the following conditions:

Colour will not be more than 5 PPM on the Platinum Cobalt Scale

Turbidity will not be more than 0.5 units as defined section 5.2 of the DIN standard 19643

pH will be within the range 7.2 to 7.6

Minimum free chlorine concentration will be not less than 1.5 mg/L

Total chlorine concentration will not be more than 10 mg/L

Reserve Alkalinity will be maintained between 80 to 140 mg/L

Calcium Hardness will be maintained 80 to 120 mg/L

Total dissolved solids will be maintained as less than 1500 mg/L

Maximum velocity within plastic pipe work will be 3 metres/second

Copper tube shall not be used in conjunction with the pool system

Maximum suction velocity downstream of pumps will not exceed 1 m/s

Maximum velocity at bottom inlet mush room inlets will be 0.300 m/s

Maximum cyanuric level will not exceed 100 mg/L

Maximum back wash discharge rate to sewer will not exceed 2 litres/second

Water temperature will be adjustable to 40 degrees Centigrade

Water heating plant will raise the pool water content from 15 degrees C to 32 degrees C in 30 hours including balance tank content

The pool has a volume of? cubicmetres and will have a facility to fill in 10 hours and drain down in 24 hours

Hydrotherapy pool overview

The hydrotherapy pool will be a level deck wet edge pool.

The outer edge of the pool will have 300mm wide deck grate on all sides. .

The gutter grate and tile work associated with the pool is not included within the scope of this specification.

The pool channel will incorporate low noise balance tank input with integral, and removable double leaf trash racks

The pool and the pool balance tank will be drainable to the back wash tank by gravity and pumped from the back wash tank to the trade waste drain.

All chemical storage will be bunded, emergency facilities are to be provided in this contract as required by regulation.

Return to pool delivery shall be from bottom low velocity (0.30m/s) adjustable inlets.

The filtration system will provide 3 Pumps with variable speed drive controlled by pressure drop across the filter.

Provision of 3 manual backwash pre-coat Atlas D/E filters

Chlorination will be by automatic chemical control aquatic erosion calcium hypochlorite dry granular system complete with automatic local control (BMS output) and remote modem monitoring

Backwash cycles are to incorporate 11-kg de bag filter

Fluropolmer dry lamp 30000 microwatt seconds per cm2 UV irradiation system with hours run meter and lamp replacement advise to the local panel and BMS system

BOC Gasmatic Co2 pH control system with remote fill and remote and local readout at the BMS

Cross flow plate heat exchanger equal to SWEP with a pool input potential of 150 kW

All pool water heating control valves, pump and sensors for remote temperature reading at the BMS to be provided

Pool Criteria

Approx. Surface Area (m2)	120
Pool Volume (m3)	123
Turnover Rate (hrs)	1.5hrs
Nom. Recirculation (m3/hr)	83 (23 l/s)
Operating Temperature (deg cell)	28 - 38
Filter Process	DE: Regenerative Precoat Filtration

Filter Rate (m3/hr/m2)	9.6m² x 3
Total Filter Area (m2)	3 x 3.2m² = 9.6m²
Filter Rate (m3/hr/m2)	3
Backwash Rate (m3/hr/m2)	5
Backwash Flow/Filter (l/sec)	4.5
Wash Water Consumption (m3)	4.75 x 3

pipe work

ABS rated to 1200 kPa (pn 12)

DE Filters

The filtration system will consist of three ultra-fine filtration vessels equal to ATLAS. The filters will be of the regenerative up-flow type using replaceable diatomaceous earth media filtering down to a minimum of 2 microns. The filtration vessel will be designed for commercial swimming pool application in accordance with NSF approval.

Filters vessels will be rated to 350 kPa and be delivered to site complete with media, lifting lugs, air release socket, sample socket, flanged inspection hatch, pre-coat tank fixing, gauge socket, inlet nozzle, backwash nozzle and filter water outlet nozzle.

Chemical dosing installation

The chemical dosing system will comply with the requirements of all relevant Authorities. The chemical dosing plant is to be sourced from one manufacturer.

Allowances are to be made for the supply and installation of all discharge tubing from the specified dosing system to the specified injection points. The discharge tubing will be conduit encased and be installed above the floor slab in a neat workmanlike manner using bends, not short radius elbows.

All lines will be installed to avoid air pockets during normal operation. All tubing, valves, fittings, etc will be of materials that are guaranteed for the specific service conditions

Automatic chemistry controller

Supply and install all necessary equipment and associated hardware for the automatic control of free chlorine and pH.

The control Instrument will provide digital read outs capable of displaying the measured values on a continuous basis through a local outlet monitoring (BMS connection) and remote monitoring via an integral modem.

Control Instruments will be rated to IP65 and shall be mounted on a backboard complete with interconnecting wiring and approved probe holder. To optimise the treatment control, the control instrument shall be equipped with PID control or HRR.

Benchmark standards for the selected chemical controller will be the **Strantrol 5** with remote readout capability and intercommunication output through both local data point (BMS system) and remote modem readout capability.

Note that the pool will be stabilised with cyanuric acid. The measuring probes are to be housed in an approved flow cell with pressure reducing valve, isolating valve, flow regulation valve, rotameter for flow indication and adjustable flow switch.

Water chemistry controllers will be as manufactured by either Prominent (PID), USF: Strantrol (HRR), Wallace Tiernan: Stranco (PID) . Control units other than the above makes will not be considered for this installation

pH control

Provide a BOC Gasmatic CO2 system with remote fill capability including all necessary fittings. Lease arrangements for the system will be undertaken by the client however all coordination and installation of the system will be provided by the contractor.

Pressure regulation and metering systems will be supplied as a complete wall mounted panel interlinked with the main filtration and pool control system. The flow of Carbon Dioxide will be controlled by a solenoid valve that is actuated by the pH control system. The flow rate will be measured and varied via a correctly designed flow meter. The pH system will incorporate a correctly designed with draw able injection diffuser or venturi that ensures optimum gas use.

The complete Carbon Dioxide system will be in accordance with the requirements of the current dangerous goods regulations and local authorities. The Contractor will also ensure that the installation complies with the recommended practice as set down by the supplier of the carbon dioxide gas.

Chlorination

Chlorination shall be maintained within the hydrotherapy pool by means of a calcium hypochlorite dispensing system. The entire system will be fully automated and controlled by the central automatic water chemistry unit

The complete dispensing unit shall be equal to a Pulsar HTH 3 commercial pool and spa water sanitation system or the Granados GR20E. The dispenser unit shall include recirculation pump, storage and dispensing tank.

Calcium hypochlorite will maintain a 65% hypochlorite strength upon delivery and be equal to the system manufacturer's proprietary product in all cases.

Flow control

Rate of flow through each pool filter system will be controlled by means of a variable speed drive sensor. The sensor will operate via a pressure sensitive switch measuring the pressure drop across each filter. The nominated subcontractor shall establish and certify system flow (at both clean and dirty filter loads)by volumetric analysis or ultrasonic flow meter.

No flow switch

Provide an approved no-flow switch in discharge line of each system. This switch may be a paddle type flow switch as manufactured by Kelco Engineering or approved equal. These flow switches will be the basis of providing an electrical interlock with the chemical treatment and the pool heating plant.

Flow Switches are critical to the system design and must be constructed of materials that are specifically suited to heated chlorinated pool water. Flow switch will be wired with an adjustable time delay whereby all associated equipment (chemical dosing, heating etc.,) and remain off-line for a period of up to fifteen minutes after an initial flow (from at least two flow switches) has been established. Time delay will be finally set by the installer to suit the system's ability to purge start-up air from the system. In the event that a flow switch detects a loss of flow that equates to less than 50% of the total system flow, the associated plant will automatically shut down in same sequence that would be normally adopted for a manual shut-down.

To satisfy the above requirements allow for either PLC controls, or a series of timers & interlocks. Specific details are to be provided within tender returns

Digital flow meters

Supply and install digital flow transmitters/meters at each filter. Meters will be equal to Burkert Digital Flow Transmitter Type 8045 in all cases. The meters(s) will be installed with a Burkert insertion fitting complete with associated wiring and DC power supply as recommended by the manufacturer. Include outputs for BMS connection.

Fluid level controllers

Water levels within the hydrotherapy pool balance and backwash tank shall be controlled by Multi Trode level sensing equipment. Probes will be ordered to suit the requirements of each individual bank.

Pool make up water will be controlled by a Multi Trode probes connected to a Multi Trode MTR relays. Upon receiving signal from the probe a single solenoid valve will be energised to openand close the tank fill line. Backwash Tank operation and Level indication will be controlled by a Multi Trade probe connected to a MTZPC Duplex Pump Controller. The MTZPC alarm will be connected to an audible sounder or bell within the plant room.

UV treatment

The hydrotherapy pool will be protected with a Fluropolmer dry lamp UV Disinfection system or Prominent DulcodesPowerline UV disinfection system. The UVC radiation dose at a UV transmission of 96%/cm at the end of the lamp operating time shall be 600J/m^2 . The unit will be complete with UV disinfection system controller, swept stainless steel connection bends isolation valves and strainer on discharge line.

CHAPTER 12 ENERGY AND CONSERVATION

12.1 ENERGY FROM THE HYDRAULICS PERSPECTIVE

The most significant practical, simplistic and cost effective development in hydraulic services energy conservation in recent history that has slipped quietly into the residential and to a lesser degree the Health Care market, and has received minimal attention, is the increased thermal resistance and heat / energy conservation of the now significant market share use of polymer pipes, polyethylene, polypropylene and Polybutylne and polymer thermal insulation .

The entry of polymer into the Health Care hydraulic services field has been of more impact in Germany and in Western Australia, the Metal trace elements to Polymer reaction failures in New South Wales and Queensland have been a significant problem that has not been fully resolved.

The focus on energy conservation for most Heath Care projects is the use of gas driven Total Energy systems .Co-Gen or Tri Gen, gas fired power generation systems that also utilise the abundant waste heat for comfort heating, domestic hot water heating, absorption cooling, sterilizing steam production, an impressive list.

Energy and conservation in Health Care and its hydraulics services component do not seem to attract the same level of attention from environmental organisations such as “Green Star” as do other service and construction disciplines.

The use of Shared Domestic hot water and Comfort Heating, or the high thermal resistance polymer pipe, which saves significantly more thermal loss and energy consumption than a comparable metallic pipe reap no benefit in the Environmentally Sustainable Greenstar points system.

The 25 years old, and now near standard industry practice of fixture flow control and dual flush cisterns are still regarded as innovative?

Waste heat recovery from laundries, kitchen grease wastes, animal cage washer’s hot waste, domestic showers and AC chillers, or condenser water, are not on the agenda, nor is waste heat recovery from the hot gas of mortuary and kitchen refrigeration.

These concepts are viable for Coles and Woolworths Supermarkets, and aged technology in commercial laundries, but they seem to be a challenge for Health Care installations.

The case for waste water heat recovery is a closed case in Australia, not so in Sweden?

The following paper “The case for Small bore Pipes”, is an example of a now dated review being submitted to” Australian Standards” for consideration.

A pipe sizes reform which includes NATA Laboratory tests that showed a **69%** saving in water alone and a probable similar saving in energy and Medical personnel time ,at a capital cost reduction .

The interesting question is” What does it take in our industry to stimulate some interest “?

The paper which was published by the AHSCA Newsletter and has been drawn to the attention of Australian Standards. It has received a near zero direct response, or apparent interest from standards, or the design wing of the hydraulic services industry, curiously there was an article published in the **Autumn 2010 Plumbing Connection** which carried the title *“The committee for plumbing installations /regulations is reviewing its regulations in hope of reducing dead leg water to a maximum at any tap outlet at any time to 2L….*The review is probably still in progress?

TABLE4.6(A) ACCEPTABLE MAXIMUM PIPE LENGTHS FROM HOT WATER OUTLETS OR FIXTURES –NON CIRCULATING SYSTEMS

DN	10	15	18	20	25
Internal diameter mm	7.0	10.0	12.5	15	20.5
Length metres	52	25	16	11	6
Note Alternative solutions to pipe lengths specified in the table may be used providing the amount of dead water draw off at any outlet does not exceed 2 litres					

The article goes on to say that in a typical household the annual water wasted as a result of excessive reticulated pipe work length and poorly located water heaters may add up to 15000 litres per house per year .Due to this waste the committee is currently reviewing its regulations in hope of reducing dead leg water to a maximum at any tap outlet at any time to 2 litres.

The“ Plumbing Connection” publication advised it would follow up on this concept, it’s a good while ago now and nothing has changed, why might that be?

2000 years ago The Roman orator and statesman Marcus Tullius Cicero, is said to have used the expression **“cui bono”** (Who benefits) to the Roman consul Lucius Cassius Longinus Ravilla in a famous trial . Cicero won and avoided the penalty of being sown into a leather sack with a rabid dog and a poisonous snake which was then thrown into the Tiber.

12.2 THE CASE FOR SMALL BORE PIPES

By-Law 14 Was the Sydney Water regulation that preceded AS/NZS 3500 .The By-Law was in Imperial dimensions and included a clause that maximised the permissible length of half inch pipe (12.7 mm) to six feet

The six foot rule was justified by the following informal explanation

The By-Law was written many years ago and when written it was targeting the cottage industry ,the six foot rule was a simple means of ensuring that the few unscrupulous plumbing contractors out there would not provide a half inch service for an entire dwelling “

Over long periods of time, we tend to lose sight of the logic that supports regulations and Code recommendations .Also it is not considered valid by the writer, to brand today’s licensed plumbers as unscrupulous.

There is a plausible case to put forward justifying much smaller pipes in warm and hot water systems, also to a lesser degree cold service pipes, but there is obviously no thermal advantage, or water saving advantage with cold services.

The following letter was an approach made by the AHSCA to Australian Standards 5-- 2010

RW:bw

5th May 2010

Standards Australia limited

WS-14 Committee

Exchange Centre Level 10

20 Bridge Street Sydney NSW 2001

Attn: Alan Law

Dear Alan

RE: THE CASE FOR SMALL BORE PIPES

We attach for your attention a paper published in a recent AHSCA Newsletter to members.

The paper reviews the “Case for Smaller Pipes “and provides supporting data from a NATA Certified Testing Laboratory.

This paper was prepared by a very experienced past founding member of the AHSCA who has a personal interest in conservation of energy and water.

The paper takes a cursory look at the historic reasons for the minimum pipe diameters that are currently used as common trade practice and offers an option that is a more cost effective in respect to both capital and recurrent costs, particularly for domestic hot and warm water services. As supported by the technical data attached as an appendix, the eventual broad adoption of the concept as outlined would save the community considerable energy, plus an added bonus of convenience being achieved by reducing the waiting time to clear residual hot water from dead leg branch connections.

Historically, and currently, domestic Hot and Cold water services that are approved for use have legislated a maximum mandatory permissible length and diameter. This is believed to have been inherited from the early By-Laws that predated high rise development, the original target being cottage plumbing, and the intent to protect home owners from undersized water services. It is of interest that hot water services received little attention in By-Law 14, which was eventually rectified in the production of AS3500. The mandatory regulations or Australian Standards recommendations that control pipe diameters and pipe length should be relevant only to:

- the pressure available
- the flow rate required

the thermal loss

the frictional resistance, and

the velocity of the water as an acoustic consideration.

A RELEVENT OBSERVATION

It is curious that Public Utilities are pressing the use of low flow control fixture delivery rates, dual-flush toilets and low energy lighting to the extent that incandescent lighting fittings are to be phased out.

Conversely the thermal/energy saving advantage of using plastic pipes for hot water reticulation has not registered in the pursuit of environmental sustainability.

The “Case for Small Pipes“ Offers the following.

A new environmentally-friendly design concept for small pipe diameters within the

constraints of existing practice.

For Example, the NSW Health Policy Memorandum

TS 11 determines that a “Dead Leg” shall consist of a 10 metre maximum length of

pipe (logically, the cooled water draw-off should be determined by water volume, not

pipe diameter).

A different, but not unique, hot water ring main loop.

The small pipe concept is not bound to this type of circulation.

It could be any of the following:-

Conventional flow and return

Conventional return pumping

Non-circulating system with multiple branch services to a number of fixtures

from a single heat source.

A much lesser volume habitat for Legionella colonisation in warm water reticulation.

In conclusion, AHSCA (NSW) Inc. believe that Australian Standards could assist

considerably in advancing the progress of domestic hot and cold water services design by making an energy saving recommendation that points out the inherent advantage of the plastic pipe thermal resistance and adjusting the current standards where the clauses restrict the use of smaller pipe diameters, possibly reinforcing the advantages of source to point reticulation over sequential branch conventional systems.

We trust that the forgoing is of interest to Australian Standards and we look
forward to your consideration of our proposal please contact the undersigned should you require any further information on *(Telephone number deleted).*

Yours Faithfully,

AHSCA (NSW) Inc.

Rod Ware

1st Vice President-Technical

Enc.

cc. David Creasey

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ABN 23 031 331 289

OVERVIEW

A small bore point to point system is valid for both hot and warm water .However the greater advantages are more relevant to warm water systems used in Health Care systems in conjunction with automatic activating sensor taps.

The growth of hand washing basins and the use of sensor taps in the Health Care field has in recent history expanded significantly as part of the drive to contain Hospital acquired infections, many of which are seen to originate from hand contact.

A count of fixtures in part of the intensive care ward in a modern teaching hospital revealed 16 beds and 25 adjacent basins with sensor taps and Thermostatic mixing valves, (TMV) some TMVs are serving up to three basins, and as far as the current health rules allow, providing the overall pipe length is currently 10 metres or less then this is permissible practice.

On testing the sensor valves some take up to 9 activations to obtain warm water. It takes a long time at 6 litres per minute or less, to remove the cold water that is in the section of pipe from the TMV to the Tap

12.3 AS/NZS 6400-2400 STAR RATINGS

Table 3.1 is included to demonstrate the trend in using less flow of water at consumer points, This trend compliments smaller pipes ,and smaller pipes means less drain down ,and less waste ,also less energy loss in thermal emission from the pipe wall ,and for heating up the wasted water content.

AS / NZS 6400-2006 FLOW RATES AND STAR RATINGS

AS/NZS 6400:2005								
Table 3.1—Rating specifications for showers (extract)								
			Rating					
			0 Stars	1 Star	- 2 Stars	3 Stars	3 Stars	3 Stars
Item	Product type	Water Consumption unit	(warning)					
1	Showers	L/min	More than 16.0	More than 12.0	More than 9.0	More than 7.5	More than 6.0	
			or failing the	but not more	but not more	but not more	but not more	
			performance	than 16.0	than 12.0	than 9.0	than 7.5	
			requirements					
5	Tap Equipment		More than 16.0 or	More than 12.0	More than 9.0	More than 7.5	More than 6.0	Not more than
	flow controllers		failing the	but not more	but not more	but not more	but not more	4.5
			performance	than 16.0	than 12.0	than 9.0	than 7.5	
			requirements					

12.4 AS3500 .1.2

Table 1.1 Lists DN 10 – 15 – 18 – 20 -25- 32- 40- 50

As the pipes and Tubes for use in Australia (Tubes are usually OD pipes ID)The Table following sets out water volumes in 10 metres of pipe or tube at the diameters conventionally used for dead leg reticulation, and with water flowing at 6 litres per minute through the system to a single tap. It is noted that 10 metres is the allowable dead leg length maximum as determined by Clause 2.4 Page 3 NSW Policy Directive,

DN Size	**Actual Internal bore**	**Volume in 10 metres**	**Time to evacuate** **Seconds**	**Pressure drop For 10 metres**	**Water Velocity m/sec**
7.5	5-mm	0.196-litres	1.96	140 kPa	5.0911

(See footnote)				Estimated	
10	7.7- mm	0.465 litres	4.65	69 kPa	2.147
15	10.9-mm	0.933 litres	9.33	13.15	1.076
20	17-mm	2.270-litres	22.77	4.15	0.440

Foot note: - 7.5 mm Polyethylene pipe is not currently listed as a standard diameter in AS3500 .also the water velocity exceeds the 3 metres per second upper limit recommended by Australian Standards practical testing does not reveal excessive noise generation from this water velocity, the valve internals are subjected to such velocities in normal use.

12 5 HEALTH CARE SAMPLE

Based on a 25 Basins and 16 bed example

The ratio for Staff to hospital patients is in the order of 2.4 to 3 staff per bed .Using this ratio the 16 beds would be supported by about 40 persons ,not all in direct contact as medical personal , based on a theoretical average of 1 doctor and 4 nurses on duty most of the time ,and contact visiting the patient say 4 times a day ,the basin usage could be in the order of 16 beds x 4 times day = 64 tap usages .

BASED ON THIS AVERAGE RATE OF USE THE CONSUMPTION PER DAY WOULD BE AS BELOW

DN Pipe	Water waste	Energy Waste	Waiting time
7.5	12.544 litres	364 Watts	2.09 minutes
10	29.76-litres	865 Watts	4.96 minutes
15	59.71 litres	1736 Watts	68.8 minutes
20	145.28 litres	4224 Watts	1457 minutes

EXPRESSED OVER A YEAR (16 BEDS)

7.5mm pipe wastes 4578 litres and 66.43 kW per year and 12.71 hours waiting time

10-mm pipe wastes 10862 litres and 157 kW per year and 30.17 hours

15 –mm pipe wastes 21794 litres and 316 kW per year and 418 hours

20- Mm pipe wastes 53027 litres and 1541.76 kW per year and 8863 hours

As a pro-rata relationship between consumption and beds, and based on water costs of $1-00 kl and 6 cents a kW gas energy the forgoing calculations indicate that an 800 bed hospital could consume and cost as shown in table 3

TABLE 3 PRO-RATA CONSUMPTION COSTS PA FOR 800 BEDS

DN Pipe used	$ Water Cost	$ Energy	Man hours Waiting Time	Consumables cost
7.5	$228	$199.29	635.5 hours	$427
10	$543	$471	1508 hours	$1014
15	$1089	$948	20900 hours	$2037
20	$2651	$4625	443150 hours	$7276

12.6 THE JEM FLOW TEST RIG

The Jemflow Test rig verifies satisfactory flow for showers and basins. It also demonstrates that there is a hidden cost in using metallic pipes such as copper because of the larger amount of heat energy absorbed, and lost by the copper The specific heat of copper metal is 0.385 J/g·K. How many joules of heat are necessary to raise the temperature of a 1.59 kg block of copper from 21.0°C to 86.8°C?

E = mass x specific heat x change in temp.

As15432 Type B 15mmx.0.9 mass = 0.302 kg/m

10 metres 15 mm tube = ’10 x 0.302 =3.02 kg
specific heat = .385 J/gK x 3.02 kg= 1.1627 385 J / kg k
change in temp = 15 - 50 C = 35

E = (3.02kg) (385J/ kg K) (35 K)
E = 122897.39J= 122.89 kJ

This is the additional energy loss over and above the heat loss from the actual water that can be expected after heating a copper tube 10 metres long with 50 degree water and allowing that water to cool .the time frame of cooling will vary dependent upon the value of thermal insulation and the air temperature surrounding the pipe. There is of course a loss from the same diameter plastic pipe from the water content, however the thermal loss is about half from plastic than copper, or any other metal.

12.7 POINT TO POINT 7.5 MM HOT AND WARM WATER RETICULATION

The proposed point to point from a TMV manifold small bore system shows clear running cost advantages, not noted is the practical proposition of running 10 metres of small bore pipe to each individual tap, which increases the potential of the TMV to serve possibly four user points as against the current two, or possibly three points if the planning permits. The concept is equally valid for central warm of hot water systems.

The time consumed by medical staff represents the most significant saving and would remove the obvious frustration of waiting for the warm water to arrive, this frustration appears to be amplified by the use of hands free sensor taps, with modern technology the expectation is instant service, failure to comply with this expectation usually discredits the sensor tap technology rather than the true culprit.

The forgoing notes concentrate on the saving of water, energy and time; the notes do not include the cost of sewerage removal, which is a value added bonus.

The Jemflow Laboratory test is attached as the following appendix.

JEM Australia Pty Ltd – P. O. Box 3161 Putney. Sydney. Australia. 2112

Phone: +61 2 9807 8592 - Fax: +61 2 9807 8594. E-MAIL: admin@jemaustralia.com

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12.8 TESTING COMPARATIVE PERFORMANCE OF SMALL BORE TO CONVENTIONAL PIPING

Aim

To determine the amount of water that is discharged from a heated water piping system before the desired temperature is delivered to the user discharge point. Each piping system has a maximum dead leg of 10 metres from the temperature controlling device to the user discharge point.

Heated Water Systems Tested

System 1 (Conventional System)

This is a conventional heated water piping layout that is commonly used in health care buildings to provide heated water at a temperature no greater than 43.5 degrees C. It is supplying three discharge points through a combination of copper tube complying with AS1432 in sized DN 20 and DN 15 (see figure 1).

System 2 (Small Bore Manifold System)

This system consists of a manifold on the outlet of the temperature controlling device, three individual 10 metre runs of 7.15mm internal diameter PE pipe to each of the discharge points (see figure 2).

Test procedure.

Each system was tested using the following procedure:

1. Provide a continuous supply of heated water not less the 60 degrees C to the inlet of the temperature controlling device.

2. Provide a continuous supply of cold water not greater than 25 degrees C to the inlet of the temperature controlling device.

3. Run cold water through the piping system until the discharge temperature at the furthest point is equal to the temperature of the cold water supply to the temperature controlling device.

4. Operate the furthest discharge point (10 metre length) measure and record the quantity of water discharged until the water temperature reaches 43.5 degrees.

NOTE: This temperature is maximum heated water temperature for health care buildings.

5. Repeat step 3 and 4.

6. Operate the furthest discharge point (10 metre length) measure and record the quantity of water discharged until the water temperature reaches 38 degrees.

NOTE: This is a practical temperature for heated water usage.

7. Repeat step 3

8. Repeat step 6

9. Calculate the time and velocity of the water to discharge at a flow rate of 4 litres per minute (6 star WELS) and 6 litres per minute (5 star WELS).

On completion of the test on the manifold system measure and record the flow rate from the furthest discharge point (10 metre length) at a dynamic pressure of 150 kPa and then at 250 kPa.

RESULTS

SYSTEM 1 (Conventional System)			
Temperature	Test 1	Test 2	Test Average
43.5 degrees C	5.5 litres	4.7 litres	5.1 litres
38 degrees C	2.6 litres	2.55 litres	2.58 litres

SYSTEM 2 (Manifold System)			
Temperature	Test 1	Test 2	Test Average
43.5 degrees C	1.9 litres	2.0 litres	1.95 litres

38 degrees C	0.8 litres	0.8 litres	0.8 litres

COMPARISON OF THE TEST AVERAGES		
Temperature	43.5 degrees C	38 degrees C
System 1 (conventional)	5.1 litres	2.58 litres
System 2 (manifold system)	1.95 litres	0.8 litres
Usage Reduction	3.15 litres	1.78 litres
Percentage Reduction	62%	69%

TIME TO DELIVER HEATED WATER AT 38 DEGREES C		
Flow Rate	System 1 (Conventional)	System 2 (Manifold System)
4 litres per minute	39 seconds	12 seconds
6 litres per minute	26 seconds	8 seconds

SYSTEM 2 FLOWRATE

(a) Flow rate at a dynamic pressure of 150 kPa the flow rate is 12 litres per minute.

(b) Flow rate at a dynamic pressure of 250 kPa the flow rate is 16.2 litres per minute. This flow rate is most likely limited by the delivery capacity of the temperature controlling device.

12.9 TEST CONCLUSION

System 2 (manifold system) provides significant reduction in water usage and has the ability to reduce water consumption per use by **69%.** In addition there is a significant reduction in hot water energy consumption. The manifold system as tested could supply up to 4 separate basins simultaneously and on a 40% diversity could be connected to 10 basins.

13 SOLAR

Note .A philosophical approach to the inclusion of a solar contribution to the Domestic Hot Water Service loads of Hospitals has been addressed in the “Notional Hospital Chapter”. However there is a much broader consideration of solar to be addressed.

A solar contribution to any project using domestic hot water services (And warm water services) should logicallyreduce the production of carbon dioxide and other by-products of fuel combustion and the actual manufacturing process to create the solar collection system and be of a commercial benefit to the enterprise using the plant. Life cycle costing is a critical pre-requisite.

There are at this point in time six prominent manufactured product methods of capturing solar energy available to designers.

The glazed flat plate collector.

The evacuated tube or inert gas filled tube collector.

The plastic multi pipe webbed collector strip system.

The focusing parabolic collector.

The photovoltaic cell.

The refrigeration cycle heat pump.

Reviewing the above list in reverse order.

6) REFRIGERATION TECHNOLOGY

Using the heat gathering physics of state change from liquid to gas , and gas to liquid by compression and de-compression (The vapour compression cycle) has been used in Australia since 1861 James Harrison Boywon River Geelong Australia .

The heat pump uses the same technology but reverses the direction of transfer, the low grade heat being gathered from the air and amplified and delivered to water by a hot gas to water heat exchanger (Air to water heat pump) .The domestic sized heat pump unit has become popular in that market increasing market share over the past 10 years as energy costs increase.

In health care the opportunities of using the hot gas waste heat from Air Conditioning chiller, Mortuary refrigeration, and Medical ice making machines has been a rare event, possibly because few chillers are manufactured locally and modifications have an impact on warranties.

As noted previously, Coles Supermarkets use this technology as standard practice. The heat pump has the advantage of extracting the suns energy from the heated air, rather than from radiant heat .The advantage of this arrangement is that heat pumps work at night, also they have no problems with extreme weather, and it would be difficult to overheat with a heat pump. Heat pump performance is measured by the C.O.P (Coefficient of Performance) this will range from 3 to 4

Meaning that a $ to drive the heat pump will return $3 to $4 of equivalent heat value.

A secondary and related heat extraction from the air conditioning cooling system is a direct cold feed to Condensers water flow heat exchanger ,condenser water flow can operate at 35°C which gives the potential to have a pre-heating cold feed supply based on (15-35°C)Δt = 20°C ,Several non-health care buildings utilise this feature .Deutscher Bank Sydney . Sails in the Desert Hotel in the Northern Territory. Suncorp Building Sydney, possibly there are others.

As with any energy conservation system Life cycle costing should be based on the value of the energy returned over the life cycle of the plant ,a balance between the environmental cost of manufacturing and transporting the plant ,its actual running cost ,maintenance ,and interest on the capital cost are all negative issues , some of these costs will be subject to inflation estimates ,the return must exceed the cost to claim viability .However the reduction of other plant and the reduced cost that is associated with that reduction are part of the credit column.

5).THE PHOTOVOLTAIC CELL.

The prior philosophical chapter which touched on the need to understand some aspects of other disciplines does relate closely to this method of harvesting solar energy ,it must obviously be a competitor for solar collection space .

As published in the November New Scientist and available as a Multimedia guide to energy production ,use and sustainability at www.energyrealities.org The better and more expensive silicon cells currently produced are around 28% efficient in turning sunlight into electricity . At the low end of the cost and efficiency scale 11% most commercial cells available are 16% approximately and currently they can be installed for about $1 per watt of capacity.

New developments in the design of cells (ETA Extremely thin absorber) are understood to be very cost competitive and render about 11% .The absorber is a few nanometers thick and production costs of $0.50 watt are anticipated.

The proposition of combining this very thin cell with other building surface materials is not reviewed in the data, if practical such a proposition would have a significant impact.

The advantage with direct power generation from the sun is the very low line loss when compared with using hot water as the transport medium. Also the distribution and management of the end product of electrical energy is accommodated by existing technology.

4).THE FOCUSING PARABOLIC COLLECTOR.

The focusing parabolic collector may comprise a long and parabolicshaped cross section collecting surface which has the geometric quality that all solar radiation captured by its surface area is focused at a single point ,this being a glass and vacuum sheathed pipe that may contain water or thermal oil.

The collector's angle is adjustable east to west pointing at the northern suns path crossing from horizon to horizon. The collecting parabolic shell is designed to fully rotate in rain or hail and provide a protective cover to the receiving element, and also protect the highly reflective and vulnerable internal surface of the parabolic shape. These are complex and very high heat producing solar systems that will produce temperatures sufficient to run absorption AC chillers, or generate steam.

3) THE PLASTIC MULTI PIPE WEBBED COLLECTOR STRIP SYSTEM.

This webbed Polybutylene pipe system which clips to roof fabric strip collector is very much a case of low cost with modesty efficiency and big collecting area, the target users are domestic swimming pools where the temperature required is 27°C or less and the rule of thumb area is to duplicate the pool surface area.A fringe benefit is the cooling effect to the roof fabric and the problem of industrial fall out from air pollution obscuring a transparent surface as is the case with glazed collectors.

2.) THE EVACUATED TUBE OR INERT GAS FILLED TUBE COLLECTOR

Reputed to be more efficient than flat plate collectors .However Sydney University Studies did not confirm a significant difference in performance, other than where the evacuated tube system is mounted in a vertical configuration, this together with more resistance to freezing might be the reason that this type of collector is popular in Europe. The sales data for theAP evacuated tube collector is extensive and comprehensive technical data and is included in the following under the headingEnvironmental Sustainability.

1) THE GLAZED FLAT PLATE COLLECTOR

The original mass produced solar collector which remains the most used means of collecting the Suns radiant heat for Domestic Hot Water systems. The well tried thermo syphon system from collector to storage is recommended, regrettably architecture does not always compliment storage tanks at a level above a north facing solar collection array and the complexity of pump control systems that actually do work well is delicate and vulnerable equipment. Flat plate collectors are generally a number of vertical collecting tubes silver soldered to a black metal surface area to capture as much radiant heat as is practical .Impressed pattern collectors, much the same as the cooling coils in the wall of a domestic refrigerators freezer were manufactured in stainless steel in the 1970s by a company called “Snowside”, an innovative and ideal unit for Chlorinated pool water.

The glass for plate collectors is critical for maximum radiation transfer coupled with sufficient strength to resist hail stones.

The big issue with flat plat collectors is the heat balance, particularly for low loads in extreme weather, the drain down proposition to shut off heat input can reveal many problems, such as re-filling a system that still holds thermal capacity in metal parts sufficient to generate steam on re-filling.

Solar systems designed to drain down should have air inlet valves to prevent partial vacuums and to allow filling. Where valved the solar array must be fitted with a pressure relief valve, and in cold climates a protection system to prevent freezing.

13.1 SOLAR IN HEALTH CARE COST IN THE USA

Average cost per kWh in United States from Energy Management Systems for Commercial Buildings, Pike Research, 2009

2 Energy Information Administrations

3 Profit Margins: ASHE Healthcare energy guidebook, 2003

4 Energy Intensity: Energy Information Administration

Original compiled by **Schneider Electric - Healthcare Solutions – Michael Sullivan – 30 April 2010**

13.2 ENVIRONMENTAL SUSTAINABILITY

It would seem a reasonable proposition for private enterprise to set up within a "Public Health Care" amenity a PPP Private Public Partnership, solar system that sold heat as a product, leasing plant space at a peppercorn rate, buying gas and augmenting that primary fuel with a solar contribution and delivering energy at a competitive and profitable rate that sustains the enterprise, if we are a capitalist society and we need clean energy, why does this not happen?

The use of a Solar contribution for heating domestic hot water and for Photo Voltaic power generation is now in Australia as a well-established government subsidised socially acceptable architectural disfigurement of residential street scapes and roof tops .

It does not appear to be the case in Health Care?

This may be because the Gas tariff for very large users is too competitive for solar investment?

The following evacuated tube data is from a manufacturer and is considered to be an excellent data review of a most advanced system, other than possibly the focusing parabolic collector.

The focusing solar collector as noted previously, generates sufficient high grade heat to run an absorption chiller unit for air conditioning, the best and possibly the only example of such a system sits on the roof of the ROTEX Australia Pty Ltd Unit 4-5 60 Fairford Rd Padstow NSW 2211, fabrication workshop, an example of a quiet achiever in action.

The following is borrowed from “Zane Solar” Pool Hearting Systems

The Solar Constant :- recent satellite probes confirm that the hourly suns energy at the outer layer of the earth’s atmosphere is 4.860 +/- 3.5% MJ/M² Of this about 30% is lost passing through the atmosphere and by radiation back into space so that the maximum that can reach the earth’s surface is approximately 3.406 MJ/M² on a horizontal plane At any one time this will vary considerably from place to place depending on local climate and latitude .For practical purposes an average hourly insolation in the 2.271 to 2.498 MJ/M² range (6kW/day m²)

USEFUL SOLAR

The significant disadvantage with solar is its timing, the best solar results are not well coordinated with the highest demand periods for Hot water, we overcome this by storing the energy in water (Or batteries).

Hot water is a convenient medium and has an obvious affinity with the hydraulic services designer. Hot water also has some disadvantages.

It is corrosive

It will in the corrosion process absorb trace elements that are not welcome in health care.

It has high line losses both by direct thermal emission and pumping cost.

It has a limited volume to energy capacity 4.186mj /litre/°C

The useful temperature band is small

It is space consuming and expensive.

EUTECTIC SALTS

Thirty years ago Dr Maria Telkas of Delaware University proved that Eutectic Salts technology was sound Eutectic salts ,also known as Glaubers salts can be a 60% mixture of sodium nitrate and 40% potassium nitrate (Commonly called saltpetre) when heated go through a phase change from solid to liquid ,as with any phase change this requires heat energy ,whilst the salts remain liquid they retain the heat ,when the heat is required the salts revert back to a solid and release the heat ,the advantage being that the phase change stores in the region of ten times the heat that a comparable volume of water would contain.

Phase change materials do have the ability to store the thermal energy that motivates the change of state ,ice to water, water to steam , liquid wax to solid .eutectic salts crystals solid to liquid and the vapour compression cycle of compressed gas to liquid gas.

The ice storage system has been used to compliment chiller production and rationalize the peak load to an average load. On a much larger scale pumping to elevated mountain lake / reservoirs stores kinetic energy for later use in hydroelectric turbines, but on a commercial scale the bulk storage of heat has been limited to the very efficient thermal insulation of the ROTEX hot water unit.

Phase change thermal release evidently takes time and this in practice has proved to be a problem.

SOLAR CONTROL

The standard flat plate collector will collect about 6 kW/m² day ,unless the system operates with a natural thermo siphon ,it is going to need a means of circulating the water through the collector when solar radiation is available , the obvious choice is to use a pump ,how is the pump controlled ?

The author went to Fiji in 1968 to review the performance of solar units on a small hotel, the system had a thermostat at the high point of the solar collector array, when the thermostat registered 40°C the pump started, a slug of cold water pumped round the system, it filled the collectors and eventually reached the thermostat and shut down the pump. It was a batch loading system. The results were not impressive

The author has checked another system it was fitted with a differential thermostat ,the water flow to the collectors was measured and the flow out was measured ,if there was a temperature gain the pump stayed on line pumping away ,this system was showing better results but had one problem ,it needed a trial run of the pump to make the differential measurement ,if the pump stopped because water in was hotter than water out ,it needed to re check the situation periodically.

Fiji is a group of islands which have few natural mineral resources and zero oil resources ,energy is a high cost item which makes solar very attractive. Fiji is not an industrialised society, high tec products are not manufactured and replacement is favoured over repair, there is however an interesting level of local initiative in manipulating the technical products of the western world to meet local expertise .The most effective solar control system was resolved in this way.

A black mild steel boiler plate 300mm square in a glazed frame was mounted on the roof ,the back of the plate had an adjustable contact thermostat set at 50°C started the pump and stopped it at 45 degrees .

The advantage with this system was

It was cheap.

It was easy to understand.

If a cloud passed over the sun the thermal inertia of the steel plate kept the pump on line.

It started when there was solar gain and stopped when there was no gain.

It was cyclone proof.

A.P EVACUATED TUBE SOLAR COLLECTORS

The following is considered an excellent Trade presentation of data

The AP range of solar collectors use twin-glass selectively coated evacuated tubes as the solar absorber.

Each evacuated tube is fitted with a metal heat transfer fin, which serves two purposes, firstly to aid heat transfer, and secondly to secure the copper heat transfer heat pipes tightly against the inner wall of the evacuated tube.

The copper heat pipes are evacuated and contain a small volume of purified H_2O, which, due to the vacuum, at low temperatures (>30°C) boils and vapourizes.

The excellent heat transfer properties of the heat pipes facilitate the transfer of thermal energy from within the evacuated tubes to the collector header.

The header comprises two 18mm copper pipes, which have copper "ports" brazed between them. The 18mm copper pipes are contoured to the shape of copper ports in order to increase contact area. In addition the contoured shape of the header creates turbulent water flow, thus further enhancing heat transfer.

The heat pipes plug into the header ports, which are tapered at the end to ensure firm contact for optimal heat transfer. The header is insulated with compressed (~70kg/m^3) glass wool and housed by 0.8mm thick aluminium outer casing.

The manifold and evacuated tubes are secured to a frame constructed of 1.5mm thick 304-2B stainless steel, with all bolts and fittings also made from grade 304 Stainless steel.

For installation on a flat surface, a flat roof adjustable angle frame is available, which is also made from 1.5mm 304-2B stainless steel, with attachment feet made from 2mm thickness stainless steel.

The AP solar collector is suitable for installation in an active, split system configuration, in either a closed or open circulation loop.

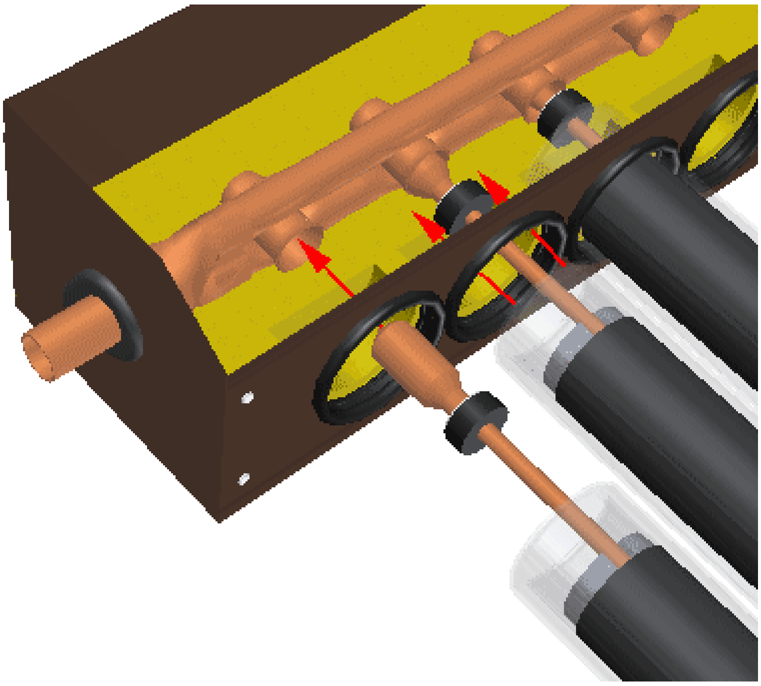
The header is suitable for potable water flow, or the use of glycol-water mix for enhanced freeze protection in climatic conditions that require such protection.

The manifold is designed to be able to withstand wet or dry stagnation without damage to the system; however in a well-designed system stagnation should rarely occur. A temperature relief valve set at <99°C / 212°F should be incorporated into the solar loop plumbing (or on the storage tank) to allow dumping of hot water/pressure if the system stagnates.

The copper header is rated to withstand a maximum pressure **of 800kPa / 116psi.**SPF and **SRCC tested according to 600kPa max pressure** (the standard in Europe and USA.

Collector Size	**10 tubes**	**18 tubes**	**20 tubes**	**22 tubes**	**30 tubes**
Overall Length [1]	1980mm / 80"				
Overall Height [2]	156mm / 6.14" (manifold + standard frame)				
Overall Width [3]	796mm / 31.3"	1356mm / 53.4"	1496mm / 58.8"	1636mm / 64.4"	2196mm / 86.4"
Absorber Area [4]	0.8m^2 / 0.86ft^2	1.44m^2 / 15.5ft^2	1.6m^2 / 17.2ft^2	1.76m^2 / 18.9ft^2	2.4m^2 / 25.8ft^2
Aperture Area [5]	0.94m^2 / 10.1ft^2	1.69m^2 / 18.2ft^2	1.88m^2 / 20.2ft^2	2.07m^2 / 22.3ft^2	2.82m^2 / 30.3ft^2

Gross Area	1.57m² / 16.95ft²	2.68m² / 28.8ft²	2.96m² / 31.8ft²	3.24m² / 34.8ft²	4.35m² / 46.8ft²
Gross Dry Weight	34.8kg / 76.5p	58.2kg / 128p	63.5kg / 139.7p	71.3kg / 156.8p	94.8kg / 208.5p
(Standard Frame)					
Fluid Capacity	290ml / 9.8oz	490ml / 16.57oz	520ml / 17.58oz	550ml / 18.6oz	710ml / 24oz



CUTAWAY VIEW OF MANIFOLD SHOWING COPPER HEADER AND HEAT PIPE INSERTION

COMPONENT SPECIFICATIONS

Copper Header	
Material	>99.93% Copper Sn<0.012%, Zn<0.04%, Pb<0.003%, Fe<0.004%, Ni<0.003%, As<0.002%, S<0.003%, Bi<0.001%, Sb<0.002%
Length (mm) Rear Port Models (Inlet centre to outlet centre)	L= (X-1) x 70 + 80 (X=No. tubes) L = (X-1) x 2.759" + 3.15"
Length (mm) End Port Models (overall length)	L = (X-1) x 70 + 240 (X=No. tubes) L = (X-1) x 2.759" + 9.45"
Header Pipe Dimensions	∅18mm OD x 1.2mm 0.7" OD x 0.047"
Brazing Rod Materials	45% Silver, 30% Copper, 25% Zinc (BAg45CuZn) & 93% Copper 7% Phosphorus (BCu93P)
Inlet & Outlet	∅22mm OD 0.866" OD (Attachment by supplied brass compression fittings only)
Temperature Sensor Port	∅10 OD x 1.0mm ∅0.39"OD x 0.039"
Recommended Flow Rate	0.1L/tube/min (10tube = 1 L/min) 0.026G/tube/min (10tube = 0.26G/min)
Max Flow Rate	15L/min / 3.9G/min regardless of collector size.
Max Operating Pressure Rating	800kPa / 116psi (850kPa / 123psi PRV acceptable)
Manifold Casing	

Manifold Length	L= (X-1) x 70mm + 160mm (X=No. tubes) L = (X-1) x 2.759” + 6.3”
Lid Length (mm)	Manifold Length + 6mm / 0.236”
Height (lid on)	131mm / 5.157”
Width	140mm / 5.512”
Tube Spacing	70mm / 2.759”
Manifold Material	0.8mm Aluminium (Grade 3A21) Silver Enamel Painted or Black Powder Coated (PF - Phenol Formaldehyde Resin)
Frame	
Material	1.5mm / 0.059” thick 304-2B Stainless Steel
SS Tube Clips	301 Stainless Steel
Bolts, Washers and Nuts	304 Stainless Steel
Insulation	
Material	Compressed Glass Wool
Insulation Factor	K = 0.043W/mK

Evacuated Tubes (Solar Absorber)	
Tube Length	1800mm / 70.8” (Actual length to tip = 1810-1830mm / 71.25”-72”)
Outer Tube Dimensions	∅58mm x 1.6mm / ∅2.28” x 0.063”

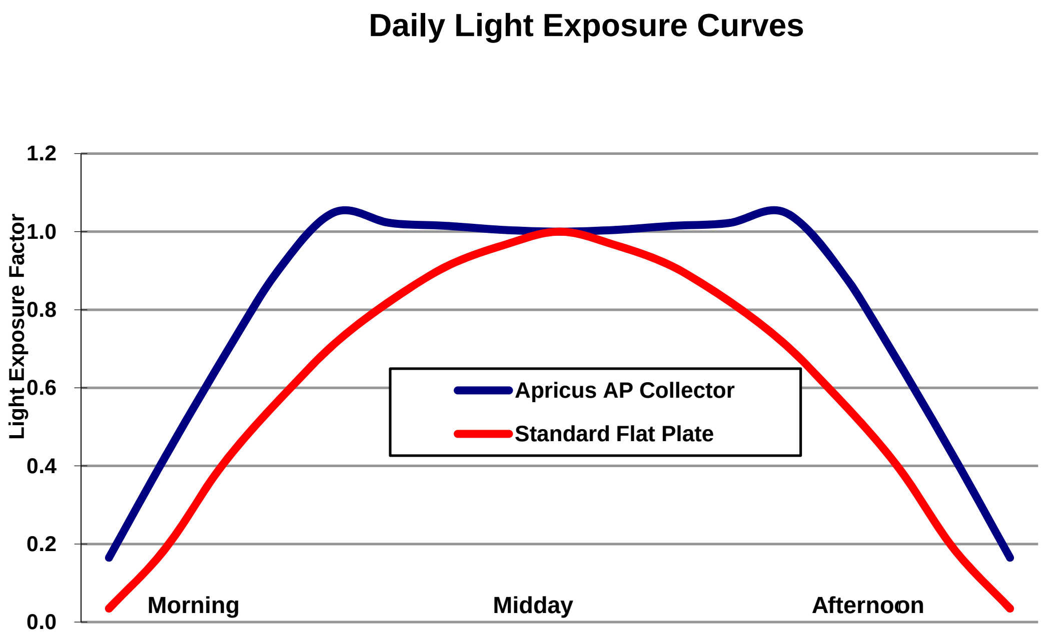
Inner Tube Dimensions	∅47mm x 1.6mm / ∅1.85” x 0.063”
Weight	2kg / 4.4pounds
Solar Tubes Material	Borosilicate Glass 3.3
Solar Tube Coating	Graded-index coating Al-N on Al on glass
Thermal Expansion	3.3x10-6 °C
Absorptance (α)	>92% (AM1.5)
Emittance (ε)	<8% (80°C)
Vacuum	$P<5x10^{-3}$ Pa
Stagnation Temperature	>200°C >395°F
Heat Loss	<0.8W/ (m^2 °C)
Maximum Strength	0.8Mpa 120psi
Absorber Area per Tube	$0.08m^2$ $0.86ft^2$
Heat Pipes & Heat Transfer Fins (Heat Transfer)	
Length	1800mm 70.8”
Material	Oxygen Free Copper (TU1) Cu+Ag> 99.99% (O_2<16ppm)
Copper Pipe Dimensions	∅8mm OD x 0.7mm thick
Condenser Dimensions	20mm OD x 30mm
Heat Transfer Material	Purified Water (Non Toxic)
Maximum Working Temperature	300°C 577°F
Startup Temperature	<30°C <86°F

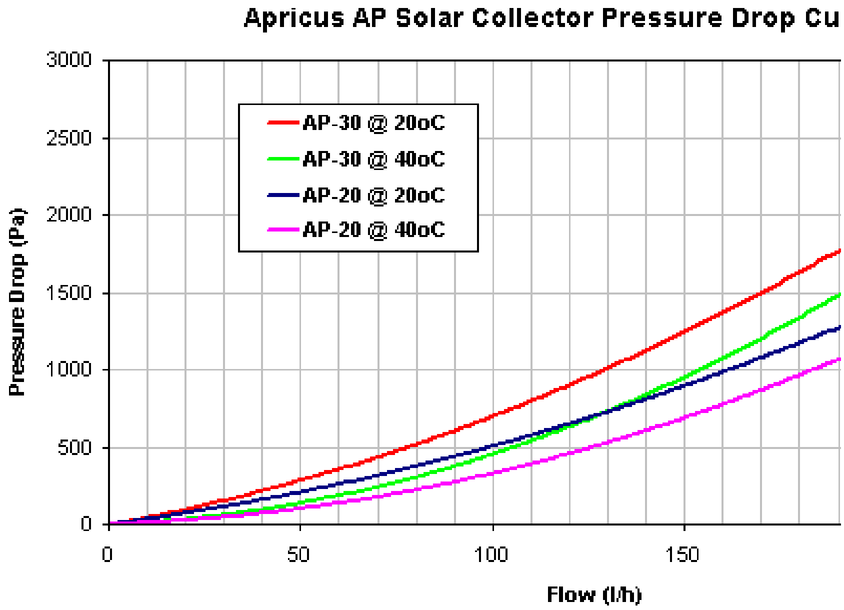
Vacuum	P<5x10^{-3} Pa
Vertical Installation Angle	20-70^{o}
Horizontal Installation Angle	0^{o} +/- 5^{o}
Heat Transfer Fins	0.2mm thick Hot Dipped Zn Coated Iron (Q235 grade steel, 100g/m^{2} Zn coating)
Freeze Protection Sleeve	∅8mm OD x 1mm x 150mm 304-SS
Rubber Components	
Material	HTV Silicone Rubber
Density	1.15 g/cm^{3} +/- 0.05
Durometer Hardness (Shore A)	60
Elongation	320%
Rebound	54%
Maximum Working Temperature	300^{o}C 577^{o}F
Tensile Strength	6.4 Mpa
Tear Strength	12.5 KNM

PERFORMANCE AND QUALITY

Stagnation SPF Report No. C632LPEN	245^{o}C, when G = 1000W/m^{2}, Ambient Temp =30^{o}C 477^{o}F, when G = 317Btu/ft^{2} , Ambient Temp = 86^{o}F

Efficiency SPF Report No. C632LPEN	ηo (-) = 0.717, a1 (W/m^2K) = 1.52, a2 (W/m^2K^2) = 0.0085 G = 800W/m^2 / 253Btu/ft^2 based on Absorber area.									
Quality Certifications	SPF Solar Collector Quality Test Certificate No. C632QPEN (SPF Quality Test According to: EN 12975-2: 2001, Section 5)									
	SRCC OG100 Award of Collector Certification Certification No. 100-2004003A,B,C,D Testing conducted by Bodycote Materials Testing Canada Inc.									
	Australian Standards Mark Plumbing AS2712 (License No. SMKP20405)									
Incidence Angle Modifier	0^o	10^o	20^o	30^o	40^o	50^o	60^o	70^o	80^o	90^o
$K\theta$ (longitudinal)						0.93				
$K\theta$ (transversal)	1.0	1.02	1.08	1.18	1.37	1.4	1.34	1.24	0.95	0.0


Daily Light Exposure Curves
Light Exposure Factor
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Apricus AP Collector
Standard Flat Plate
Morning
Midday
Afternoon



PRESSURE DROP

The pressure drop of the AP-20 and AP-30 solar collectors is shown in the graph below. In a domestic application, the pressure drop levels are very minimal. Pressure drop levels for other manifold sizes can be easily estimated based on the curves presented. For installations with more than one collector, simply multiple by the number of manifolds used to obtain total pressure drop.

EMBEDDED CARBON EMISSIONS

The following table provided approximate energy usage and resultant carbon emission involved in the product of the various components of the AP solar collector, therefore provide a total embedded carbon value.

Material	Weight (kg)	Raw Material Standard Energy Usage Values	Manufacturing Factor*	Energy Usage (kWh/kg)	Total Energy Usage (kWh)	Total CO_2 (kg)**
304 Stainless Steel	8.1	0.98 kgC/kg	2	6.44	52.2	52.2
Aluminium	2.6	15 kWh/kg	1.2	18	46.8	46.8
Copper	11.8	1.123 kgC/kg	2	7.78	91.8	91.8
Glass	65	0.257 kgC/kg	1.2	1.01	65.7	65.7
Silicone Rubber	2	1.2 kgC/kg	2	7.89	15.8	15.8
Cardboard Packing	18.5	1.57 kgC/kg	1.2	6.19	114.5	114.5
				TOTAL	**386.7**	**386.7**

CHAPTER 14ULTRA-PURE WATER

14.1 ULTRA-PURE WATER:

Ultra-pure water used in hospitals for dialysis treatment. Pathogen Free animal watering systems and more recently for the water supply for the manufacture of Clean Steam for the sterilising of surgical instruments. Ultra-pure water is processed mains water; the process involves preliminary filtration and membrane osmosis's

14.2 RAW WATER QUALITY: - TABLE OF MAXIMUM ACCEPTABLE TRACE ELEMENTS

Contaminant	Maximum Concentration mg/Lª
Calcium	2(0.1 mEq/L)
Magnesium	4 (0.3 mEq/L)
Potassium	8 (0.2 mEq/L)
Sodium	70 (3.0mEq/L)
Antimony	0.006
Arsenic	0.005
Barium	0.10
Beryllium	0.0004
Cadmium	0.001
Chromium	0.014
Lead	0.005
Mercury	0.0002
Selenium	0.09
Silver	0.005
Aluminium	0.01

Chloramines	0.10
Free Chlorine	0.50
Copper	0.10 See note b
Fluoride	0.20
Nitrate (As N)	2.00
Sulfate	100.00
Thallium	0.002
Zinc	0.10

NOTE A The Physician has the ultimate responsibility for ensuring the quality of the water used in dialysis

NOTE B Copper tube is not recommended as a service to RO and is not permitted to convey Ultra-Pure Water under any circumstances as copper, or a copper alloy.

14.3 A BRIEF HISTORY

The Reverse Osmosis plant will be delivered to site as a skid mounted plant and will be installed by experts in the field, it is important that the Hydraulics designer has an understanding of the history and the process and the new developments that are available, mainly these developments focus on the durability of the membrane. .In 1957-8 the first Australian Kidney transplant team were training in Hammersmith Hospital West London, the kidney machine used at that time to support the patients urinary system during the operation relied on a membrane of French sausage skins that were in fact part of a pigs internal intestinal organs and performed the osmosis function as they had for their original owner .We have travelled a long way in half a century.

14.4 THE KIDNEY

A healthy Kidney maintains the body's internal equilibrium of water and minerals and removes from the blood the daily metabolic load of fixed hydrogen ions. The Kidneys also function as a part of the endocrine system producing erythropoietin, dialysis does not replace this function, it is an imperfect treatment to replace by diffusion (Waste removal) and convection (Fluid removal) it does not correct the endocrine functions.

14.5 BASICS OF THE URINARY SYSTEM.

The urinary system in the body of mammals comprises the Kidneys which are a pair of organs for filtering impurities from blood and maintaining the body's internal equilibrium of water and minerals

Sodium, Potassium, Chloride, Calcium, Phosphorus, Magnesium, Sulphate.

The kidney also functions as part of the endocrine system producing erythropoietin and calcitriol involved in the production of red blood cells and bone formation.

The Kidney has three layers

Cortex

Medulla

Pelvis

The Cortex and Medulla contain tiny blood filtration units called nephrons (More than a million) for each kidney. Urine the main waste product of kidney filtration collects in the kidneys (pelvis).

The blood plumbing to the kidney originates with the renal artery entering the medulla in a number of locations and further divides into a number of tiny coiled blood vessels called glomerulus.

Surrounding the glomerulus is a sac called Bowmans capsule ,pressure forces water and dissolved chemicals from the blood in this area ,the filtered result continues through a tubal surrounded by capillaries ,these reabsorb into the blood most of the water and useful chemicals as amino acids.

The treated blood then leaves the kidney by the renal vein, wastes remaining in the tubal flow to the pelvis and leaves the kidney as an amber fluid via the ureter tube and on to the bladder.

A pair of kidneys can process 190 litres of blood per day.

THE AUTHOR THANKSDOCTOR ALAN PASSMORE FOR HIS INTEREST, REVIEW AND ASSISTANCE WITH THE MEDICAL INFORMATION.

14.6 DIALYSIS

The word originates from two Greek words meaning through and loosening

The Dialysis machine performs some of the functions of the human Kidney.

As noted, it is an imperfect system to replace kidney function, and it will not provide the endocrine functions of the kidney.

Dialysis may be used as a holding measure (Pre renal transplant) for patients who would otherwise die from renal failure; it may also be used in other medical applications and may be required as a service connection in the following.

Haematology (1)

Cardiothoracic

Cardiology

Cardiac Acute Care (2)

ICU Intensive Care Unit (1) per bed space

Surgical special care (1) at each special care bed

Medical special care (1)

Central Sterilizing Department (As advised for clean steam)

Some medical authorities may require RO in the Infectious diseases unit.

Pathogen free animal breeding units

Research laboratories will in most instances determine the extent of RO services in the brief

Dialysis works on the principle of the diffusion of solutes across a semi permeable membrane. .Blood flow by on one side of the semi –permeable membrane and the dialysate or fluid (RO Water) flows on the other side of the membrane.

The concentration of undesired solutes (Potassium Calcium and Urea ,the urine of mammals) are high in the blood , and low or absent in the dialysis ,constant replacement of the dialysis solution ensures that the concentration of undesirable solutes is kept low on this side of the membrane .

14.7 HAEMODIALYSIS MACHINE

The Haemodialysis machine is a separate and free standing unit owned by the hospital and connected to the RO water supply and a Tundish drain provided in the hydraulics services scope of works.

The patient is connected to the machine for a number of hours per week in which time the patient's blood is pumped through the blood compartment of the dialyzer by a peristaltic action pump and exposed to the surface of a semi permeable membrane (Sulphone plastic recent sandwich technology has increased the life expectancy of membranes), the cleansed blood is returned back to the body.

Ultra filtration occurs by increasing the hydrostatic pressure across the dialyzer membrane, this is usually done by applying a negative pressure to the dialysate compartment.

The pressure differential or gradient causes water and dissolved solutes to move from the blood to the dialysate and will remove several litres of excess fluid during a 3 to 5 hour treatment session.

Note Dwellings with Home Dialysis machine have Blue water meters.

14.8 AN OUTPATIENTS DIALYSIS CLINIC

The following describes the Reverse Osmosis installation for the renal dialysis clinic of a large general hospital for the treatment of 17 patients and 2 auxiliary points for machine and system testing.

The RO Machine output duty:-

One litre /minute/patient, (Plus added outlets for test or emergency use).

Clinic Number of dialysis (Connector module point's) required 17 patient locations .Additional outlets in dirty utility room 3 (max 2 in uses at any one time) Maximum Points in use simultaneously is 19 the Plant duty is 20 litres per minute

NOTE: RO MACHINES ARE TO BE REGISTERED WITH ARTG AS A MEDICAL DEVICE AS PER AUSTRALIAN REQUIREMENTS FOR THIS TYPE OF EQUIPMENT.

The RO Plant will be located near the clinic with access for staff and an access path via non patient areas for maintenance staff and deliveries of consumables .All essential monitoring shall be duplicated with a satellite panel in the sister in charges office or work station, particular attention is drawn to alarms, and warnings of plant performance changes that will effect the well-being of the patients in the clinic, (or ward).

14.9 THE RO PLANT

All Medical use RO Plants are subject to an Australian Registration procedure. The American National Standard ANSI/AAMI RD62:2006 Water Treatment equipment for Haemodialysis applications may be the required standard for projects outside of Australia.

The core of the RO plant is the membrane that separates any other substance but water crossing the Nanocomposite membrane barrier .Membranes are vulnerable to bio-fouling which has a detrimental affect on the efficiency and life of the membrane .The first viable membranes were cellulose acetate ,the current generation of membranes are polyamide thin film ,recent developments incorporate synthesised nanoparticules into a thin film ,this type is called a Thin Film nanocomposite or TFN membrane, these membranes are adaptable to existing machines .

14.10 RO PLANT AND PROCESS METHODOLOGY:

Each RO machine unit will be designed as a double stage reverse osmosis process system with the ability to operate in both modes. Permeate will pass through a first and second stage membrane – in effect a dual pass through the membranes prior to distribution.

The system will produce permeate complying with or exceeding European and AAMI renal standards in both single and dual pass modes. RO Machines are to be registered with ARTG as a medical device as per Australian requirements for this type of equipment

Each machine will be capable of operating in either single or double stage pass mode, effectively allowing some redundancy within the unit. Under normal operation the unit will ideally operate continuously in dual pass mode.

Permeate may cycle directly through the distribution loop network or alternatively via a stainless steel permeate storage vessel contained within the unit. Pressure within the system will be regulated via vertical multi stage pump(s) with a built in additional capacity of 25% over the designated RO machine capacity and output for each war or clinic.

All pump and metal pipe materials will be Grade 316 stainless steel suitable for contact with RO permeate.

The entire unit will be contained within a robust pre-fabricated painted (enamel, powder coated or similar) metal cabinet. The cabinet will allow full access to all sides of the unit with removable panels on the back/ sides of the unit and hinged doors on the front face.

Shared pre-treated water systems are not acceptable.

14.11 SYSTEM PRESSURE

The minimum estimated incoming pressure at the cold water inlet point to the pre- treatment filter train is 250 kPa

RO machine equipment suppliers are to ensure adequate pressure is available at all times to ensure correct operation and backwash of the pre- treatment filters. If the pre- treatment filters cannot operate at the

minimum designated available pressure at the connection point (250 kPa)
the machine supplier must allow for a separate booster pump at the inlet to the filter train and pre-treatment system.

14.12 BUFFER TANK

Provide a 300 litre buffer tank in front of the booster pump.

The buffer tank will be complete with float valve assembly, removable top and overflow.

The pressure pump unit will be controller by the RO machine PLC / micro processor.

14.13 FILTERS

Each filter will be sized to handle double the maximum RO permeate production capacity of the machine they are connected to and preferably sized to allow for slow rate filtration through each unit**.** In all cases filtration rates will be in accordance with both the European and the Association for the Advancement of Medical Instrumentation (AAMI) standards for renal treatment systems

14.14 MULTI MEDIA FILTER(S)

Filters will cater for the removal of all suspended solids and colloidal matter removing all particulate matter down to minimum rating of 25 microns.

A softener and brine tank will be provided to facilitate the removal of water hardness from the incoming supply.

14.15 ACTIVATED CARBON COLUMN

Dual GAC filters will be installed to act as part of the water polishing process and remove all traces chlorine gas from the water supply system. Units will be in series with an EBCT 5mins/bed with minimum total contact time of 10 minutes.

Low micron filters will be provided at the completion of the filtration train to remove fines prior to RO permeate production.

The unit will be configured in parallel and consist of a 5 micron filter and a second 1 micron filter

14.16 PLC AUTOMATED R.O MACHINE CONTROL

Each RO machine unit will be fully controlled by a programmable logic controller (PLC) or micro-processor units. The PLC / micro-processor unit will control all functions within the RO machine including backwash cycles, re generation cycles heat disinfect cycles, pumps and switch gear. The unit will feature a LCD display screen or similar capable of providing comprehensive data of all operation parameters of the machine. The face panel will be simple and effective in its design and ideally function as a user friendly touch screen.
Daily operational parameters will be available including times, dates and all relevant output data. The system will be capable of analysing all cycles of the machine process with a successful or unsuccessful output notice incorporated within the data output. Data will be capable of down load via an in built modem within the unit or connection port for a portable notebook computer.

Emergency auto dial function to a 24 hr service operator in the event of a critical fault notification in the PLC/micro-processor enabling remote fault diagnosis / corrective action functions will be considered an advantage and desirable feature within any machine. The unit will be complete with pre-programmed machine set points for all operational parameters of the RO system. Of high importance will be system parameters that are critical to permeate quality and patient safety. All alarms will register visually at the machine display panel and be accompanied by an audible alarm tone and indication at the remote nurse station module. The alarm tone may be muted, but cannot as a feature, be deleted by personnel other than a qualified service technician .Sensitive electrical components are to be housed within a separate sealed metal cabinet within the main machine cabinet. All wiring will be clearly marked and identified. In addition to the main PLC / micro-processor controller a single nurse station remote control module will be provided for each unit. The nurse station unit will be capable of displaying machine run, machine fault, heat disinfection cycle run, emergency machine stop and heat disinfect stop/machine reset function signal via indicator lights.

14.17 UV IRRADIATION

The provision of ultra violet irradiation treatment to the filtered pre-treatment water supply is required as part of the installation .The UV process must be constant ,maintenance for the removal and replacement of lamps must not remove UV irradiation ,the system must be shut down ,or the UV plant duplicated. UV will assist in deterring bacterial proliferation within the associated hydraulic pathways, pressure vessels and membrane elements. The UV unit will be sized to meet the maximum RO machine permeate output and capable of neutralising bacteria and water borne pathogens within the incoming raw water supply. A second and independent UV unit will be located within any recirculated RO water system loop.

The RO unit shall incorporate a lamp life indicator and lamp re-placement warning system which is activated by lamp life hours run and UV emission strength either shall trigger the warning signal.

The UV system should preferably comprise a central quartz silicon core of water to be irradiated with four equally spaced UV irradiation lamps that reduces the possibility of shadowing, and are removable from a dry housing.

Note For plant maintenance consistency UV Plant for warm water shall be of the same manufacture

14.18 HEAT DISINFECTION

Each of the hospitals Ultra-Pure Water systems should be capable of undertaking and withstanding a daily fully automatic high temperature heat disinfection cycle of the distribution loop (and permeate storage vessel where provided). The heat disinfection will be undertaken at a minimum temperature of 85 degrees C. The heat disinfection circulation pump shall be constructed to withstand the temperature nominated and shall circulate the system water content at a temperature difference not exceeding 5 degrees C .

The entire disinfecting operation is to be undertaken (including cool down period) in a four hour time period.

Heat will be provided through Incalloy or Grade 316 Stainless steel shielded electric elements contained within the unit at either the distribution loop, permeate storage vessel or supplementary holding tank.

The heat disinfection cycle will be programmed through the RO Machine PLC / micro- processor to occur on a minimum 2 day cycle basis (or at greater intervals if required by the operating staff) during machine down time.

The cycle will be monitored to ensure correct function and data logged to indicate performance of the system with a pass/fail function on a LCD face panel. The heat disinfection cycle will be capable of emergency stop function via the nurse station controller. This function will include automatic cool down and notification when system becomes fully operation. Each RO machine unit will be fully controlled by a programmable logic controller (PLC) or micro- processor units. The PLC / micro - processor unit will control all functions within the RO machine including backwash cycles, re generation cycles heat disinfect cycles, pumps and switch gear.

14.19 UPGRADING EXISTING RO PLANT

The RO machine should be capable of upgrading for future additional capacities. The unit will without alteration to the existing, cabinet, circulation pumps or distribution loop be able to upgraded to produce a permeate output at least 25% above the specified outputs required under this contract.

This it is envisaged any future capacity upgrades would be facilitated by the insertion of additional membranes into the machine. All internal pipe work and electric's within each machine will be sized to handle future higher output capacities, with the entire machine configured to ensure minimal disruption at the time of machine upgrade.

14.20 DISTRIBUTION NETWORK

Each system will incorporate a cross linked polyethylene (PEX) tube distribution loop with high grade stainless steel fittings throughout. The loop will be heat insulated and sized to according to the system loads. Velocities within the distribution loop will not be less than 1.5 metres per second and not exceed 3.0 m/s in any case.

Distribution loops will be thermally insulate maximum length from the heat source 150 metres with any dead leg branch pipes kept to an absolute minimum length with a guaranteed maximum temperature drop through the loop disinfection process of 5 degrees Celsius.

14.21 ULTRA-PURE WATER DELIVERY AND DIALYSIS WASTE REMOVAL

At each nominated bed head services and communications consul, provide dedicated connector modules with instant couplings and new tundishes.

Allow for extensions from existing drainage points where required. The permeate supply point and haemodialysis waste (Swaglock or Hocke) connectors are to be manufactured from 316 grade stainless steel with different diameter snap connectors for waste and permeate lines to avoid possible cross connection.

Each permeate connector will have a blue 10mm outer ring (waste red) around the connector where it joins the face panel. Tundishes shall comply with authority standards in particular air gap and cross connection regulations as defined in the relevant Australian Standards and Hospital guidelines (AS 3500, TS11)

14.22 CLEAN STEAM AND THE DISINFECTING AND STERILIZING OF SURGICAL INSTRUMENTS.

Clean Steam for Sterilisation was first published by the UK National Health Service (NHS) Health Estates in 1997 as Health Technical Memorandum 2031 by the London Stationary Office.

The requirement for surgical/medical clean steam first came to the author's attention in 2009 during the concept design stage of a multi storey hospital in the UAE.

The UK memorandum notes that impurities in sterilising steam can have an adverse effect on the patient if introduced into the blood stream as contaminants carried on sterile instruments.

14.23 PYROGEN

Pyrogens are of particular concern because unlike other contaminates there are no controls on the levels of Pyrogens in the public water supplies from which steam is generated.

Pyrogens are extremely heat stable and are only destroyed after prolonged exposure to high temperatures of 180ºC for 3 hours or 250ºC for 30 minutes; they are not inactivated by any of the standard sterilization processes

AN/NZS 4187-2003

Cleaning disinfecting and sterilizing reusable medical and surgical instruments.

Section 2 Clause 2.1 Water Quality page 17 does not address the Pyrogen issue, however it does address water hardness and the effects of mineral deposits giving the following table and cautions re the effects of calcium and magnesium in the water supply (It is noted the London UK water is hard)

Water Hardness	Range. µg/g
Soft to medium	0 to 75
Dialysis Medium to hard	76 to 140
Hard to very hard	141 to 240
Very hard to extreme	> 240

The Heath Issues that are involved in this subject are not considered to be within the scope of the hydraulic consultants /designer's scope of expertise, nor is it reasonable for the hydraulics designer to offer expert advice in respect to this matter, however it is considered pro-active and possibly incumbent upon the hydraulics designer to draw his clients attention to the matter in a manner that is recorded for future reference.