Jemena NSW Gas Networks
DESIGN GUIDE

ADG-003

DESIGN GUIDE FOR GAS CENTRALISED HOT WATER SYSTEMS

Issue 4 – 01/08/2007
Rev1

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1. Purpose

This document provides guidance to hydraulic designers and building developers in designing and certifying energy efficient gas centralised hot water system for residential dwellings. It is the responsibility of the designer to assess the individual site, installation and usage characteristics in defining the appropriate design criteria that best matches the intended duty of the centralised hot water system. It is the responsibility of the building developer to certify that the centralised hot water system has been installed in accordance with the certified design.

2. References

This guide does not take precedence over any statutory codes nor building standards and must be read in conjunction with all relevant building codes and plumbing and gas fitting standards.

In particular the following standards & references:

- AS 5601-2004 – Gas Installations;
- AS/NZS 3500 - 2003 – National Plumbing and Drainage;
- Part 4 – Heated Water Services;
- Part 5 – Domestic Installations;
- Building Code of Australia;
- The Rheem Hot Water Manual; and
- Installation of Plumbing Australia (table 56).

Related Jemena Guides and Documents:

- ADG-001 - Design Guide to Internal Natural Gas Reticulation;
- ADG-002 - Design Guide to Natural Gas Metering;
- AAG-001 - Developers Guide to Natural Gas Connection for Medium Density & High Rise Sites; and
- AAG-103 - Consumers Guide to Natural Gas Centralised Hot Water Systems.

3. Overview

Gas hot water can be supplied to multiple dwellings through either individual gas storage or gas instantaneous hot water systems in each apartment, or else through a gas centralised hot water system (**GCHWS**).

For residential blocks of about fifteen or more stacked residential apartments, a gas centralised hot water system has several advantages over individual gas hot water systems including:

- less space requirement (and possibly better aesthetics because there are no hot water appliances visible on balconies);
- lower installation cost and maintenance costs; and
- more adaptable to energy saving methods.

A typical gas centralised hot water system comprises the following interconnected parts:

- a central hot water heater or a manifolded bank of hot water heaters with adjacent insulated buffer storage vessels with circulating pumps;
- an insulated central piping loop run throughout the building;
- short lengths of insulated piping to each apartment; and
- gas and hot water meters.

An incorrectly designed gas centralised hot system may result in inadequate hot water supply and/or excessive heat losses. This will correspond to high gas bills to the consumer. A correctly sized, well-insulated , well-reticulated central hot water system will provide good hot water flows to all apartments and will have good energy efficiency. This is achieved through correct sizing and minimising wasted thermal losses from the central hot water heaters, vessels and piping.

It is necessary that the "designer" of a gas centralised hot water be a person recognised by an appropriate engineering body. Design of the gas centralised hot water must be carried out at the earliest possible stages of the development.

4. Common Factor

4.1 Measure of Performance

The most important characteristics of a well designed gas-centralised hot water system are a correctly sized central hot water heater and well sized and reticulated central supply and return hot water piping.

A useful benchmark energy performance indicator for a GCHWS is a calculated value called, **"Common Factor" (CF).** This is derived from an estimate of all heat generated in the CHWS divided by all the hot water heated from 15^{O}C to 65^{O}C (50^{O}C) produced through the CHWS. The value not only takes into account the energy converted to hot water that is used but also the standing heat lost by the hot water equipment and piping. A similar value called, **"Generalised Common Factor"** (GCF) can also be used. GCF is derived from the CF by dividing CF by 50. The GCF value therefore takes into account all the energy quantities of CF per degree Celcius.

Jemena stipulates that all centralised hot water systems connecting to gas be designed, installed and maintained to achieve a CF of no greater than 0.40 MJ/lit, or a GCF of no greater than 8.0 kJ/lit.^{o}C . This ensures that the system delivers comparable energy efficiencies to that of other gas fired hot water systems while retaining all the above installation and cost benefits.

There are several factors that influence the CF for a centralised hot water system:

- average daily hot water usage per home unit;
- occupancy rate;
- the energy required to heat the water;
- pipe heat loss; and
- water heater maintenance rates (stand-by losses) and effciencies;
- Heating augmentation such as solar or co-generation.

It is the designer's responsibility to define the above variables to match the actual centralised hot water system installation and patterns of usage.

4.2 Design Principles

The following are principles to achieve a better common factor. These principles should not be used in isolation of other design principles and should be used in conjunction with current natural gas and plumbing codes.

4.2.1 Design the Centralised Hot Water System at the early stages of the building development

A Centralised Hot Water System for a residential apartment block must not be installed as an afterthought. It is best practice to ensure that the detailed scope of the proposed gas hot water system is determined at the concept phase to enable adequate space and access within the building to position the centralised hot water piping, equipment and meters.

4.2.2 Minimise Hot Water piping length

Minimise the lengths of system piping to minimise energy losses.

4.2.3 Minimise Hot Water pipe diameter

Minimise the diameter of the centralised hot water piping to achieve the maximum allowable flow stipulated in the plumbing code. This will ensure minimal heat loss.

4.2.4 Optimise Hot Water heaters

Size the hot water system correctly to minimise standing losses..Use the highest efficiency hot water system available (minimum 5 star gas hot water heaters or better).

4.2.5 Maximise Hot Water piping insulation

Ensure all supply and return hot water piping is well insulated. The Building Code of Australia sets minimum standards.

4.3 Water Demand

The designer is responsible for determining the daily water demand. This will be dependent on the expected occupancy, dwelling size and water consuming appliances.While110 litres/apartment/day has been used for the example in this document, design daily water demand can vary significantly from this figure. It can, for example be as high as, 200 litres/ apartment / day or lower than 20 litres / apartment / day.

4.4 Heating Augmentation

The total gas consumed by gas hot water heaters can be reduced by augmenting centralised hot water systems with appropriately designed and installed solar-thermal panels. The net energy recovered from solar panels can be included in the calculation of common factor.

Where any form of heat augmentation is proposed, the designer shall calculate the systems common factor, with and without heat augmentation.

4.5 Cogeneration

Cogeneration is now being sized for the hot water load within buildings and the resultant “free electricity” consumed within the building. This reduces the size of the cogeneration unit and ensures that the heat produced is not wasted ensuring the cogeneration plant is more cost efficient.

While the cogeneration plant produces “free electricity”, this is provided at the expense of the hot water efficiency and hence impacts the calculation of CF and GCF.

Where cogeneration is proposed, the Designer shall calculate the Common Factor:

- Firstly without cogeneration (utilising the backup gas boiler only) operating. This design and calculation shall be in accordance with all the requirements of this document.
- Once this has been achieved, secondly for the exact same system except that only the cogeneration plant is operating.
- Both these CF calculations are to be submitted to Jemena. It is expected that the actual Common Factor will be within the range provided.

5. Design Process

The following section provides guidance to a designer in the process of designing a GCHWS.

5.1 Confirm System Determinants

- System pressure as provided by Jemena on behalf of Jemena NSW Gas Networks. Refer to Jemena document, ***“Jemena NSW Gas Networks DESIGN GUIDE ADG-002 “***.

- Provision of adequate area for a gas central hot water plant. Positioned typically in car park or on roof to facilitate ease of flueing and maintenance. Positioned also as close as practical to adjacent natural gas main and path valve.

- Provision of adequate riser area and ceiling provision to accommodate insulted hot water supply and return piping to/from CHWS and apartments.

- Number and size of apartments.

5.2 System Design

The designer will carry out the steps below.

5.2.1 Size the Hot Water Plant

Based on the number and relative sizes of apartments calculate the maximum and average hot water loads for the building in accordance with diversity factors outlined in AS/NZS 3500 parts 4 and 5 and in reference to available industry information such as, "The Raypak Hot Water Manual"[1]. The hot water load values so determined enable the specification of size and type of centralised hot water plant and exact sizing of supply and return hot water piping for the central loop and to each apartment.

5.2.2 Determine Position of Hot Water Plant

Positioning of the gas hot water heater is subject to factors such as aesthetic, access for installation and maintenance; positions of risers; fuel supply and flueing requirements to AS 5601-2004; position of gas and water mains.

[1] Courtesy of Rheem Australia Pty Ltd.

5.2.3 Draft Piping Reticulation

Draft proposed hot water piping onto architectural floor plans for every floor allowing for hot water pipe insulation and other piping services. From these, draft an isometric piping sketch showing supply and return hot water piping from the proposed central hot water plant to each apartment. Utilising available data on unit sizes plot piping diameters on the isometric sketch with acceptable hot-water pressure drops and velocities in accordance with method detailed in AS-3500.

Specify :

- proposed insulation/lagging for the flow and return pipes (type and wall thickness);
- proposed gas hot water heaters - model numbers, quantities and positions;
- gas load for the central hot water system specified;
- index length used in pipe size calculation;
- system pressure; and
- pressure drop utilised.

5.3 System Design Check - Efficiency

There are a number of engineering design checks and verifications that may need to be performed. This section provides guidance for checking the system design for thermal efficiency using Common Factor (CF) (or, GCF) as the measure. If the CF is too high (ie: greater than, 0.40 MJ/lit.), then the designer must amend the design to meet the specified minimum energy efficiency performance requirements.

Details of how to calculate a CF for a residential apartment building is presented as a simple example in Appendix A of this document. A summary of steps leading to the calculation of GCF is as follows:

1. Assessment of hot water flow;
2. Hot water pipe sizing;
3. Pipe work heat loss;
4. Heat calculations;
5. Water heater selection;
6. Calculation of common factor;
7. If CF is greater than 0.4 MJ/lit, [or GCF greater than 8.0 kJ/lit^{o}C], modify CHW piping and/or equipment and then return to step 1; or
8. If CF is less than or equal to 0.40 MJ/lit. then calculation is complete and thermal design should be accepatble.

6. System Certification

Jemena will not supply metering equipment for a centralised hot water system until it receives a certification from an appropriately qualified and competent party, confirming the system has been designed to meet the specified minimum energy efficiency performance requirements, and a certification from the building developer confirming that the certified design has been installed.

6.1 Certifier qualifications and competency

A certifier shall have competencies and experience as deemed appropriate by the Australian Hydraulics Association (AHSCA) , or other recognised engineering body.

6.2 Certification of Generalised Common Factor

The certifier shall certify that the centralised hot water system installed will meet the minimum energy efficiency performance standard when operating inaccordance with expected usage and conditions.

The buliding developer shall supply Jemena with a certification using the form “ADG-003A Certifaction of Common Factor” and provide calculations consistent with the Jemena Model, “ADG-003B” or equivalent. See Appendices A & B of this document.

Before Jemena will supply metering equipment, the builder developer shall also supply Jemena with a certification using the form “ADG-004 Confirmation of GCHWS Installation”, to confirm that the certified design has been installed. If the installation varies from the certified design the builder developer shall supply Jemena with a new certification by an appropriately qualified and competent party which reflects the actual installed gas centralised hot water system.

APPENDIX A

CALCULATION OF COMMON FACTOR - WORKED EXAMPLE

The following simple example of a basic CHWS design is included in this guide to outline the use of one possible method of heat loss calculation to determine CF.
It is presented to assist the hydraulic engineer/consultant to nominate a gas centralised hot water system and then to determine an optimum final design through an iterative procedure based on calculation of the CF.

EXAMPLE

A five storey block of forty(40) residential units comprising ten (10) x 1 bedroom; twenty (20) x 2 bedroom and; ten (10) x 3 bedroom units.
A calculation of CF (Common Factor) will be undertaken based on this apartment configuration and assuming normal hot water consumption to determine the adequacy of a proposed gas centralised hot water system to work efficiently with normal standing thermal losses from piping and equipment .

1. ASSESSMENT OF FLOW

Diversity factor takes into account the likelihood of a number of hot water outlets being turned on at the same time. The diversity factors are typically based on the number of home units.

A typical method for determining diversified flow as set out in AS 3500[2] is as follows.

- The number of hot water draw off points in each unit is identified along with the number of bedrooms based on the buildings specifications and summarised in Table A.1 of the
The following table sections are taken from Agility Applications Model "DG-003B"

Table A.1

[A] HOT WATER AND ENERGY DEMAND SECTION

Table A.1 - Calculation of Number of Points from Inputted Apartment Details

APARTMENT DWELLINGS	KITCHEN	BATH ROOM	LAUNDRY	EN-SUITE	DISH WASHER	NO. OF BEDROOMS	SUM OF POINTS / UNIT	NO OF UNITS	SUM OF POINTS
10	1	1	1	0	1	1	5	10	50
20	1	1	1	1	1	2	7	20	140
10	1	1	1	1	1	3	8	10	80
0	0	0	0	0	0	5	5	0	0
0	0	0	0	0	0	0	0	0	
								TOTAL NO. OF POINTS=	270

Table A.1 summarises the overall hot water flow data for the building. The Total number of Points is copied from table A.1. This figure is then used to read off the coincidence factor, provided in Appendix B of this document and flow rate can then be calculated from Table A2 – Total Design Flow Rate, below.

[2] Refer also to, "Raypack Hot Water Manual" courtesy of Rheem Australia Pty Ltd.

Notes:

- Flow Rate = (The No. of Points) * (Coincidence Factor)*4.6 lit/min
- Max. Hourly Demand = [Flow rate(lit/min.)] * 15 (min/hr)
- A figure of 15 mins./hr represents the peak hot water demand period for one hour.

This process is carried out for the overall system to determine the maximum hot water flow required. This figure is then used to size the hot water heater for the central plant. The same process is repeated for each pipe run to generate the flow rates required for the pipe sizing calculation.

2. PIPE SIZING

There are numerous available methods of calculating the size of hot water piping.
Sizing in this example were carried out in accordance with the method presented in AS/NZS 3500.1.2:1998 – Appendices B & C through the following steps repeated for each level containing a run of flow pipe (Riser, Dropper or Lateral) in the building, starting with the first floor and proceeding upwards. Once pressure gradient and flows rates are known the size of the pipe diameter can then be calculated.

It is important to note that within the range of water velocities allowed for in AS3500 the hydraulic designer should target the minimum diameter possible for supply & return hot water piping both minimise the standing heat losses while satisfying the maximum velocity limit of the Plumbing Code. Typically hot water velocities for multi-dwellings should fall between 1.0 and 2.1 L/sec in accordance with AS 3500.

3. PIPING HEAT LOSS

For energy efficient centralised hot water design it is essential to minimise heat losses from hot water pipe work by both:

- minimising hot water pipe diameters to the minimum that good flow design practice will allow as described above; and
- thermally insulating the hot water piping.

All hot water flow and return lines regardless of the material (ie. Polymer piping) will need to be insulated. The type and thickness is dependent on achieving the C.F. requirements while satisfying relevant building codes.

Various available insulation materials can be used to insulate hot water supply and return piping. Published heat loss specifications (in both W/m and kJ/H/m) from insulation material suppliers are available and can be used as shown below to determine the level of heat loss for the proposed piping size and configuration. For the table presented below it is assumed the pipes contain water at 60°C and the ambient air temperatures conditions for winter and summer are set at 15°C and 20°C respectively.

A designer should meet winter conditions (ie 15°C) as this is the worst case. Calculating the CF in summer (ie at 20°C) will show the reduction in the CF (ie reduction in the running costs).

During the design process table B.1 in the DESIGN SHEETS, may be used to assist in tabulating the insulation specification data. The reticulation heat loss is then summed for the whole system and recorded in units of MJ/h.

Table B.1

4. HEAT CALCULATIONS

Table B.1 PIPEWORK HEAT LOSSES

PIPE SIZE	INSULATION THICKNESS (mm)	" 65 °C HOT WATER / 15 deg.C AMBIENT with Thermotec 4 zero insulation")	" 50 °C TEMPERED WATER System/ 15deg.C AMBIENT with ARMAFLEX insulation")	INPUT LENGTH OF PIPE HERE	UNIT HEAT LOSS FOR COLUMN <F>	UNIT HEAT LOSS FOR COLUMN <G>
(mm OD)	<Nominate insulation type here>	(kJ/H/m)	(kJ/H/m)	(m)	(kJ/H)	(kJ/H)
15	nil	112.3	50.4	0	0.0	0.0
15	20	31.7	19.1	23	729.1	439.3
15	25	25.2	16.9	95	2,394.0	1,605.5
20	nil	144.7	78.5	0	0.0	0.0
20	20	36.6	25.9	0	0.0	0.0
20	25	31.3	22.7	295	9,233.5	6,696.5
25	nil	177.1	97.9	0	0.0	0.0
25	20	40.3	28.4	0	0.0	0.0
25	25	37.4	25.2	98	3,665.2	2,469.6
32	nil	218.2	124.9	0	0.0	0.0
32	20	47.5	32.2	0	0.0	0.0
32	25	41.8	28.1	65	2,717.0	1,826.5
40	nil	258.1	149.0	0	0.0	0.0
40	20	58	36.4	0	0.0	0.0
40	25	50.8	31.1	18	914.4	559.8
50	nil	324.7	200.2	0	0.0	0.0
50	20	64.1	44.6	0	0.0	0.0
50	25	58	38.5	20	1,160.0	770.0
65	nil	372.9	262.6	0	0.0	0.0
65	20	71.6	54.7	0	0.0	0.0
65	25	64.4	46.4	8	515.2	371.2
80	nil	439.6	313.6	0	0.0	0.0
80	20	85.3	63	0	0.0	0.0
80	25	76.3	49.7	0	0.0	0.0
100	nil	590.1	398.2	0	0.0	0.0
100	20	106.2	76.3	0	0.0	0.0
100	25	88.9	59.2	0	0.0	0.0
	Total Central Hot Water Piping Heat Loss (MJ/H) =				21.3	14.7
	Total Central Hot Water Piping Heat Loss (MJ/day) =				511.9	353.7

We can now calculate the heat required to generate the hot water for the building.

Step 1. Energy required to heat water to the required temperature.

Energy (MJ/L) =

$$\frac{\text{Temp. Rise (°C)} \times 0.004187\ \text{(MJ/L. °C)}}{\text{\% Thermal Efficiency of Water Heater}}$$

Notes:

- The required temperature at the outlet of the hot water heater is typically 65°C. Assuming that the cold water inlet temperature is 15°c the temperature rise will typically be 50°C.
- In the example presented, overall efficiency is assumed 80%.

Step 2. Estimate Daily Water Use

Daily Water Usage (L/day) = Number of Units x Average daily consumption (in L/unit/day). The Estimated Daily Water Use is calculated in the spreadsheet in units of (L/day).

Step 3. Total Energy Requirement to Heat Hot Water

The total daily energy usage to heat the required amount of hot water is determined by, multiplication of steps 1 and 2 above as follows:

Total Energy (MJ/day) = Energy Required to raise temp (MJ/L) x Daily water usage(L/day).

Table A.2

Table A.2 Calculated Nominal Hot Water Flow (at 65deg.C Before Mixing With Cold Water) and Equivalent Energy Content

TOTAL NO. OF POINTS	CALCULATED COINCIDENCE FACTOR	HOT WATER POINT DELIVERY (lit./min/point)	MAX. WATER DELIVERY FROM BOILER (lit/min)	AVERAGE HOT WATER SUPPLY FROM HOURLY RECOVERY RATE FROM GCHWS (lit/hr)	SPECIFY DAILY HOT WATER DEMAND PER APARTMENT (lit/apart./day)	CALCULATED DAILY HOT WATER (65°C) DEMAND (lit/day)	ENERGY REQUIRED TO HEAT 1.0 LITRE WATER TO TEMP (MJ/lit)	GAS ENERGY INPUTED TO BOILER FOR WATER CONSUMED (MJ/day)
270	0.166	4.56	204.4	3,066	110	4,400	0.262	1,151

5. SELECTION OF WATER HEATERS

Hot water heaters in a centralised hot water system can be individual instantaneous or storage heaters configured in groups of more than one, and may also include the use of storage tanks to buffer hot water demand to (reduce cycling).

Typically, hourly recovery rates are used to size the heaters, and this data should be obtained from information supplied by the manufacturers. Note that one factor that can influence the Common Factor is the thermal efficiency of water heaters, their standing loss and this maintenance rate. These may become an important selection criteria of a water heater if a Common Factor of 0.4 is difficult to achieve.

When a heater is selected to meet the maximum flow as calculated above the details of the heater are recorded in ADG-003B and the maintenance rate in MJ/day is also recorded.

Table B.2 OTHER HEAT LOSSES	
HW METER LOSS @ 0.1MJ/hr PER Meter (MJ/day)	98.4
BOILER MAINTENANCE RATE (MJ/day)	19.6

Table B.3 ENERGY GAINS FROM AUGMENTATIONS (MJ/day)		
SOLAR THERMAL PANELS (MJ/day)	define panels and config	0.0
CO-GENERATION (MJ/day)	150kWe - Jacket HR @ 160MJ/day for DHW	0.0
OTHER RENEWABLES		
TOTAL ENERGY AUGMENTATION		0.0

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6. CALCULATION OF THE COMMON FACTOR

This stage is a check to see that the centralised hot water system design achieves the nominated common factor threshold of, > 0.40 MJ/lit of total hot water used.
If CF < 0.40 then the specified design complies and the installation may proceed.

If however, CF > 0.40 then the design must be modified to increase the efficiency of the system. This can be achieved by reviewing the piping system design, specifying other insulation, or a more efficient hot water heater.

The Common Factor is calculated as follows:

C.F (MJ/L) = Total Daily Gas Consumption (MJ/day) / Daily Water Usage (L/day)

Where:

Total Daily Gas Consumption (MJ/day) = HEAT LOSS + HEAT REQUIRED + MAINTENANCE – ENERGY AUGMENTATIONS (SOLAR)

[C] HEAT CALCULATIONS AND COMMON FACTOR

	CONSUMED HOT WATER ENERGY (MJ/day)	BOILER MAINTENANCE AND METER/VALVE LOSSES (MJ/day)	LOSSES FROM CHWP MANIFOLD (MJ/day)	HEAT GAINS FROM AUGMENTATION (MJ/day)	TOTAL ENERGY	COMMON FACTOR (MJ/lit)	GENRALISED COMMON FACTOR (kJ/lit/deg.C)
COLUMN <F> INSULATION	1,151.4	118.0	511.9	0.0	1,781.3	0.40	8.1
COLUMN <G> INSULATION	1,151.4	118.0	353.7	0.0	1,623.1	0.37	7.4

APPENDIX B

WORKSHEET FOR CALCULATING COMMON FACTOR

The following spreadsheet is available on the Jemena website as an active spreadsheet and is presented here as as example only.

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ADG-003B - DESIGN GUIDE - MODEL FOR ESTIMATION OF COMMON FACTOR FOR GAS CENTRALISED HOT WATER SYSTEMS (GCHWS) (ISSUE 3 - 21/5/07)

Note [1] : All cells with white backgrounds are unlocked and require designer input. All other cells are locked and cannot be changed.

DATE -	26-May-07
ADDRESS -	
NUMBER OF APARTMENTS -	40
SPECIFY PROPOSED BOILER PLANT HERE -	
GCHW THERMAL EFFICIENCY	80.00%
BOILER MAINTENANCE RATE (MJ/DAY)	19.6
TEMPERATURE RISE (^{o}C)	50

[A] HOT WATER AND ENERGY DEMAND SECTION

Table A.1 - Calculation of Number of Points from Inputted Apartment Details

APARTMENT DWELLINGS	KITCHEN	BATH ROOM	LAUNDRY	EN-SUITE	DISH WASHER	NO. OF BEDROOMS	SUM OF POINTS / UNIT	NO OF UNITS	SUM OF POINTS
10	1	1	1	0	1	1	5	10	50
20	1	1	1	1	1	2	7	20	140
10	1	1	1	1	1	3	8	10	80
0	0	0	0	0	0	5	5	0	0
0	0	0	0	0	0	0	0	0	
								TOTAL NO. OF POINTS=	270

Table A.2 Calculated Nominal Hot Water Flow (at 65deg.C Before Mixing With Cold Water) and Equivalent Energy Content

TOTAL NO. OF POINTS	CALCULATED COINCIDENCE FACTOR	HOT WATER POINT DELIVERY (lit./min/point)	MAX. WATER DELIVERY FROM BOILER (lit/min)	AVERAGE HOT WATER SUPPLY FROM HOURLY RECOVERY RATE FROM GCHWS (lit/hr)	SPECIFY DAILY HOT WATER DEMAND PER APARTMENT (lit/apart./day)	CALCULATED DAILY HOT WATER (65°C) DEMAND (lit/day)	ENERGY REQUIRED TO HEAT 1.0 LITRE WATER TO TEMP (MJ/lit)	GAS ENERGY INPUTED TO BOILER FOR WATER CONSUMED (MJ/day)
270	0.166	4.56	204.4	3,066	110	4,400	0.262	1,151

[B] HEAT LOSS AND GAIN SECTION

Table B.1 PIPEWORK HEAT LOSSES

PIPE SIZE	INSULATION THICKNESS (mm)	"65°C HOT WATER / 15 deg.C AMBIENT with Thermotec 4 zero insulation")	"50°C TEMPERED WATER System/ 15deg.C AMBIENT with ARMAFLEX insulation")	INPUT LENGTH OF PIPE HERE	UNIT HEAT LOSS FOR COLUMN <F>	UNIT HEAT LOSS FOR COLUMN <G>
(mm OD)	<Nominate insulation type here>	(kJ/H/m)	(kJ/H/m)	(m)	(kJ/H)	(kJ/H)
15	nil	112.3	50.4	0	0.0	0.0
15	20	31.7	19.1	23	729.1	439.3
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65	nil	372.9	262.6	0	0.0	0.0
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80	20	85.3	63	0	0.0	0.0
80	25	76.3	49.7	0	0.0	0.0
100	nil	590.1	398.2	0	0.0	0.0
100	20	106.2	76.3	0	0.0	0.0
100	25	88.9	59.2	0	0.0	0.0
	Total Central Hot Water Piping Heat Loss (MJ/H) =				21.3	14.7
	Total Central Hot Water Piping Heat Loss (MJ/day) =				511.9	353.7

Table B.2 OTHER HEAT LOSSES

HW METER LOSS @ 0.1MJ/hr PER Meter (MJ/day)	98.4
BOILER MAINTENANCE RATE (MJ/day)	19.6

Table B.3 ENERGY GAINS FROM AUGMENTATIONS (MJ/day)

SOLAR THERMAL PANELS (MJ/day)	define panels and config	0.0
CO-GENERATION (MJ/day)	150kWe - Jacket HR @ 160MJ/day for DHW	0.0
OTHER RENEWABLES		
TOTAL ENERGY AUGMENTATION		0.0

[C] HEAT CALCULATIONS AND COMMON FACTOR

	CONSUMED HOT WATER ENERGY (MJ/day)	BOILER MAINTENANCE AND METER/VALVE LOSSES (MJ/day)	LOSSES FROM CHWP MANIFOLD (MJ/day)	HEAT GAINS FROM AUGMENTATION (MJ/day)	TOTAL ENERGY	COMMON FACTOR (MJ/lit)	GENRALISED COMMON FACTOR (kJ/lit/deg.C)
COLUMN <F> INSULATION	1,151.4	118.0	511.9	0.0	1,781.3	0.40	8.1
COLUMN <G> INSULATION	1,151.4	118.0	353.7	0.0	1,623.1	0.37	7.4

DIVERSITY FACTORS USED FOR CHWS DESIGN

SHEET 1 OF 2

NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)	NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)	NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)
1	1.0000	4.560	68.4	61	0.2040	56.745	851.2	121	0.1840	101.524	1,522.9
2	0.8500	7.752	116.3	62	0.2025	57.251	858.8	122	0.1840	102.363	1,535.4
3	0.7600	10.397	156.0	63	0.2020	58.031	870.5	123	0.1840	103.202	1,548.0
4	0.7000	12.768	191.5	64	0.2007	58.572	878.6	124	0.1830	103.476	1,552.1
5	0.6650	15.162	227.4	65	0.2005	59.428	891.4	125	0.1830	104.310	1,564.7
6	0.6450	17.647	264.7	66	0.2003	60.282	904.2	126	0.1830	105.144	1,577.2
7	0.6300	20.110	301.6	67	0.2001	61.135	917.0	127	0.1820	105.400	1,581.0
8	0.5970	21.779	326.7	68	0.1998	61.954	929.3	128	0.1820	106.230	1,593.4
9	0.5700	23.393	350.9	69	0.1995	62.771	941.6	129	0.1820	107.060	1,605.9
10	0.5450	24.852	372.8	70	0.1992	63.585	953.8	130	0.1810	107.297	1,609.5
11	0.5240	26.284	394.3	71	0.1990	64.428	966.4	131	0.1810	108.122	1,621.8
12	0.5070	27.743	416.1	72	0.1988	65.270	979.1	132	0.1810	108.948	1,634.2
13	0.4840	28.692	430.4	73	0.1986	66.110	991.6	133	0.1810	109.773	1,646.6
14	0.4660	29.749	446.2	74	0.1984	66.948	1,004.2	134	0.1800	109.987	1,649.8
15	0.4520	30.917	463.8	75	0.1982	67.784	1,016.8	135	0.1800	110.808	1,662.1
16	0.4370	31.884	478.3	76	0.1981	68.654	1,029.8	136	0.1800	111.629	1,674.4
17	0.4250	32.946	494.2	77	0.1980	69.522	1,042.8	137	0.1800	112.450	1,686.7
18	0.4120	33.817	507.3	78	0.1978	70.354	1,055.3	138	0.1800	113.270	1,699.1
19	0.4000	34.656	519.8	79	0.1976	71.183	1,067.8	139	0.1790	113.457	1,701.9
20	0.3900	35.568	533.5	80	0.1974	72.012	1,080.2	140	0.1790	114.274	1,714.1
21	0.3800	36.389	545.8	81	0.1972	72.838	1,092.6	141	0.1790	115.090	1,726.3
22	0.3720	37.319	559.8	82	0.1970	73.662	1,104.9	142	0.1790	115.906	1,738.6
23	0.3630	38.071	571.1	83	0.1966	74.409	1,116.1	143	0.1790	116.722	1,750.8
24	0.3540	38.742	581.1	84	0.1962	75.152	1,127.3	144	0.1780	116.882	1,753.2
25	0.3450	39.330	590.0	85	0.1960	75.970	1,139.5	145	0.1780	117.694	1,765.4
26	0.3370	39.955	599.3	86	0.1956	76.706	1,150.6	146	0.1780	118.505	1,777.6
27	0.3300	40.630	609.4	87	0.1953	77.479	1,162.2	147	0.1780	119.317	1,789.8
28	0.3230	41.241	618.6	88	0.1950	78.250	1,173.7	148	0.1780	120.129	1,801.9
29	0.3160	41.788	626.8	89	0.1946	78.976	1,184.6	149	0.1770	120.261	1,803.9
30	0.3100	42.408	636.1	90	0.1942	79.700	1,195.5	150	0.1770	121.068	1,816.0
31	0.3050	43.115	646.7	91	0.1940	80.502	1,207.5	151	0.1770	121.875	1,828.1
32	0.2960	43.192	647.9	92	0.1936	81.219	1,218.3	152	0.1770	122.682	1,840.2
33	0.2900	43.639	654.6	93	0.1932	81.932	1,229.0	153	0.1760	122.792	1,841.9
34	0.2850	44.186	662.8	94	0.1930	82.728	1,240.9	154	0.1760	123.594	1,853.9
35	0.2800	44.688	670.3	95	0.1926	83.434	1,251.5	155	0.1760	124.397	1,866.0
36	0.2750	45.144	677.2	96	0.1922	84.137	1,262.1	156	0.1760	125.199	1,878.0
37	0.2700	45.554	683.3	97	0.1920	84.925	1,273.9	157	0.1760	126.002	1,890.0
38	0.2660	46.092	691.4	98	0.1916	85.622	1,284.3	158	0.1750	126.084	1,891.3
39	0.2600	46.238	693.6	99	0.1912	86.315	1,294.7	159	0.1750	126.882	1,903.2
40	0.2570	46.877	703.2	100	0.1910	87.096	1,306.4	160	0.1750	127.680	1,915.2
41	0.2530	47.301	709.5	101	0.1905	87.737	1,316.1	161	0.1750	128.478	1,927.2
42	0.2490	47.688	715.3	102	0.1902	88.466	1,327.0	162	0.1750	129.276	1,939.1
43	0.2440	47.844	717.7	103	0.1900	89.239	1,338.6	163	0.1740	129.331	1,940.0
44	0.2410	48.354	725.3	104	0.1900	90.106	1,351.6	164	0.1740	130.124	1,951.9
45	0.2370	48.632	729.5	105	0.1900	90.972	1,364.6	165	0.1740	130.918	1,963.8
46	0.2340	49.084	736.3	106	0.1890	91.355	1,370.3	166	0.1740	131.711	1,975.7
47	0.2310	49.508	742.6	107	0.1890	92.217	1,383.3	167	0.1740	132.504	1,987.6
48	0.2280	49.905	748.6	108	0.1890	93.079	1,396.2	168	0.1730	132.532	1,988.0
49	0.2250	50.274	754.1	109	0.1880	93.444	1,401.7	169	0.1730	133.321	1,999.8
50	0.2230	50.844	762.7	110	0.1870	93.799	1,407.0	170	0.1730	134.110	2,011.6
51	0.2200	51.163	767.4	111	0.1870	94.652	1,419.8	171	0.1730	134.898	2,023.5
52	0.2180	51.692	775.4	112	0.1870	95.505	1,432.6	172	0.1730	135.687	2,035.3
53	0.2160	52.203	783.0	113	0.1870	96.357	1,445.4	173	0.1730	136.476	2,047.1
54	0.2140	52.695	790.4	114	0.1860	96.690	1,450.4	174	0.1730	137.265	2,059.0
55	0.2120	53.170	797.5	115	0.1860	97.538	1,463.1	175	0.1730	138.054	2,070.8
56	0.2100	53.626	804.4	116	0.1860	98.387	1,475.8	176	0.1720	138.040	2,070.6
57	0.2090	54.323	814.8	117	0.1860	99.235	1,488.5	177	0.1720	138.825	2,082.4
58	0.2080	55.012	825.2	118	0.1850	99.545	1,493.2	178	0.1720	139.609	2,094.1
59	0.2060	55.422	831.3	119	0.1850	100.388	1,505.8	179	0.1720	140.393	2,105.9
60	0.2050	56.088	841.3	120	0.1850	101.232	1,518.5	180	0.1720	141.178	2,117.7

SHEET 2 OF 2

NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)	NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)	NUMBER OF POINTS	COINCIDENCE FACTOR	FLOW RATE (l/min)	Max. Demand (lit/hr)
181	0.1720	141.962	2,129.4	241	0.1680	184.625	2,769.4	301	0.1650	226.472	3,397.1
182	0.1720	142.746	2,141.2	242	0.1680	185.391	2,780.9	302	0.1650	227.225	3,408.4
183	0.1720	143.531	2,153.0	243	0.1680	186.157	2,792.4	303	0.1650	227.977	3,419.7
184	0.1720	144.315	2,164.7	244	0.1680	186.924	2,803.9	304	0.1650	228.730	3,430.9
185	0.1720	145.099	2,176.5	245	0.1680	187.690	2,815.3	305	0.1650	229.482	3,442.2
186	0.1720	145.884	2,188.3	246	0.1680	188.456	2,826.8	306	0.1650	230.234	3,453.5
187	0.1710	145.815	2,187.2	247	0.1680	189.222	2,838.3	307	0.1650	230.987	3,464.8
188	0.1710	146.595	2,198.9	248	0.1680	189.988	2,849.8	308	0.1650	231.739	3,476.1
189	0.1710	147.375	2,210.6	249	0.1680	190.754	2,861.3	309	0.1650	232.492	3,487.4
190	0.1710	148.154	2,222.3	250	0.1670	190.380	2,855.7	310	0.1640	231.830	3,477.5
191	0.1710	148.934	2,234.0	251	0.1670	191.142	2,867.1	311	0.1640	232.578	3,488.7
192	0.1710	149.714	2,245.7	252	0.1670	191.903	2,878.5	312	0.1640	233.326	3,499.9
193	0.1710	150.494	2,257.4	253	0.1670	192.665	2,890.0	313	0.1640	234.074	3,511.1
194	0.1710	151.273	2,269.1	254	0.1670	193.426	2,901.4	314	0.1640	234.822	3,522.3
195	0.1710	152.053	2,280.8	255	0.1670	194.188	2,912.8	315	0.1640	235.570	3,533.5
196	0.1710	152.833	2,292.5	256	0.1670	194.949	2,924.2	316	0.1640	236.317	3,544.8
197	0.1710	153.613	2,304.2	257	0.1670	195.711	2,935.7	317	0.1640	237.065	3,556.0
198	0.1700	153.490	2,302.3	258	0.1670	196.472	2,947.1	318	0.1640	237.813	3,567.2
199	0.1700	154.265	2,314.0	259	0.1670	197.234	2,958.5	319	0.1640	238.561	3,578.4
200	0.1700	155.040	2,325.6	260	0.1670	197.995	2,969.9	320	0.1640	239.309	3,589.6
201	0.1700	155.815	2,337.2	261	0.1670	198.757	2,981.4	321	0.1640	240.057	3,600.8
202	0.1700	156.590	2,348.9	262	0.1670	199.518	2,992.8	322	0.1640	240.804	3,612.1
203	0.1700	157.366	2,360.5	263	0.1670	200.280	3,004.2	323	0.1640	241.552	3,623.3
204	0.1700	158.141	2,372.1	264	0.1670	201.041	3,015.6	324	0.1640	242.300	3,634.5
205	0.1700	158.916	2,383.7	265	0.1670	201.803	3,027.0	325	0.1640	243.048	3,645.7
206	0.1700	159.691	2,395.4	266	0.1670	202.564	3,038.5	326	0.1640	243.796	3,656.9
207	0.1700	160.466	2,407.0	267	0.1670	203.326	3,049.9	327	0.1640	244.544	3,668.2
208	0.1700	161.242	2,418.6	268	0.1670	204.087	3,061.3	328	0.1640	245.292	3,679.4
209	0.1700	162.017	2,430.3	269	0.1670	204.849	3,072.7	329	0.1640	246.039	3,690.6
210	0.1700	162.792	2,441.9	270	0.1660	204.379	3,065.7	330	0.1640	246.787	3,701.8
211	0.1700	163.567	2,453.5	271	0.1660	205.136	3,077.0	331	0.1640	247.535	3,713.0
212	0.1700	164.342	2,465.1	272	0.1660	205.893	3,088.4	332	0.1640	248.283	3,724.2
213	0.1690	164.146	2,462.2	273	0.1660	206.650	3,099.8	333	0.1640	249.031	3,735.5
214	0.1690	164.917	2,473.8	274	0.1660	207.407	3,111.1	334	0.1640	249.779	3,746.7
215	0.1690	165.688	2,485.3	275	0.1660	208.164	3,122.5	335	0.1640	250.526	3,757.9
216	0.1690	166.458	2,496.9	276	0.1660	208.921	3,133.8	336	0.1640	251.274	3,769.1
217	0.1690	167.229	2,508.4	277	0.1660	209.678	3,145.2	337	0.1640	252.022	3,780.3
218	0.1690	168.000	2,520.0	278	0.1660	210.435	3,156.5	338	0.1640	252.770	3,791.5
219	0.1690	168.770	2,531.6	279	0.1660	211.192	3,167.9	339	0.1640	253.518	3,802.8
220	0.1690	169.541	2,543.1	280	0.1660	211.949	3,179.2	340	0.1640	254.266	3,814.0
221	0.1690	170.311	2,554.7	281	0.1660	212.706	3,190.6	341	0.1640	255.013	3,825.2
222	0.1690	171.082	2,566.2	282	0.1660	213.463	3,201.9	342	0.1640	255.761	3,836.4
223	0.1690	171.853	2,577.8	283	0.1660	214.220	3,213.3	343	0.1640	256.509	3,847.6
224	0.1690	172.623	2,589.4	284	0.1660	214.977	3,224.6	344	0.1640	257.257	3,858.9
225	0.1690	173.394	2,600.9	285	0.1660	215.734	3,236.0	345	0.1640	258.005	3,870.1
226	0.1690	174.165	2,612.5	286	0.1660	216.491	3,247.4	346	0.1640	258.753	3,881.3
227	0.1690	174.935	2,624.0	287	0.1660	217.248	3,258.7	347	0.1640	259.500	3,892.5
228	0.1690	175.706	2,635.6	288	0.1660	218.004	3,270.1	348	0.1640	260.248	3,903.7
229	0.1690	176.477	2,647.1	289	0.1660	218.761	3,281.4	349	0.1640	260.996	3,914.9
230	0.1690	177.247	2,658.7	290	0.1650	218.196	3,272.9	350	0.1630	260.148	3,902.2
231	0.1680	176.964	2,654.5	291	0.1650	218.948	3,284.2	351	0.1630	260.891	3,913.4
232	0.1680	177.731	2,666.0	292	0.1650	219.701	3,295.5	352	0.1630	261.635	3,924.5
233	0.1680	178.497	2,677.4	293	0.1650	220.453	3,306.8	353	0.1630	262.378	3,935.7
234	0.1680	179.263	2,688.9	294	0.1650	221.206	3,318.1	354	0.1630	263.121	3,946.8
235	0.1680	180.029	2,700.4	295	0.1650	221.958	3,329.4	355	0.1630	263.864	3,958.0
236	0.1680	180.795	2,711.9	296	0.1650	222.710	3,340.7	356	0.1630	264.608	3,969.1
237	0.1680	181.561	2,723.4	297	0.1650	223.463	3,351.9	357	0.1630	265.351	3,980.3
238	0.1680	182.327	2,734.9	298	0.1650	224.215	3,363.2	358	0.1630	266.094	3,991.4
239	0.1680	183.093	2,746.4	299	0.1650	224.968	3,374.5	359	0.1630	266.838	4,002.6
240	0.1680	183.859	2,757.9	300	0.1650	225.720	3,385.8	360	0.1630	267.581	4,013.7

APPENDIX C

ISOMETRIC DIAGRAM DERIVED FROM BUILDING PLANS