APPENDIX IV

Steam Services for Hospital Autoclaves & Sterilising Services

Queensland Health Capital Works

STEAM SERVICE FOR HOSPITAL AUTOCLAVE APPLICATION AND STERILISING SERVICES

INDEX

EXECUTIVE SUMMARY

The quality of steam supplied to any sterilising appliance or Central Sterilising Services Department must be carefully controlled to ensure there is no risk of infection from ineffectively sterilised items.

Problems with “spotted” or “wet” steriliser loads attributed to unsatisfactory steam quality have been reported from various hospitals in Victoria, New South Wales and Queensland in recent times.

In many hospitals, recent redevelopments have resulted in older style, central energy, steam plant replaced by modern construction, higher energy efficiency steam boilers. These older steam boilers inherently included generous water/steam storage volumes, enabling them to cope with erratic and instantaneous, heavy steam demand - loads that occur with central sterilising services and laundries. This inherent feature helped, in part, to ensure steam of acceptable quality was always available for sterilisation purposes.

The objective of ensuring complete sterilisation of hospital items is not a simple matter of steam boiler performance alone. The continuously changing nature of items to be sterilised, together with increasing use of plastic components, and the newer wrappings associated materials continuously being trialed all impose stricter steam quality needs for sterilisation purposes.

The key factors influencing the steam quality reaching the central sterilising equipment are identified and commented upon for the guidance of hospital maintenance engineers and system designers. Future changes in procedures and practices will need to be assessed for compatibility with present generation steam services installed in accord with the most recent recommendations.

Issues addressed in this Design Guide include –

Steam Boiler Plant
Water Treatment for Steam Boiler Plant
Steam and Condensate Piping Design
Essential Power and UPS Needs
CSSD Staff Operating Procedures/Practices

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GLOSSARY OF TERMS AND ACRONYMS

BMS

Building Management System.

Carryover

Contamination of the steam with boiler water droplets. Foaming and rapidly rising bubbles bursting may result in small droplets of water containing suspended and dissolved solids being drawn away with the steam.

Condensate

Condensed steam that is returned to the boiler feed water tank or deaerator where together with softened make-up water (if required) returns to the boiler as feed water.

Dry Steam

Pure steam (no water particles).

Dryness Fraction (χ)

The quality of wet steam is expressed by its dryness fraction, which is the ratio of the mass of pure steam in a given mass of steam plus water mixture.

$$\therefore \quad \chi = \frac{\text{mass of pure steam}}{\text{mass of steam plus water mixture}}$$

Feed Water

Feed water is used to maintain boiler level. It is usually made up of condensate return water supplemented by softened make-up water.

Make-Up Water

Make-up water is softened water used to supplement losses in the feed water system, steam system, etc.

Modulating Control

Automatic control of boiler components such as burners, feed water valves, etc. with continuously variable adjustments possible between maximum and minimum or any point in between. Not on/off operation.

pH

The pH scale of 1 to 14 is a measurement of the acidity or alkalinity of a solution, (the lower the value, the more acidic the solution). pH 1 or 2, strongly acidic, pH 7 is neutral, pH 13 or 14 strongly alkali.

PLC

Programmable Logic Controller.

ppm

Parts per million.

Priming

Contamination of the steam supplies with gross quantities of water. May be caused by failure of the feed water controls, damaged steam separation equipment or swell due to a sudden increase in steam demand.

Purge

A period of time during the burner lighting sequence where air from the forced draught fan is used to ensure that the furnace is clear of all flammable vapours and gases that may result in a furnace explosion when ignition occurs.

Saturated Steam

Steam (or saturated vapour) that is in physical contact with the boiling water from which it has been generated, the saturation temperature of the boiling water, and therefore the steam, corresponds to that particular pressure. (*Refer to the pressure-temperature conversion provided in this document*).

Soft Water

Soft water is raw (usually mains supply) water that has been treated, usually by ion exchange, to replace scale forming calcium and magnesium salts for sodium salts, which are extremely soluble.

Superheated Steam

Steam (or vapour) not in physical contact with the boiling water from which it has been generated, at a temperature above the saturation temperature corresponding to its pressure.

Swell (sometimes referred to as 'Surge')

Rapid expansion of boiler water due to a sudden increase in burner firing rate at a time of low boiler pressure or the result of large quantities of 'cold' water entering the boiler and temporarily reducing boiler pressure. This has the effect of reducing the steam space in the steam drum and if severe, can result in priming.

TDS

Total Dissolved Solids, this is a measure of the concentration of all soluble material (except gases) in boiler water. Acceptable quantity domestic water is usually in the range of 200 to 400 TDS.

UPS

Uninterruptable Power Supply.

Wet Steam

Steam at saturation temperature containing water (usually very fine particles held in suspension in the form of a mist).

STEAM DEMAND AND QUALITY

Steam delivered to the autoclave is required to be saturated steam without superheat and at the desired working pressure, with a dryness fraction of 0.97 or better.

Sterilisers require large quantities of steam for the initial 5 to 10 minute period, then minor occasional demand for the remaining 30 to 50 minutes of a sterilising cycle. With multiple sterilisers, the occasional and unpredictable coincidence of all sterilisers demanding steam together may place an abnormally high demand upon the steam system with the risk of poor quality steam being supplied from the boiler or created in the piping system.

CREATION OF WET STERILISER LOADS

Wet steriliser loads can be caused in a variety of ways. One factor is delivery of excessively wet steam to the steriliser, overwhelming all water removal precautions to dampen the steriliser load. Other contributing factors can involve steriliser plant limitations, incorrect packing/loading and inefficient procedures.

Wet Steam from Boilers

Steam flows out of a boiler when the distribution system pressure drops below boiler pressure as a result of a steam appliance starting a cycle/valve opening. The internal pressure of the boiler also reduces and additional boiler water flashes/vaporises into steam under the slightly lower pressure. The escaping steam produces bubbles and if impurities are present in the water may result in foaming. The bubble walls may form water droplets when bursting and became entrained in the steam to be carried-over as wet steam.

The larger the steam demand, the larger the amount of "cooler" makeup water pumped into the boiler to maintain the water level, with a consequential additional temporary temperature and pressure drop until the heating system restores operating pressure and temperature.

Adequate steam clearance volumes in the steam chamber, with large clearance height before entering the discharge outlet baffles, provide more opportunity for steam bubbles to collapse before being drawn out of the boiler, thus maintaining the desired dryness fraction.

Generous steam/water interface area in the boiler top chamber helps to limit the height of the foam volume during steam release and assists in earlier bubble collapse with less water carrying-over into the steam system. Average steam escape velocity is to be kept below 0.15 m/s at design pressure and peak flow, since this can increase to 0.3 m/s at the lowest operating pressure in the cycle.

Water quality also affects the tendency to carryover. As the TDS value increases, bubbles remain small, with increasingly higher surface tension property and longer persistence time before bubbles will collapse. High TDS encourages foaming and the possibility of carryover.

The burner of a boiler/generator may cycle on/off, high/low or modulate depending on the type of control system. The ability of the burner to modulate reduces the period of time that the burner is off and therefore reduces the pressure fall in the boiler when the steam demand suddenly returns, minimising prepurge time delays in burner restart and thus indirectly reducing swell and the possibility of carryover.

The merit of reducing off cycle times becomes more important when using a fuel such as natural gas, propane or fuel oil where burner safety controls include pre-purge safety times up to 5 minutes in duration, where the burner is locked-out.

Modulating burner control reduces the frequency of stopping/starting, giving overall better immediate response to sudden load demands. Fully modulating control range of 15% to 100% of continuous steam demand output is recommended.

With electric steam boilers/generators, obviously no purge time is required, so the number of heater capacity steps is less critical.

Where a steam accumulator is installed, high/low burner control instead of a more expensive modulating control may be adequate as the accumulator acts as a buffer between the boiler and the appliances smoothing out the steam demand.

Wet Steam in Piping Systems

Carryover from the boiler together with condensate formed in maintaining system temperature (ie. piping heat losses) accumulates as nuisance condensate. If this condensate is not collected and removed at every convenient opportunity, it gradually accumulates to ‘block-off’ the available pipe opening restricting steam flow. As well, water droplets are increasingly picked-up and carried along with the steam flow into the appliances resulting in excessively wet steam.

Distribution pipe sizing can also affect steriliser performance. If piping is critically sized with larger pressure losses at average steam flows, peak steam demands will not be catered for so cycle times will need to be extended to compensate for the restrictions on availability of steam.

The higher piping velocities also increases the chance of pick-up and transportation of entrained water droplets, degrading the operation of any water separators, steam traps, etc, and increasing the chance of excessively wet steam entering the steriliser.

Water Effect Inside Sterilisers

Any water entrained in the steam flow and injected directly onto packs inside the autoclave, can hit the packs and leave marks of its presence.

Steam needs to permeate through the wrapping of the steriliser packs to reach the items inside before it can heat them; this permeation process takes time. In giving up its heat to the contents of the packs, the steam condenses into water. When the temperature inside the packs increases sufficiently, the condensate re-evaporates under vacuum conditions. Once again a vapour, time is required for the steam to permeate through the wrapping before it can escape from the steriliser. There is also a necessary 'resting' time after a pack is removed from a steriliser before it is advisable to unpack the items.

Production tests establish the required times for all parts of a successful sterilisation cycle. Departing from proven cycle times can result in items displaying signs of water marking and raising concerns of an unsuccessful cycle.

Various steriliser equipment defects can also result in water marking of processed items.

Refer later appendix – Sterilising Services Fact Sheet #1.

If superheated steam enters an autoclave, this also has an undesirable effect on some wrappings, hindering the permeation of steam into and out of the packs and promoting water-spotting problems.

BOILER PLANT

Staffing Policy

The number of staff available to supervise the operation of any boiler plant impacts on the operating costs of the plant and also influences the type of boiler plant selected to serve an application.

Steam plants may be required to be operational 24 hours per day, depending on hospital activities. Efforts to reduce recurrent operating costs have lead to unattended type steam boilers being increasingly favoured.

Applications with steam boilers of smaller stored water/steam capacity and surface area, and therefore limited instantaneous steam output capability,

influences the probability of wet steam being generated and the need to incorporate additional precautions into the steam system to ensure only saturated steam at a dryness fraction of 0.97 or better reaches the autoclaves.

Steam Boiler Types

Refer to AS2593 table 1.1, Boilers–Unattended & Limited Attendance

Boiler Pressure Rating

Value analysis usually supports boilers rated up to 1200 kPa, but typically operated at 800 kPa steam pressure, while sterilisers require 200 to 400 kPa supply pressure, depending on manufacturer and individual models.

Pressure Reduction Valve Application

Pressure reducing valves are required to control the final steam supply pressure to sterilisers. These valves require steam traps in close proximity but correct installation is critical to avoid superheated steam being produced and damaging pack wrappings. Usually a distribution pipe length of 3 to 6 metres downstream of a pressure reducing valve is sufficient to dissipate any such localised superheating.

To minimise localised superheating, pressure reducing valve duty is recommended to be selected for less than 2:1 pressure ratio. Pilot operated type pressure reduction valves in a lead/follow pair combination are also recommended for each group of sterilisers.

Preferred Steam Boiler Characteristics

Steam boilers are recommended to include the following quality features –

- Generous water/steam storage volume to provide adequate steam to meet instantaneous demand without an excessive pressure drop.
    - minimum Operating Water Volume of 3 litre/kW
    - minimum steam space volume of 1.1 litre/kW
- Generous furnace volume to maximise heat transfer
    - Maximum 2 cubic metre volume/MW.
- Water to steam interface surface area/steam flow ratio shall exceed 2.5 m^2/MW of steam flow.
- Maximum allowable steam release velocity at the steam/water interface –
    - (a) shall be 0.3M/s where efficient “dry pan” or “dry pipe” steam discharge baffles are fitted.
    - (b) shall be 0.15M/s without “dry pan” or “dry pipe” discharge type baffling.
- Boiler pressure rating required is assumed 1200 kPa.
- Continuous steam output rating with a dryness fraction of 0.97 or better measured at standard air conditions of 20^o C dry bulb and 17^o C wet bulb with 80^o C feed water.
- Gross boiler efficiency shall exceed 80% from 20% to 100% of continuous steam output.

- Fully modulated burner control from 15% to 100% of continuous steam output rating, including the option of permanent pilot control.
- Modulating feed water control to provide a steady supply of feed water to the boiler minimising the effects of swell and foaming caused by large quantities of ‘cold’ water suddenly entering the boiler.
- Minimum of two (2) feedwater pumps even under 500 kW boiler rating.
- TDS monitoring and automatic blowdown.
- Boiler water sampling pot with cooling heat exchanger and collection pressure vessel.
- Boiler blow-down vessel.
- Include steam heating coil feature with temperature control valve for boilers required to operate in lag or standby mode on occasion.
- Deaerator to minimise non-condensable gases such as oxygen and carbon dioxide entering the boiler and becoming highly corrosive impurities within the boiler but most importantly in the condensate system where policy restricts the use of corrosion inhibitors.
- Control panel with Uninterpruted Power Supply and generous status indication with provision to service the PLCs only, if automatic restart is possible on restoration of electric power to the burner etc.
- Interface with BMS.
- Stairs, walkways and platforms providing walk-up access to all boiler components.
- Flue gases shall meet environmental limits.

STEAM GENERATORS

Steam generators may be a cost effective alternative to steam boilers for facilities with low steam demand (ie. to supply a solitary central sterilising service). Steam generators are designed to provide low pressure steam and are in effect an evaporator.

Generally, water is delivered from a reservoir by a feed water pump into a coiled generating tube where, by means of a heat source (usually electric heating or a gas or fuel oil burner) the water is converted into steam. The water passes through the coil just once and is flashed into steam in the process.

Such appliances are, in effect, forced circulation, once through boilers. They do not require steam or water drums or headers although certain types may incorporate steam separators or accumulators.

It is important to remember that Queensland Health does not recommend the use of amines for boiler water treatment where the steam from the boiler has direct contact with surgical instruments in sterilisers or direct contact with food. For this reason, the quality of the make-up water for these appliances will have to be impeccable or suspended solids will deposit on the walls of the coil resulting in poor heat transfer and wet steam; if suspended solids are carried downstream with the steam, they may damage ancillary equipment including the steriliser(s) and may even be deposited on the contents of the steriliser(s).

BOILER TYPES

There are three distinct types of boilers -

- Electric boilers.
- Fire-tube boilers (more accurately called smoke-tube boilers).

  In which the hot gases from combustion of fuel in the furnace pass through the tubes, while the boiler water surrounds the furnace and tubes.
- Water-tube boilers

  In which the boiler water passes through the tubes, while the gases from combustion of fuel in the furnace, pass around the outside of the tubes.

These boilers are discussed here in more detail along with the electric boiler which is basically utilises an electric element immersed in the boiler water as the heat source.

Electric Boilers

Electric steam boilers function well with predictable steady loads. The available stored water volume above the minimum safety water level setting needs to be checked against steam output requirements and demand cycle times to confirm suitability in a specific application.

Electric boilers may not be suitable if concerns exist about the quality of the raw water supply, with increased need to closely control water quality to avoid scaling of the electrodes/elements resulting in poor heat transfer, reduced steam output and wet steam.

Fire-Tube Boilers

Fire-tube steam boilers typically combine the features of a moderate stored water/steam volume with reasonably fast recovery heat output, important in an erratic load situation.

The available stored water volume above the boiler minimum safety level may not be large enough to ideally suit the load profile with a selected boiler shell size and selected burner size. Most manufacturers can extend their normal casing to create extra useable water volume, and this option can be a worthwhile investment for negligible extra cost.

Adding an accumulator storage vessel into the piping system, with its associated pressure control valves and heating service, can also provide extra stored water/steam.

Water-Tube Boilers

Some of the advantages of water-tube boiler over fire-tube boilers include -

- Rapid steam raising ability
- Savings in space
- Wider safety margin in the event of explosion

Water-tube steam boilers typically have a smaller stored water/steam volume than a fire-tube boiler. The available stored water volume above the minimum safety water level setting needs to be checked against steam output needs and demand cycle times to confirm suitability in a specific application. This type of boiler has the quickest recovery time of the three boiler types.

STERILISER STEAM USAGE

Designers need to be advised of instantaneous steam demand required at different stages of the steriliser cycle.

Ignoring first warm-up of the working day, there is a large initial steam flow for each steriliser to heat the steriliser packs, possibly for 5 to 10 minutes. Subsequently there is a small maintenance steam flow required for minor heating and equipment heat losses. If a steam ejector provides the vacuum cycle, extra steam flow will be needed for this purpose at a later stage of a cycle.

Note. Mechanical vacuum service is recommended.

Manufacturer’s literature needs to be consulted to obtain steam usage data with a focus on the combined instantaneous requirement for the sterilisers installed in each location.

Autoclave manufacturers can provide this data in a convenient form to assist designers.

Typical requirements, depending on size, vary between -

- Start-up time 5 to 10 minutes.
- Instantaneous peak steam flows 50 to 120 kg/hr for startup
- Average cycle time 40 to 50 minutes
- Average steam flow of 50 to 90 kg/hr during the cycle

Actual steam use per cycle may be in the range 10 to 30 kg of steam, depending on size.

Occasionally all sterilisers will cycle on together. This imposes a short-term peak steam demand greatly exceeding an average steam flow-rate.

BOILER CAPACITY

The assessment of boiler size to serve multiple sterilisers whilst maintaining other equipment/purposes (ie. laundry equipment, calorifiers, space heating, etc.) –

- Instantaneous maximum demand must be determined with approximate peak time period.
- Steam usage load profile throughout a working day.
- Decision on critical classification of the steam service (ie. essential or non-essential).
- Number of boilers proposed (100% redundancy is recommended for continuity of steam in the event of unexpected breakdowns and for maintenance purposes).
- Loss of mains electrical supply, electrical requirements supported by an emergency diesel generator(s) and sufficient stored fuel on site to provide both diesel and steam plant for the desired period of time.

Recommendation:

The boiler plant is to be sized to cope with a total load including –

- The sum of the peak instantaneous demand steam flow of 70% to 100% of plant including all largest appliances in base load assessment.
- Add the average cycle demand of the remaining 30% to 0% of plant.
- Apply a services multiplying factor not less than 1.4 for line and other losses.
- Apply a services multiplying factor not more than 0.9 when using demineralised water for makeup water.

The stored capacity of steam available for instantaneous release needs to be assessed, with following recovery periods also considered. This duty assessment impacts on the capital cost of boiler plant. The use of boilers with increased water/steam storage or separate pipeline storage accumulators needs to be assessed in the financial analysis.

In anticipation of boiler breakdowns and annual maintenance overhaul requirements, the number of boiler units are recommended to be increased by one (1) extra unit for redundancy.

This well-known redundancy provision requires the steam demand to be served not by ‘N’ units, but ‘N + 1’ units of equal size per installation.

Eg. Two x 100% capacity boilers, three x 50% capacity boilers, four x 33% capacity boilers etc.

BOILER CONTROL SYSTEMS

With the increased use of PLCs and computer based controller modules in boiler control panels, it is recommended that the controllers be protected against unplanned loss of mains electrical power. This will assist in preventing nuisance lock-out of the equipment when mains supplied power is restored or there is a changeover to emergency electrical power.

The control system needs segregation from the power accessory items of the boiler and critical electrical power is supplied to the control and monitoring systems from a UPS. It is not suggested to operate the burner/combustion air fan or feedwater pumps from UPS but it is recommended to have a normal and emergency electric power supply available for operation of fans/pumps.

Each manufacturer needs to be consulted on the feasibility of such arrangements for their range of boilers.

PIPING SYSTEMS

The large difference between average steam demand and occasional maximum peak instantaneous demand requires a decision on the pipe sizing criteria to be applied.

Piping is to be sized for maximum peak steam flow with 100% of appliances at instantaneous peak without diversity.

Select pipe size with steam velocity of 10 to 15 m/s, as well as modest total pressure drop for the total piping distribution system, usually less than 25 kPa.

Generously sized headers are required adjacent to all grouped equipment to assist in collecting and removing entrained water. Header diameter can be sized as two or three pipe diameter steps larger than the equivalent combined supply service pipe diameter or design for a header barrel velocity less than 5 m/s at maximum steam flow.

Detailed attention needs to be paid to condensate removal at every collection point. The best industry practice needs to be followed for locations of steam traps.

The usual steam trap locations include -

- Adjacent to boiler plant before piping is reticulated to all equipment.
- Bottom of every rising or dropping steampipe.
- At each distribution header.
- At each steam separator.
- After each pressure reduction valve set.
- Adjacent to inlet of each item of equipment.

Refer to industry design and installation manuals for additional guidance on trapping practices and header applications. Comments in regard to pressure reduction valves were provided earlier.

Steam Accumulators

Accumulators are not a preferred choice, as the associated control valves add extra complications to the reliability of steam supply and require additional maintenance.

It is recommended the piping services and plant room layouts be arranged to permit addition of a pass-through accumulator vessel at a later date in expectation of inadequate plant performance and steam supply difficulties.

If the load assessment and value analysis favoured installation of one or two steam accumulators with smaller sized boilers, the accumulators are recommended to be located close to the boilers. This provides effective heating, ease of supply of softened and heated feed water and ease of return of condensate or overflow back to the boiler feed water tank/deaerator.

Accumulators are recommended to be of the horizontal configuration to maximise the water/steam transfer area and preferably keep the vaporisation release velocity below 0.011 m/s (200 kg/hr per m^2). Commentary in the appendix discusses accumulator sizing.

Condensate Return Piping

Queensland Health does not recommend the use of amines for boiler water treatment where the steam from the boiler has direct contact with surgical instruments in sterilisers or direct contact with food. The oxygenation of steam occurring in the sterilising process results in oxygen and carbon dioxide being carried into the condensate system with the steam. Carbon dioxide dissolved in condensed steam, forms corrosive carbonic acid; if oxygen is also present, it will enhance the corrosive action. Ammonia, in combination with oxygen attacks copper alloy.

For these reasons, non-condensable gases must be reduced as much as possible from feed water before it enters the boiler.

If concerns exist regarding condensate system corrosion due to high quantities of carbon dioxide, ammonia and oxygen being present in the condensate, consideration should be given to using 316 stainless steel for condensate pipe-work.

WATER TREATMENT

Boilers require a certain amount of make-up water to supplement losses in the steam system, condensate system or from blowing-down the boiler.

Raw (mains supplied) water must be softened before it is suitable for use as make-up water, the most common method used in hospitals to provide soft water to boilers as make-up water is 'Base Exchange Softening' where scale forming calcium and magnesium salts are exchanged for sodium salts, which are extremely soluble.

The boiler water treatment package is to include deaeration of the feed water system and the addition of an oxygen-scavenging chemical before the boiler to eliminate or reduce non-condensable gases such as oxygen and carbon dioxide. As mentioned earlier, carbon dioxide dissolved in condensed steam, forms corrosive carbonic acid, if oxygen is also present, it will enhance the corrosive action. Ammonia, in combination with oxygen, attacks copper alloy.

Excessive TDS in boiler water encourages persistent bubble life and increases the risk of carryover due to foaming. Blowing-down the boiler utilising an automatic blow-down system and a conductivity senor will maintain TDS at an acceptable level. Chemical dosing is necessary to maintain pH but these chemicals will increase the resulting TDS.

As a general guide, boiler water needs to be slightly alkaline with pH close to 9 and TDS maintained between 2,000 to 3,000 ppm for the average water-tube boiler. If excess carryover is considered a problem, then a lower TDS value should be trialed for a time to assess the system performance.

When a steam accumulator is included in the system, the water/steam in the storage vessel has a very low TDS, in the vicinity of 150 ppm but may be as low as 20 ppm, with no tendency to carryover, so the steam released from an accumulator on high demand has less tendency to froth up and a better chance of remaining almost dry.

Chemical dosing is recommended to be automatically and proportionally controlled.

Conductivity monitoring is the indirect mechanism used to automatically gauge TDS value. For a TDS of 2,000 ppm, unneutralised conductivity of 4,000 μS/cm would be required.

Advice is to be sort from water treatment specialists regarding local chemical dosing requirements and blow-down frequency.

Refer to the guidelines provided by water treatment companies for further information.

STERILISER OPERATING PROCEDURES

After every effort is made to supply steam with a dryness fraction of 0.97 or better to the sterilising equipment, steriliser users need to be consistent in the operation of the autoclaves, attempting as much as possible to minimise simultaneous start-up of autoclaves. As well, all packs need to be loaded and wrapped in a consistent manner to the tested prototype packs. Selected packs should be monitored regularly to confirm sterilisation adequacy. These activities will be covered by established quality assurance protocol

The attached annexure '*Sterilising Services Fact Sheet #1*', contains some suggestions where changes in procedures can contribute to wet of packs.

At the time of discovery of any unacceptable performance, it is important for notes of the circumstances of each incident to be recorded to assist engineering staff to correctly identify and rectify the problem(s).

ADDITIONAL ADVICE

Reports of unusual problems or requests for additional assistance need to be referred to Queensland Health - Capital Works and Asset Management Branch and subsequently to Department of Public Works, Project Services, Health, Law and Order Portfolio, Engineering Services Section - L Taplin or R Haskell ph (07) 3224 4375, fax (07) 3224 6151 or e-mail haskelr@projectservices.qld.gov.au.

PRESSURE-TEMPERATURE CONVERSION FOR SATURATED STEAM

Note. These conversions are an approximation and have been rounded; they are to be used as a guide only. Steam tables must be consulted for accurate conversions.

		Degrees	
PSIG	kPaG	Celsius	Fahrenheit
0	0	100	212
1.5	10	103	217
7.3	50	112	234
14.5	100	120	248
29.0	200	134	273
43.5	300	144	291
58.0	400	152	306
72.5	500	159	318
87.0	600	165	329
101.5	700	171	340
116.0	800	175	347
130.5	900	180	356
145.0	1000	184	363
159.5	1100	188	402

REFERENCES

Australian Standards -

AS1200 (1988)	Boilers & Pressure Vessels
AS1228 (1990)	Boilers – Water-tube
AS1797 (1986)	Boilers – Fire-tube
AS2593 (1995)	Boilers – Unattended & Limited Attendance
AS3653 (1993)	Boilers – Safety, Management, Combustion & other ancillary equipment
AS3873 (1995)	Pressure Equipment – Operation & Maintenance
AS3892 (1995)	Pressure Equipment – Installation

Spirax Sarco Steam Products Supplier

DB 8/5 Database – Steam Services for a Hospital Steriliser

DB-GAB-A03 Australian Database – Steam Accumulators Today

Reference MP/01/18 of 'Open University' Project – Steam Storage (April 1997)

TR-GCM-03 Technical Reference – Steam Distribution (caution with pipe size standards)

Anco Australasia Pty Ltd

SM003 On-Site Testing Program

SM005 Control Ranges (of water quality for Steam Boilers)

Queensland Health – Communicable Diseases Unit – Adviser in Sterilising Services

Sterilising Services Fact Sheet #1 (January 1998)

The Efficient Use of Steam - O. Lyle (HMSO) SBN 11 4101302.

EXAMPLE

ACCUMULATOR SIZE ASSESSMENT

Installed equipment -

Boiler Plant - 150 kg/hr steam output at 1000 kPag.

Sterilisers -

Three rated at 120 kg/hr peak steam demand, 90 kg/hr average demand.

Three rated at 90 kg/hr peak steam demand, 60 kg/hr average demand.

One rated at 70 kg/hr peak steam demand, 30 kg/hr average demand.

Load cycle time is one hour – 60 minutes.

Worst peak steam demand - (3 x 120) + (3 x 90) + (1 x 70) = 700 kg/hr for 10 minutes.

Design steam demand – 700 x 1.4 = 980 say 990 kg/hr for 10 minutes

Boiler/burner differential pressure control may be set between 100 to 200 kPa.

Assess accumulator size for 200 kPa pressure change, ie. reduce to 800 kPag supply pressure.

Consult steam tables for Specific Enthalby values for water and latent heat of evaporation.

1000 kPa

Enthalby of water 781.6 kJ/kg (at 184^{0}C)

8000 kPa

Enthalby of water 743 kJ/kg (at 175.4^{0}C)

Latent heat of vapourisation 2030.9 kJ/kg.

Shortfall in steam supply for 10 minutes.

990 - 150 kg/hr = 840 kg/hr.

Shortfall in steam mass

840 (kg/hr) x 10/60 (min/hr) = 140 kg steam.

Minimum mass of water required to generate 140 kg of flash steam with pressure change from 1000 to 800 kPag.

= Mass steam x Latent heat of vapourisation at 800 kPa/Difference in Specific Enthalby of water between 1000 and 800 kPa.

= 140 x 2030.9 (kJ)/(781.6-743) (kJ/kg).

= 7,366 kg of water at 800 kPa.

Minimum volume of water to generate 140 kg of flash steam.

= 7366 (kg water)/895 (kg/C.M. at 800 kPa).

= 8.23 C.M..

(Note - density of water at NTP is 1000 kg/C.M.).

Assume accumulator is 90% water volume and 10% steam volume.

Minimum accumulator volume

= 8.23/90% C.M..

= 9.15 C.M..

Minimum water release area without wet steam.

= 840 (kg/hr)/200 (kg/hr/S.M.).

= 4.2 S.M..

Review economics of different diameter vessels and boiler room space available.

Horizontal Accumulator

1.5 m diameter x 5.2 m long provides

9.5 C.M. total volume.

At 90% volume, water depth is 85% of diameter (1.275 m) and water surface area is 71% of maximum cross-section area (19.1 S.M.).

Water surface area is well above minimum limit of 4.2 S.M..

Vertical Accumulator

2.4 m diamter x 2.2 m high provides 9.15 C.M. total volume and 4.2 S.M. fixed water surface area.

At 90% volume, water depth is also 90% (1.9 m).

Accumulator Design

Vessel design also considers steam injection arrangements, makeup water control, overflow control, temperature control etc., reheating capability of boiler plant for low demand portion of load cycles and selection of flow control valves in accumulator pipeup arrangement.