WINDIMURRA VANADIUM PTY LTD

WINDIMURRA VANADIUM PROJECT

PIPING BASIS OF DESIGN

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PERTH

T: (61 8) 9481 3200
F: (61 8) 9481 2249

370 Murray Street
Perth WA 6000

PO Box 7537
Cloisters Square WA 6850

BUNBURY

T: (61 8) 9792 5633
F: (61 8) 9792 5644

4/14 Ommanney St
Bunbury WA 6230

PO Box 1045
Bunbury WA 6231

ROCKINGHAM

T: (61 8) 9550 1900
F: (61 8) 9550 1901

Unit 6/3 Benjamin Way
Rockingham WA 6168

W: www.proteuseng.com.au
E: proteus@proteuseng.com.au

Proteus Consultants Pty Ltd
ABN 75 731 449 224

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1.0 INTRODUCTION

This document covers the general requirements for the design of piping systems.

The purpose of this document is to provide reference information and guidance to assist the detailed engineering design of specific projects. This document should be read in conjunction with the pipe material and valves specifications as well as design criteria that apply to the project.

2.0 DESIGN LIFE OF PIPEWORK

For mine-sites and mineral processing plants, unless otherwise specified for the particular project, the plant design life is normally 20 - 30 years. For infrastructure projects (e.g. water supply) the design life may be longer (e.g. 50 – 100 years).

Where it is not practical for the wear life, corrosion life or fatigue life of specific piping components to meet or exceed the specified plant life, these items should be identified in the maintenance schedules for routine condition monitoring, periodic NDE or change-out.

3.0 PROVISIONS FOR FUTURE EXPANSION

In general, unless otherwise agreed for the specific project, it is recommended that any new pipe support racks should be initially designed with approximately 20 - 50% spare space and load carrying capacity for future piping.

This criteria will be specific to the project and is normally specified by the client or determined by economic considerations.

4.0 STANDARDS

The applicable Australian and/or International standards shall be listed in the project specific design criteria prepared for each project.

In general, process piping systems for minesites and mineral process plants may be designed to one of the following standards:

AS 4041	Pressure Piping
AS 2018	Liquid Petroleum Pipelines
AS 2885	Pipeline – Gas and Liquid Petroleum
ASME B31.1	Power Piping
ASME B31.3	Chemical Plant and Petroleum Refinery Piping
ASME B31.8	Gas Transmission & Distribution Piping
ASME B31.11	Slurry Transportation Piping Systems

For glass reinforced plastic and other non-metallic piping, other specific standards may apply for each material.

For domestic plumbing, water supply, sewerage and drainage, other standards may apply such as AS 3500, the Building Code of Australia and the requirements of State and local government bodies.

5.0 STATUTORY REQUIREMENTS

Any applicable statutory requirements shall be listed in the project specific design criteria prepared for each project.

6.0 GENERAL PIPING DESIGN REQUIREMENTS

The piping material codes, valve codes, fluid codes, line numbering and valve numbering conventions and specific design details will be unique for each project and no attempt is made to describe them here. The project specific design criteria document shall contain this information.

This document covers general design philosophy issues which are expected to be common to most projects on minesites and mineral processing plants.

6.1 Design Temperature

When the temperature of the fluid in non-insulated pipework is less than 40 deg C, the design temperature of the pipe shall be the same as the temperature of the fluid.

For higher temperatures and insulated pipework, refer to the specific piping design code that applies for the project (e.g. AS 4041 Section 3.3).

6.2 Design Pressure

The design pressure of a piping system shall not be less than the maximum pressure expected in service. This will normally be significantly higher than the normal operating pressure because of considerations which may include but are not limited to the following:

- Pump shut-off (dead head) pressure.
- Water hammer or maximum surge pressures due to pump starting/stopping and valve operation.
- Process upset conditions.

Where pressure within the system is limited by a relieving device, the design pressure shall not be less than the set pressure of the relieving device plus the percent overpressure of the relieving device (normally <10% of set pressure).

The design pressure of a piping system shall also be no greater than the maximum allowable design pressure of the selected line Material Class as per the Standard Specification for Piping Materials and Valves designated for the project.

6.3 Corrosion Allowance

The standard piping material specifications that are specific to the project shall often nominate a corrosion allowance based on the design limits set by the standard specification.

In the case of critical piping systems such as those requiring detailed pipe stress analysis, a specific corrosion allowance shall be designed and nominated on the piping isometric drawings.

The design of corrosion/erosion allowances shall also be based on fluid chemistry, slurry rheology and required design life.

6.4 Line Sizing

To minimise scale growth, settlement and wear in general process lines carrying liquid solutions and mixtures, typical recommended line velocities are shown in the table below:

Recommended Pipe Velocities (m/s)	DN50 to DN100	DN150 to DN200	DN300 to DN400	DN450 to DN600
Pumped Slurries				
Suction Lines (min/max)	1.2/1.4	1.2/1.5	1.3/1.7	1.8/2.3
Discharge Lines (min/max)	1.5/1.6	1.8/2.4	2.0/2.6	2.6/3.8
Water & Aqueous Solutions				
Pump Suction (min/max)	1.0/1.2	1.3/1.6	1.3/1.7	1.8/2.3
Pump Discharge (min/max)	1.2/2.0	2.1/2.5	2.5/3.1	3.2/4.6
Acid				
Suphuric Acid (max)	0.5	0.5	0.5	0.5
Steam				
Saturated	20	25	33	40
Superheated	20	25	40	55
Flash Steam with Particulates	15	15	15	15
Air & Other Gases (Low – Medium Pressure)				
Saturated	20	25	30	35
Dry	20	35	40	55
Vacuum Lines	22	27	30	33
Gravity				
Aqueous Liquids	1.2	1.5	1.8	3.0
Slurry – Settling Velocity Plus 20% minimum				

Special consideration shall be given to sulphuric acid lines where it is recommended that line velocities be kept below 0.5 m/s to avoid hydrogen scouring.

The velocities tabled above are to be used as a guide only for tentative line sizing. Final line sizing shall also depend on analysis of the following:

- Friction head-loss calculations and consideration of allowable pressure drop and pump sizing.
- Rheology of non-newtonian solid/liquid mixtures.
- Limiting Settling Velocity for settling slurries.
- Component wear considerations.

Guidance on slurry rheology as well as calculating the limiting settling velocity of solid/liquid mixtures may be found in the Warman Slurry Pumping Manual which is available on the internet (www.weirminerals.com).

Particular attention is required when variable speed drive pumps are used with settling slurries and shear-thickening (non-newtonian) slurries. In these cases the velocity range may be very wide and may operate below the limiting settling velocity or in the shear thickening range for short periods which can lead to line blockage, high pressures and pump tripping.

It is also worth noting that pumps are often sized to cater for 20% additional flow above that required by the process flowsheet.

6.5 Pipe Stress and Flexibility Analysis

Critical Lines

Critical lines require a mandatory stress and flexibility analysis by a suitably qualified and experienced piping designer to determine the requirements for any expansion joints, variable rate and constant effort spring hangers, determine the needs for guides, end stops, anchors and other types of supports. Critical lines may include but are not necessarily limited to:

- Metallic or FRP/GRP Lines attached to sensitive equipment (e.g. that cannot tolerate loads from external pipe connections).
- Metallic or FRP/GRP Critical process systems that require high reliability and safety.
- Metallic or FRP/GRP Lines operating at high temperatures such that expansion loads become significant or where there is a safety/reliability concern.
- Metallic or FRP/GRP Lines operating at high pressures where there is a safety/reliability concern.
- Metallic or FRP/GRP Lines containing toxic material.

- Lines subject to slug flow, flow induced vibration, cyclic conditions or steam out conditions.
- Relief lines from relief valves and bursting discs.
- Lines with proprietary expansion joints and spring hanger supports that require sizing and specification.

The engineer shall determine by risk assessment, professional judgement or other means, which lines require pipe stress analysis on a particular project.

Pipe stress analysis, where required, should be in accordance with ASME B31.3. using CAESAR II software.

In general, piping flexibility should be achieved by the use of piping offsets and expansion loops whenever possible. Expansion joints should be avoided unless absolutely necessary, particularly metallic expansion joints which normally have a finite fatigue life much shorter than the design life of the pipe system and may be a source of unreliability.

Metallic Piping

In addition to pressure design considerations, the designer shall consider piping flexibility and thermal expansion/contraction in the design of pipe supports.

In a simple two-anchor system of uniform pipe size the system may be considered sufficiently flexible when:

$D.Y/(L-U)^2 < 208$ [Reference AS 4041, Section 3.27.2.2]

Where D = outside diameter of pipe (mm)

Y = resultant displacement to be absorbed (mm)

L = developed length of minimum distance line between anchors (m)

U = length of straight line between joining anchors (m)

If the pipe system is not sufficiently flexible to pass the above test then a formal pipe stress analysis shall be carried out.

Note that the above equation [AS 4041 3.27.2.2] is empirical and cannot be relied up to give conservative results and there is no assurance that the terminal reactions will be acceptably low on pump and vessel nozzles even if the equation is satisfied. Therefore the designer may need to exercise some judgement in determining which lines require a detailed pipe stress analysis. As a general guideline it is recommended that all chlorine, acid and caustic lines above DN80 size be analysed.

FRP/GRP (Fibre/Glass Reinforced Plastic or 'Fibreglass') Piping

In addition to pressure design considerations, the designer shall consider piping flexibility and thermal expansion/contraction in the design of pipe supports.

The elastic modulus of FRP/GRP materials is low compared with metallic piping and high local deformation may occur at relatively low stresses. The nature of these materials is that they fail rather than yield when local deformation occurs. Therefore, it is recommended that a formal pipe stress analysis be carried out on all FRP/GRP Pipework in accordance with BS 7159 and ANSI B31.3 using CAESAR II software.

Polyethylene Pipework

Due to the low elastic modulus of this material the pipework is inherently very flexible in most circumstances and a formal pipe stress analysis is rarely required. However, due to the relatively high coefficient of expansion with PE materials, the designer shall make provision in the design of pipe support systems for the relatively large displacements that occur due to temperature expansion.

Wind and Seismic Loads

Occasional loads (wind and earthquake) for use in pipe stress analyses shall be treated as follows:

- Wind loads shall be applied as a uniform air pressure acting on the pipe in any of 4 horizontal directions. The wind pressure is calculated in accordance with AS 1170.2.
- Horizontal seismic load is applied as a uniform acceleration of the piping in any of 4 directions plus 30% of this acceleration acting perpendicular to this direction plus 50% of this acceleration acting vertically. The acceleration is calculated in accordance with AS 1170.4.
- Pipe stresses due to wind and seismic are considered separately and superimposed on the sustained load cases at normal operating conditions.
- Occasional stresses are limited to 133% of the basic allowable stress for the piping material.

Equipment Connections

Pipe reactions on all equipment connections (e.g. pump and vessel nozzles) shall be minimised wherever possible.

The drawings for piping connecting to rotating equipment shall include the following:

- Piping shall be installed up to a break point between the nearest pipe support and equipment.
- The remainder of the pipe shall be indicated on the drawings as site fitted so as to avoid any external loading on the equipment connections.

External loadings from piping applied to pump nozzles and other mechanical equipment shall be agreed with the Manufacturer and should be based on the maximum operating temperature of the line.

Where more specific information is not available from the designer, external loads from piping applied to pressure vessel nozzles DN80 and larger shall be limited to:

Forces (P, V_c, V_L): DN (mm) x 40 Newtons

Moments (M_T, M_C, M_L): DN (mm) x 60 Nm

The directions of forces and moments shall be as per Welding Research Council Bulletin 107 (WRC107). All forces and moments shall be assumed to act simultaneously and apply to the nozzle/vessel interface. The stresses due to the applied loads shall be summed in accordance with WRC107 and the resultant stress summations shall be shown to pass ASME VIII Division 2, Mandatory Appendix 4 Design Based on Stress Analysis.

The use of flexible joints (in particular metallic bellows) shall be avoided wherever possible. However, for pump suction nozzles on FRP/GRP tanks and vessels where the pipe spool is relatively short and inflexible it is recommended that a flexible expansion joint be used to avoid placing excessive loads on FRP/GRP nozzles. A sliding pump base may be considered wherever an expansion joint is impractical.

6.6 Flange Guards

Colour indicating, draw-string cloth type flange guards are recommended for all sulphuric acid, hydrochloric acid and caustic lines around flanges and valves.

For lines where fluid temperatures exceed 60 deg C, flange guards are also recommended to avoid scalding from flange leakage. However, these do not need to be colour indicating. Spray shields (e.g. from Advanced Product Systems Inc.) may be used here in lieu of flange guards.

6.7 Pipe Supports

It is recommended that all pipe supports and hangers for all piping larger than DN40 shall be designed, specified and detailed on the drawings and not left to the discretion of the installation contractor. Piping isometric drawings should be prepared for all lines larger than DN40, showing pipe support provisions. Pipe lines DN40 and smaller may be field run following the routing shown on the piping general arrangement drawings as closely as possible, with pipe support provisions determined by the installation contractor.

Wherever possible, to assist with availability and standardisation, proprietary pipe support components shall be selected from the Binder Engineering or Lisega product range.

All long runs of polyethylene (PE) pipework shall be continuously supported with cable ladder. Long horizontal runs of PE pipework shall be installed in accordance with the “snaking” requirements specified by the manufacturer.

Wherever a detailed pipe stress analysis is not considered necessary, pipe support spans for FRP/GRP lines shall be carefully designed to comply with the manufacturer’s maximum deflection criteria and sound engineering practice.

Wherever a detailed pipe stress analysis is not considered necessary, pipe support spans for carbon steel lines shall comply with Proteus Piping Standard Drawings and sound engineering practice.

6.8 Water Hammer

On long distance water lines excessive overpressures and pressure transients may be generated following power failure, pump stoppage, rapid opening and closing of valves and from the action of non-return valves.

Valves with geared operators or actuators with slow opening/closing times are recommended to make pipelines inherently safe against water hammer. The use of actuated valves rather than non-return valves for duty/standby pump pairs is also recommended (non-return valves can contribute to water hammer problems).

For any pipeline that cannot easily be made inherently safe against water hammer overpressure, some means must be provided of reducing such occasional overpressure below 150% of the pipeline design pressure capacity. Such means may include but are not necessarily limited to relief valves, vacuum breaker valves, surge towers and surge anticipation valves.

6.9 Pressure Relief Systems

Wherever practical, piping systems should be designed to avoid the need for pressure relief systems and be designed to withstand maximum shut-off pressure under all circumstances.

Where positive displacement pumps are installed, a PRV shall be included between the pump outlet and the first downstream valve.

Isolation valves between a PRV and the protected line are not permitted under any circumstances. However, in the PRV may be protected from continuous exposure to the fluid by a sacrificial bursting disc. In highly corrosive service this allows the PRV to be made from readily available materials.

Relief valves and/or bursting discs as well as their discharge lines shall be sized to discharge the full flow necessary to prevent overpressure of the protected line and so that the maximum pressure in any component does not exceed by more than the percentage indicated in AS 4041, Section 7.0.

Discharge lines from pressure relief devices shall be run along the shortest, most direct possible route to the point of release. Common discharge manifolds for pressure relief systems discharging to atmosphere shall be avoided wherever practical. Where it is necessary to have common discharge lines the back-pressure (from discharge line pressure loss) shall be calculated and taken into account when sizing the PRV.

6.10 Isolation Provisions

As a minimum, piping systems shall be designed with isolation provisions as follows:

- For ANSI B31.3 Category ‘M’ Service and Normal Service piping (Class 600 and higher, double block isolation valving with a downstream drop-out spool.
- For ANSI B31.3 Category Normal Service piping, class 150 and class 300, a valve and downstream spectacle blind.

- For ANSI B31.3 Category 'D' Service, a valve and downstream spectacle blind.

- General equipment shall have provision for isolation of piping to each equipment connection by means of valving and/or blinds as determined by service conditions.

Most sites require "double block and bleed" isolation on lines containing hazardous or dangerous fluids (e.g. acids, alkali, explosive gases). The project specific design criteria shall specify any special isolation provisions required on particular projects.

6.11 Provisions for Testing and Flushing

Wherever practical, sufficient valves and/or spectacle blinds shall be included in the design to allow for field hydro-testing of assembled pipe runs. Drain valves shall be included at the lowest point in every pipe run. Air bleed valves shall be provided at the highest point of any vertical loops.

6.12 Service Points

Adequate service points for high pressure air and service water shall be provided for general clean-up and operational purposes.

Service points shall generally be DN25 or DN40 lines with isolation ball valves and discharge directed downwards for safety. Service points shall generally be at handrail height and in convenient locations.

If required, blowdown facilities shall be provided for removal of moisture and contaminants from service supplies.

Where required, "snake" system vacuum pick-up points shall be provided for evacuation of dangerous gases and vapours from enclosed spaces.

6.13 Pressure Indication

All services shall be fitted with pressure indication at the source or equipment discharges and flow indication as required for process control.

6.14 Piping Identification and Marking

Line service designations shall be provided by standard pipe markers located at discrete intervals along the route of the line, in accordance with AS 1345, typical for all plant services and process lines.

The colour of the finish coat on painted carbon steel pipework and the pigment used in the surface layers of FRP/GRP pipework shall be in accordance with the colour coding requirements of AS 1345 to indicate the line contents. Alternatively, coloured bands may be used.

6.15 Operability and Maintainability

For operability and maintainability of piping, valve, tank and vessel systems, appropriate provisions shall be incorporated into the design in accordance with sound engineering practice and operating experience at similar plants. It is anticipated that such issues will be further identified at the HAZOP stage of the project and appropriate provisions agreed for inclusion in the design.

The following are typical items that often must be considered. However the list is not exhaustive:

- Routing of pipework must be based on safety, economics, ease of maintenance and operation and construction requirements. Furthermore the alignment of equipment and routing of pipework should offer a tidy, organised appearance.

- Major lines should be carried on overhead pipeways. In certain instances lines may be buried provided they are adequately protected.

- Spacing of lines should be such that expanding/contracting lines (including insulation) will not clash with existing lines, structures or other equipment during heat up or cool down cycles.

- Avoid dead ends in pipework, especially where solids may accumulate, fluids congeal or vapours form corrosive condensate.

- Lines should be free draining. In the case of slurry lines and viscous fluids, horizontal runs may need to be continuous sloped.

- Valves and instruments should be located so that they are readily accessible and have adequate clearance for operation of valve handles and handwheels. However the valve stem, handwheel or handle shall not protrude into accessways or operating areas..

- Depending on the type of valve, the pressure class and the expected frequency of operation, valves above a certain size may be difficult to operate manually and therefore require geared operators or powered actuators. In most common applications, valve sizes DN200 and above are expected to require geared manual operators or powered actuators.

- Sample connections, vents and drains, line strainers and other features that require operator and/or maintenance access should be located so that they are readily accessible.

6.16 General Safety and Access Criteria

Overhead piping shall allow a minimum of 2,200 mm vertical clearance over walkways and access ways.

Horizontal clearances for operator access shall be minimum 600 mm. However, 500 mm minimum is acceptable when only maintenance access is required.

Caustic and acid lines shall not be routed over walkways and access ways.