

0718P YANMAR GAS POWERED CHILLERS

Branded worksection

This branded worksection *Template* has been developed by NATSPEC in conjunction with **YANMAR** (the product partner) and may be used whilst the Product Partner is licensed to distribute it. The copyright remains with NATSPEC. As with all NATSPEC worksections, it is the responsibility of the user to make sure it is completed appropriately for the project. The user should also review its applicability for local conditions and regulations. Check www.natspec.com.au for the latest updated version.

Worksection abstract

This branded worksection *Template* is applicable to YANMAR gas powered, air cooled, scroll compressor chillers. It includes YANMAR chillers with heat pump and heat pump hot water recovery options.

Guidance text

All text within these boxes is provided as guidance for developing this worksection and should not form part of the final specification. This *Guidance* text may be hidden or deleted from the document using the NATSPEC Toolbar or the hidden text *Hide* and *Delete* functions of your word processing system. For additional information visit FAQs at www.natspec.com.au.

Optional style text

Text in this font (blue with a grey background) covers items specified less frequently. It is provided for incorporation into *Normal* style text where it is applicable to a project.

Related material located elsewhere in NATSPEC

Related material may be found in other worksections. See for example:

- *0716 Chillers – centrifugal.*
- *0717 Chillers – water cooled screw.*
- *0718 Chillers – air cooled screw and scroll.*
- *0719 Chillers – absorption.*
- *0721p YANMAR gas powered air conditioning.*
- *0773 Building management systems.*
- *0931p YANMAR gas powered micro cogeneration.*

Material not provided by YANMAR

This branded worksection *Template* includes generic material which may not be provided by the Product Partner.

Documenting this and related work

You may document this and related work as follows:

- Show access for inspection maintenance and removal of components on the drawings. Consult YANMAR documentation for recommendations. For large chillers consider how motors and compressors are to be lifted if they are removed.
- Detail noise and vibration isolation.
- Detail ventilation to AS/NZS 5149.1, AS/NZS 5149.2 and AS/NZS 5149.3. Refrigerant alarms are dealt with in **EXECUTION, INSTALLATION, Safety provisions**. Coordinate with *0771 Automatic controls* which also includes refrigerant sensors.
- Document the BMS interface including points monitored and protocol (e.g. ANSI/ASHRAE 135 (BACnet). See **PRODUCTS, CONTROLS AND ELECTRICAL**.
- Consider pump-out details, e.g. is it to be factory mounted on the chiller set, external to liquid cooler and condenser, or shown on the drawings. One pump-out unit can serve several chiller sets.
- This worksection contains text, including *Optional* text, which may be adapted for use in design and construct projects. See NATSPEC TECHreport TR 03 for information on specifying Design and Construct for mechanical services.

The *Normal* style text of this worksection may refer to items as being documented elsewhere in the contract documentation. Make sure they are documented.

Specifying ESD

The following may be specified by retaining default text:

- Gas powered chillers offer lower overall greenhouse gas emissions compared to electrically powered equipment supplied from fossil fuelled power stations.
- Capacity control to exclude energy wasting part load control.

The following may be specified using included options:

- High energy efficiency chillers for reducing operating costs and greenhouse gas emissions using this worksection as a framework.

- YANMAR standard options: heat pump function and heat pump hot water recovery options.
- YANMAR condenser coil corrosion protection for aggressive environments.
- Provisions to reduce transmitted noise and vibration.
- Durable water side components.

Refer to the NATSPEC TECHreport TR 01 on specifying ESD.

1 GENERAL

YANMAR's Energy Systems division began operation in 1984, and today has installed more than 375,000 air conditioning, chiller and cogeneration systems worldwide. Using a YANMAR-designed, lean-burn Gas Engine, which was developed from the company's world-class diesel engine technology, these environmentally friendly systems are designed for reliability, efficiency, energy conservation, comfort and long-term savings.

1.1 RESPONSIBILITIES

General

Requirement: Provide YANMAR gas powered, air cooled, scroll compressor chillers, as documented.

The Yanmar gas powered heat pump or heat pump hot water modular chiller systems provide capacity control from 10 to 100%.

Documented is defined in *0171 General requirements* as meaning contained in the contract documents.

DESIGN

The following may be used to prepare a design clause for contractor designed systems. Do not repeat design and documentation items required in **SUBMISSIONS**. Responsibilities for design coordination may need to be detailed also.

The *Optional* text in this clause may be used by changing to *Normal* style text, when the contractor is to design and select the chillers. Use *0701 Mechanical systems* to describe design parameters for mechanical systems, as a whole, including the basis for calculating the total chiller capacity.

General

Requirement: Design chillers, as documented.

Chiller selection

Selection parameters included in the **SELECTIONS** schedules should not be repeated here. The schedules' *Guidance* includes suggestions for modification to suit design and construct projects.

General: Select chillers so that the combined net refrigerating capacity at full load of all chillers is not less than the total cooling load determined in conformance with *0701 Mechanical systems*.

Use the **Gas powered chiller schedule** to define the number of chillers and the capacity split between them.

Chiller design, application and calculations

Standards: Conform to the recommendations of one or more of the following:

- AIRAH Design Application Manuals.
- ASHRAE Handbooks.
- CIBSE Guides.

Method of calculation: Manual or software that employs the data and methods in the applicable standard.

Documentation

This is a partial list of items only. Edit to suit the project. Drawings relating to whole systems should be included in *0701 Mechanical systems*.

Drawings: Show the following on the drawings:

- Detail noise, vibration isolation and ventilation.
- Chiller configuration.
- Chiller circuiting.
- BMS interface.
- For large chillers show how motors and compressors are to be lifted, if they are removed.
- Power supply drawings and starting arrangements.
- For air cooled chillers, show cooling air arrangements and measures to prevent recirculation.
- Sound attenuation or louvres.

- Ventilation and refrigerant alarms to AS/NZS 5149.1, AS/NZS 5149.2 and AS/NZS 5149.3.
- [complete/delete]

1.2 COMPANY CONTACTS

YANMAR technical contacts

Website: www.yanmarenergy.com.au/contact.html

1.3 CROSS REFERENCES

General

Requirement: Conform to the following:

- *0171 General requirements.*

0171 General requirements contains umbrella requirements for all building and services worksections.

List the worksections cross referenced by this worksection. *0171 General requirements* references the *018 Common requirements* subgroup of worksections. It is not necessary to repeat them here. However, you may also wish to direct the contractor to other worksections where there may be work that is closely associated with this work.

NATSPEC uses generic worksection titles, whether or not there are branded equivalents. If you use a branded worksection, change the cross reference here.

- *0701 Mechanical systems.*

0701 Mechanical systems deals with matters common to more than one Mechanical worksection.

- *0752 Mechanical piping insulation.*
- *0771 Automatic controls.*
- *0791 Mechanical commissioning.*
- *0792 Mechanical maintenance.*

1.4 STANDARDS

General

Chiller performance rating: To EN 16905-1 and ANSI Z21.40.4.

Chiller testing: To EN 16905-1 and ANSI Z21.40.4.

Microbial control: To AS/NZS 3666.1 as required by the NCC and the recommendations of SA/SNZ HB 32.

Refer to NATSPEC TECHnote DES 022 for information on microbial control.

Refrigeration systems: To AS/NZS 5149.1, AS/NZS 5149.2, AS/NZS 5149.3 and AS/NZS 5149.4.

AS/NZS 5149.1, AS/NZS 5149.2, AS/NZS 5149.3 and AS/NZS 5149.4 deal with safety and environmental aspects of refrigeration systems. They are based on the corresponding ISO 5149 series standards but with Australian amendments including a performance option in Appendix ZZ of each part of the standard.

See NATSPEC TECHnote PRO 007 on refrigerant options.

Pressure vessels: To AS 1210.

1.5 SUBMISSIONS

Certification

Energy and performance: Submit YANMAR certification for testing of the following for each chiller:

- Ratings to EN 16905-1 or ANSI Z21.40.4.

Products and materials

Product data: Provide the following:

- YANMAR rated performance data for the chillers offered.
- Weights including loading diagrams.
- Details of facilities and services required for the chillers offered but not documented.
- Details of accessories and features provided with the chillers offered but not documented.
- Gas requirements for the chillers.
- Electrical requirements for the chillers.
- Wiring diagrams.
- Evidence of conformance to AS/NZS 5149.1, AS/NZS 5149.2 and AS 1210.

In addition, for noise critical situations include certified sound power levels.

2 PRODUCTS

2.1 GENERAL

Product substitution

Other products: Conform to PRODUCTS, **GENERAL, Substitutions** in *0171 General requirements*.

The *0171 General requirements* clause sets out the submissions required if the contractor proposes alternative products. Refer also to NATSPEC TECHnote GEN 006 for more information on proprietary specification.

Performance rating

Standard: To EN 16905-1 or ANSI Z21.40.4.

If the standard tolerances are not adequate, specify an adjusted minimum performance.

Structure/enclosure

Air cooled chillers: Provide weatherproof sheet metal enclosures for equipment requiring weather protection.

Integrated lifting facilities

Water box handling facilities: If documented, provide integrated lifting facilities on the chiller to permit easy removal of the water box covers.

Consider lifting generally, e.g. how will other heavy items, like motors, be removed in confined plant rooms.

Product identification

General: marked to show the following:

- Manufacturer's identification.
- Model number.
- Serial number.
- Refrigerant type.
- Refrigerant charge.
- Water side pressure drop and design water flow rates.

Rating plates: Required.

Refrigerant: Show the type of refrigerant at the charging point and on indicator panels.

Refrigerants

Requirement: Provide R-410A refrigerant.

R-410A is listed Safety Group A1 AS/NZS ISO 817, that is, R-410A has low toxicity and no flame propagation. Refrigerants not listed in AS/NZS ISO 817 are not covered by AS/NZS 5149.1, AS/NZS 5149.2, AS/NZS 5149.3 or AS/NZS 5149.4 so should be avoided.

According to AS/NZS 5149.1, R-410A has an Ozone Depletion Potential of 0 and a Global Warming Potential of 2090. Although Global Warming Potential is higher than some alternatives, it is compensated for by the lower overall greenhouse gas emissions of gas powered plant compared to electrically powered plant supplied from fossil fuelled power stations.

Safety Group, Ozone Depletion Potential and Global Warming Potential for refrigerants are listed in AS/NZS 5149.1 Annex B. See NATSPEC TECHnote PRO 007 on refrigerant options.

2.2 GAS POWERED CHILLERS

General

Requirement: Provide YANMAR VRF gas powered chillers consisting of air cooled refrigerant condensers, gas powered engine driven scroll compressors, chilled water heat exchanger and associated piping and electrical connections, and engine and refrigeration controls, all mounted within the chiller enclosure.

Operating conditions

Requirement: Provide equipment that operates without excessive head pressure, unstable operation or icing within ambient temperature ranges as follows:

- Cooling: 0°C to 46°C. If cooling is required in winter and the winter outdoor ambient temperature is below 10°C, provide YANMAR air guard.
- Heating: -10°C to +26°C.

Amend upper and lower temperature to suit the actual conditions of the project site, if necessary. Cooling operation to -10°C is possible with optional YANMAR air guard. Check with YANMAR that proposed equipment is suitable for operation under the site conditions.

Type

Requirement: Provide gas powered chillers as documented and as follows:

- Heat pump: YANMAR ECWP-J series.

YANMAR heat pump chillers provide cooling or heating water via reverse cycle function. i.e. either heating or cooling but not both.

- Heat pump with hot water recovery: YANMAR ECWP-JH.

YANMAR heat pump with hot water recovery chillers provide cooling or heating water via reverse cycle function plus heat recovery from the engine in cooling mode.

Heat recovery and hot water units: Provide automatically controlled rejection of excess heat to condenser or engine radiator.

Heat pump with hot water recovery

Heat exchanger: Provide a type 316 stainless steel ASTM A240/A240M heat exchanger to transfer heat from the engine cooling system to heat recovery water.

Heat recovery is available at 70°C when operating in cooling mode but not reverse cycle heating. If using heat recovery for domestic hot water heating, conform to the PCA - NCC Volume 3 -

Plumbing Code of Australia.

System controls

Requirement: Provide an integrated automatic control system to operate the engine and refrigeration system safely and efficiently to achieve the documented performance and functions.

2.3 ENGINE DRIVEN COMPRESSORS**Engine**

Requirement: Provide YANMAR spark ignition gas engine driving two compressors.

Engine maintenance interval: Designed for maintenance at no greater frequency than 10,000 hours or 5 years, whichever comes first.

Gas type: Natural gas or LPG, as documented.

Gas train: Provide a gas train to AS/NZS 5601.1 for a type B appliance.

Defrost: Achieve defrost using engine waste heat not reverse cycle defrosting. Provide a plate heat exchanger to transfer engine heat to the refrigerant to raise system operating pressures and reduce defrost cycle time.

Compressors

Type: Open drive scroll compressors with flexible ribbed belt drive.

Standard: To UL 984.

Accessories: Provide the following:

Suction and discharge service valves are often not supplied for smaller units. Delete if not required.

- Packed and capped backseating refrigerant suction and discharge service valves.
- Access fittings for evacuation and refrigerant charging.
- Fine mesh suction filters.

Lubrication: Provide oil separator, pump or pressure differential oil system, filter and oil cooler.

Capacity control: Vary system capacity by varying engine speed. Provide electronic expansion valves and variable speed d.c. condenser fan motors.

Crankcase heaters: Provide integral positive temperature coefficient type crankcase heaters if required for safe compressor operation.

2.4 PLATE EVAPORATORS**General**

Requirement: Provide single pass, counterflow, brazed plate heat exchangers, constructed from type 316 stainless steel to ASTM A240/A240M and including refrigerant circuits, water drain and vent connections, insulation, and necessary valves and fittings.

Accessories

Water flow and return connections: RC1 tapered thread. Provide matching flexible connections.

Shipping protection: Fit blank companion flanges, bolts and gaskets or removable plugs or caps.

Drain connections: Minimum DN 20 screwed connection with valve at the lowest point. Arrange to permit complete drainage of water from the liquid cooler.

Vent connections: Minimum DN 10 screwed connection with valve. Extend valve clear of insulation.

Thermometer pockets: Provide at water inlet and outlet.

Surface temperature sensor: Provide a temperature sensor fixed to the surface of the heat exchanger for freeze protection.

Water side pressure drop test sockets: Factory test and stamp heat exchanger, or provide metal tag, stating pressure drop at design water flow. Provide pressure drop test sockets at inlet and outlet, located to measure the same pressure drop as measured at the factory.

Other accessories might include level gauge, sight glass and refrigerant pressure relief. Pressure relief should be vented to the outside of the building. See EXECUTION, INSTALLATION, Refrigerant pressure relief.

2.5 LIQUID COOLER INSULATION**General**

Requirement: Insulate the liquid cooler and other surfaces that operate below ambient temperature. Select from the following, as documented in *0752 Mechanical piping insulation*:

- Cold system with metal sheathing.
- Elastomeric foam.

Elastomeric foam insulation is standard on most chillers. Some manufacturers may not be able to supply polystyrene with metal sheathing. Elastomeric insulation is, however, relatively easy to repair if damaged and may be available with metal sheathing as an option.

See NATSPEC TECHnote DES 003 for information on the fire hazard properties of insulation and pliable membranes.

Minimum insulation R-Value: 1.8 m².K/W.

This value exceeds common practice in Australia but is included to meet BCA J5.8 which requires this R-Value for vessels, heat exchangers and tanks containing chilled water. 1.8 m².K/W is comparable to NCC requirements for chilled water piping insulation. It requires 60 to 65 mm of polystyrene or elastomeric foam. Manufacturers typically provide only 19 mm of elastomeric foam.

See NATSPEC TECHnote DES 031 for information on specifying R-Values.

2.6 AIR COOLED CONDENSERS**General**

Type: Provide air cooled condensers consisting of condensing coil, fans and associated piping and electrical connections, mounted within an enclosure.

Performance rating: Rate to AHRI 460.

Coil mechanical protection: Provide protection against mechanical damage during transport and installation.

Coil grilles: Provide corrosion protected grilles to prevent birds and foreign matter entering the coils.

Depending on location and condenser configuration, the entry of foreign matter may be a problem. For such situations consider including this *Optional* text by changing to *Normal* style text.

Equipment enclosures

General: Provide enclosures, materials and finishes that are weatherproof and corrosion-resistant, assembled and reinforced to prevent flexing and drumming. Provide mounting legs for fixing to the support structure.

Materials: Metallic-coated steel ≥ 1.0 mm thick panels, fixed to ≥ 1.6 mm folded thick metallic-coated steel sheet frames and supports. Powder coat all interior and exterior surfaces to AS 4506.

Powder coating is specified as it is more durable than an enamel finish but is also more expensive.

Moisture retention: All parts free draining with no pockets in which condensation and/or rainwater may be retained.

Backflow prevention: Provide internal baffles to prevent backflow of air through idle fans when multiple fans are sequentially switched.

Access panels: Hinged doors or lift-off panels with camlock fasteners.

Condensing coils

Type: Plate fin.

Fin pitch: Not closer than 630 fins/m.

This is a common value for commercial chillers. A more conservative value is 550 fins/m.

Fin thickness: ≥ 0.12 mm.

0.12 mm is for 10 mm and 13 mm tube. Increase to 0.19 mm for 16 mm tube. Some manufacturers use 0.16 mm, generally, claiming a useful life to 15 to over 30 years.

Frames: Aluminium alloy to AS 2848.1, designation 5005, or metallic-coated steel sheet coating class Z275.

Tube material: Copper to AS/NZS 1571 or AS 1572 designation C12200.

Header material: Copper to AS 1432 or AS/NZS 1571.

Installation: Attach to the frame and provide baffle plates between coil frames and condenser enclosure, to prevent air bypass.

Subcooling coils: Provide a subcooling coil identical to the condensing coil, to achieve the designated degree of subcooling. Locate on the air entering side of, or next to, the condensing coil and in the same coil frame.

Subcooling coils: Delete if not required, may be integral with main coil.

Subcooling: ≥ 5 K.

Additional coil corrosion treatment

This is advisable for aggressive atmospheres such as marine environments. See NATSPEC TECHnote DES 010 for more information on corrosivity.

General: If the atmospheric corrosivity category documented in *0171 General requirements* is C3, C4, C5 or T, provide YANMAR Blygold proprietary coil corrosion protection coating as follows:

Consult Yanmar for suitability for Category C5 and T locations.

- Type: Factory applied coating resistant to dilute acids, dilute alkalis, solvents, inorganic salts and salt laden air.
- Application: Apply after coil fabrication.
- Performance: When tested to ASTM B117, show no sign of attack after 11000 hours in salt spray.

These treatments include aluminium impregnated polyurethane and phenolic coatings.

Condenser fans

General: Provide statically and dynamically balanced fans, with metallic-coated steel fan guards.

Impellers: Keyed to drive shafts by means of taper-lock fixing devices or taper keys.

Vibration isolation: Provide each fan with at least four anti-vibration mountings, selected to give an isolation efficiency not less than 95%.

Draw through fans: Provide fans and motor insulation selected for the temperature of the air leaving the coil.

Include maximum permissible noise levels in the **Gas powered chiller schedule**.

Propeller fans: Direct or belt driven, with aluminium or ultraviolet light resistant polypropylene blades.

Aerofoil bladed axial fans: Direct driven, high efficiency, with aluminium, ultraviolet light resistant polypropylene or glass fibre blades.

Propeller and axial fans are effectively alternatives. Delete the type not required or leave to contractor's selection.

Centrifugal fans: Rigidly construct fan and motor to form an integral assembly.

- Drives: Multi-speed wedge belt drive to AS 2784 with pulleys of machined cast iron construction with keyed or taperlock type centres.
- Casings and impellers: Metallic-coated steel.
- Shafts: Treat shafts with a solvent removable petroleum based protective coating designed for machinery shafts and parts.

Motors:

- Degree of protection: \geq IP54.

- Finish: Air drying enamel or powder coat.

Additional fan corrosion protection

The need for this will depend on location. Delete if not required or specify corrosion protected mild steel at lower capital cost.

General: If the atmospheric corrosivity category documented in *0171 General requirements* is C3,C4, C5 or T, provide the following additional corrosion protection:

- Casing and impeller: Powder coated finish.
- Fan shaft: Type 316 stainless steel to ASTM A240/A240M.
- Fan casing: Drain to waste with two 20 mm PVC-U drains.

Seek advice on suitability for Category C5 and T locations.

Control panel

Degree of protection: \geq IP44.

IP44 provides protection against ingress of objects up to 1 mm and water splashed against enclosure from any direction. It is standard on many air cooled condensers. Alternatively, IP54 provides protection against ingress of dust and water splashed against enclosure from any direction.

2.7 REFRIGERATION SYSTEM

General

Requirement: Design refrigeration systems for minimum refrigerant leakage potential.

Standards

General: To AS/NZS 5149.1, AS/NZS 5149.2 and AS/NZS 5149.3.

Accessories

General: Provide necessary refrigerant circuit accessories, including the following:

- Discharge muffler (internal or external type).
- Liquid line filter drier.
- Suction, discharge and oil pressure indication, either gauges or digital readout from transducers via the microprocessor based control module, as appropriate.

Liquid line solenoid valves can double up with expansion valves. Other accessories, which will depend on the size of chiller and type of compressor are:

- Isolation valves both sides of the filter drier.
- Liquid line solenoid valves.
- Refrigerant charging valve.

Chillers with multiple compressors: Provide at least 2 independent refrigeration circuits.

Reverse cycle units: Provide refrigerant reversing valve and an effective outdoor coil defrost facility that prevents room temperature dropping more than 2 K during defrost.

Make sure that the system selected will defrost under extreme ambient conditions. In NCC climate zones 1, 2 and 5 this should not be a problem but if the winter ambient temperature approaches freezing, YANMAR air guard should be provided otherwise defrost times will be long and low indoor temperatures may result unless suitable precautions are taken. Even in less extreme situations reverse cycle units may not be able to start heating under low outdoor ambient in the morning without YANMAR air guard.

2.8 CONTROLS AND ELECTRICAL

Controls

Type: Menu driven, stand alone, microprocessor based module.

Alternatively, hard wired and/or electronic controls may be documented.

Remote monitoring

Remote monitoring and reset may be required, e.g. load limit, cold water temperature. Consider the method of resetting after an alarm, e.g. local or remote.

Common alarm: Provide for a common alarm signal to be connected into a remote monitoring system.

Control panel

Requirement: Provide factory wired control panel for each chiller containing the following:

- Plug-in relays.
- Terminal strips numbered to correspond to wiring diagram.

- Starter and overload protection for each motor.
- Short circuit protection: Provide each compressor and each 3-phase motor with short circuit protection by one of the following:
 - . High rupture coefficient (HRC) fuses.
 - . Circuit breaker with interrupting capacity selected to suit the anticipated short circuit current.
 - . Starter contactor with manual reset thermal or magnetic overload.
- Provide automatic lead/lag changeover for units with multiple compressors.
- HRC fuse or circuit breaker short circuit protection for each crankcase heater (if fitted) and control circuit.
- Terminals for remote indication of run and fault conditions.
- Permanent, weatherproof, wiring diagram fixed on or next to the control panel.

Safety controls: Arrange so that tripping of one item does not shut down other items that are not directly dependent on its operation.

Isolating switch: Provide system isolator for each system.

Condenser head pressure control: If documented, provide electronic condenser fan speed control to maintain minimum condenser head pressure at all operating ambient conditions.

This may be required to prevent low pressure tripping if units are to operate in cooling mode under low outdoor ambient conditions.

Pump-down control: If documented, provide solenoid valve and automatic pump-down control.

Modular connected chillers

YANMAR chillers can be connected in modular sets of up to eight units.

Requirement: If multiple chillers are connected to form a modular system, provide YANMAR modular controls and conform to YANMAR's recommendations.

2.9 INDICATION

Scroll chillers

Requirement: Provide indication of the following:

- System on.
- Fault requiring manual reset.
- High and low pressure on each circuit.
- Oil pressure failure on each refrigeration circuit.
- Compressor contactor overload on each compressor.
- Number of capacity steps active.

Accessories: Provide the following:

- Lead/lag function and on/off control for multiple compressor chillers.

Lead/lag sequence reversing may be automatic or manual.

2.10 SAFETY CONTROLS

General

Other controls may include the following:

- Sequence controllers (to start the selected chiller for normal load operation and energise the leading chilled water pump).
- Manual selection switch (to allocate the leading and lagging chilled water pumps).
- External controls (remote run, fault indication, chilled water reset, and load limit).
- Time delay relay.
- By-pass system (to modulate one of the chilled water by-pass control valves so as to maintain constant flow through the water cooler).
- High condenser-pressure cutout, high oil-temperature cutout, high discharge temperature cutout, and low evaporator temperature control.

Requirement: Provide electrical interlocks to protect against the following:

- Chilled water low flow.
- Condenser fan motor overload.

- Engine overload.
- Oil pressure failure on refrigeration compressors.
- High and low pressure for compressors.
- Short cycling of compressors.
- Low chilled water temperature.
- Motor high temperature.

Consider including the type of motor protection, e.g. thermistor. See also 0784 Motors and starters.

- For motors ≥ 5.5 kW: phase failure, single phase, phase rotation and under voltage protection.
- Contactor weld-in.
- High bearing temperature.
- High oil temperature.
- Pre-lube before compressor start and post-lube during compressor spin down.
- High refrigerant discharge temperature.

2.11 CAPACITY CONTROL

General

Remote monitoring and reset may be required, e.g. load limit, cold water temperature.

Head pressure control: Vary engine speed to control head pressure.

Scroll chillers

Operation: Control capacity by a combination of engine speed control and compressor switching.

Capacity controller: Provide a capacity controller which senses the return chilled water temperature and maintains it at the desired setting, and with the following characteristics:

- Electronic sensing of chilled water temperature, with adjustable set point.
- Full recycle to the start (fully unloaded) position on power failure or fault condition of the compressor, and suspension from operation until the respective run contactor has closed and the compressor has started in the unloaded state.
- For multiple compressors: Make sure faults in compressors do not prevent the step switch from loading other compressors.

For chillers with multiple compressors: Back-stepping facility on the controller, to prevent short cycling of the lag compressor.

Ensure relevant controls functions and valve are included in 0771 Automatic controls.

3 EXECUTION

3.1 OFF-SITE TESTING

General

Controls tests: Verify that chiller controls meet performance requirements. Verify the marked set points of instruments, gauges and switches, by measurement of the controlled medium. Record and rectify deviations.

Safety alarm circuits tests: Simulate each unsafe condition alarm.

Pressure tests: To AS/NZS 5149.2.

After factory testing the chiller should have holding refrigerant charge as a minimum standard. Loss of holding charge on installation indicates damage in transit or installation. Alternatively specify fully charged with refrigerant for factory assembled and tested units.

Pressurising: After testing, dehydrate, pressurise using dry nitrogen to ≥ 7 kPa, and seal.

3.2 INSTALLATION

General

Manufacturer's instructions: Install to YANMAR's instructions. Include completed YANMAR checklists in commissioning data.

Condition at start of commissioning: Report any damage or loss of refrigerant holding charge.

Components: Supply all necessary components, including but not limited to the following:

- Means of attachment to the structure.
- Anti-vibration mounting.
- Appropriate flexible connections.
- Trim and sealing around openings.
- Electrical connections.
- Drainage connections.
- Field connection of refrigerant lines in split systems.

Alignment: Install units level, plumb and to YANMAR's recommendations.

Fixing: Bolt units in place with minimum 4 anchors.

Arrangement: Provide clearance around units for condenser air flow and maintenance access. Make sure discharge air does not short-circuit to condenser intake.

Alternatively, adjust outdoor coil air entering temperature to compensate for elevated air temperature due to recirculation.

Plinths: If located on grassed or similar permeable surfaces, provide concrete plinths under chillers.

For plinths see 0171 General requirements. Preferably show plinths on the drawings. Consider security of outdoor equipment.

Refrigerant pressure relief

Consider specifying the type of pressure relief device. Rupture disks, by their nature, release the entire refrigerant charge whereas pressure relief valves normally stop discharging when the pressure drops to a safe value. Consequently, rupture disks are both wasteful and a source of pollution. Pressure relief valves may leak after discharge and so need replacement to prevent long term refrigerant loss.

For more information on refrigerant pressure relief systems, see ANSI/ASHRAE 15.

Standard: To AS/NZS 5149.2.

Requirement: If the chiller is installed inside a building, pipe refrigerant pressure relief devices to a safe location outside the building and as follows:

- Discharge point: To ANSI/ASHRAE 15.

AS/NZS 5149.2 requires that the refrigerant discharge to a safe place but is not specific about how this is to be achieved. Among other requirements, ANSI/ASHRAE 15 clause 9.7.8 mandates that discharges be:

- ≥ 4.57 m above adjoining ground level.
- ≥ 6.1 m from any window, ventilation opening, pedestrian walkway or exit in any building.
- Terminated in a manner that will prevent discharged refrigerant from being sprayed directly on personnel in the vicinity and prevent foreign material or debris from entering the discharge piping.

ANSI/ASHRAE 15 contains other safety requirements not included in AS/NZS 5149.2, for example means of escape from plant rooms and remote control of refrigeration plant.

- Material: Copper vent line from the pressure relief devices to atmosphere.
- Design: Take into account refrigerant volume, relief valve discharge rate and length of pipe.
- Flexibility: Provide a flexible piping connection at the safety relief valve and support pipework so no load is exerted on the valve assembly.
- Dirt leg: Install a dirt leg and sampling valve at the base of the vent pipe.
- Vermin protection: Provide a stainless steel mesh screen over the outlet to prevent insects entering the vent pipe outlet.

Safety provisions

Ventilation: To AS/NZS 5149.1, AS/NZS 5149.2 and AS/NZS 5149.3.

Machinery room alarms: To AS/NZS 5149.1 and AS/NZS 5149.3.

Alarm system: Provide vapour activated alarms to AS/NZS 5149.3.

Refrigerant sensors: Conform to 0771 Automatic controls.

Apart from warning of refrigerant loss, release of refrigerant can be hazardous because it can lead to suffocation due to oxygen displacement or have narcotic or cardiac sensitization effects.

Vibration isolation

General: Provide to each assembly at least four mountings, located to give uniform deflection under the applied load.

Isolation efficiency: $\geq 90\%$.

Chillers mounted on concrete slabs: Mount on neoprene waffle pads.

Chillers mounted on steel structures: Mount on YANMAR YGAS850J1 vibration isolators.

Engine exhaust

Requirement: Provide a flexible connection at the chiller and route to a safe location, to YANMAR's recommendations.

e.g. to discharge away from air intakes and trafficable areas.

Material: Type 316 stainless steel to ASTM A240/A240M.

Outdoor unit within 1.5 m of openable window or air intake: Connect exhaust with a YANMAR adaptor to an external SUS exhaust system no longer than 10 m and no more than 4 bends.

Drains: Provide drains to YANMAR recommendations in DN 20 PVC-u and pipe to waste for the following:

- Exhaust condensate neutraliser connection.
- Engine exhaust.

Modular chiller arrangements

Control: If chillers are installed in a multiple chiller, modular arrangement, control water flow by chiller signal drive open, drive closed pressure independent external control valves, to YANMAR's recommendations.

Pressure switch: Install the YANMAR supplied pressure differential switch across supply and return connections to validate water flow directly to each chiller.

3.3 COMMISSIONING

For information on the commissioning process refer to NATSPEC TECHnote GEN 010 and NATSPEC TECHnote GEN 020. Consider using *0127 Commissioning – information* and *0164 Commissioning*.

Require site tests if production tests are not available. Specify type of artificial load, e.g. manual operation of conditioner heater banks, or increase the outside air load.

General

Requirement: In addition to the requirements of *0791 Mechanical commissioning*, conform to YANMAR's recommendations. Record results.

Operational check

General: Conform to YANMAR's recommendations. Check operation of the chiller system including auxiliary equipment and control systems. After starting up, adjust and calibrate the chiller system.

Safety controls: Test each safety control and facility by simulating the unsafe condition that the control is intended to protect against.

Commissioning

General: Commission the chiller system under the supervision of YANMAR's representative. Complete the YANMAR commissioning checklist and include a copy, signed by YANMAR's representative, in the maintenance manuals.

Electrical testing of switchboards: If required, specify in *0781 Mechanical electrical*.

Noise testing: If required, specify in *0791 Mechanical commissioning*.

3.4 MAINTENANCE

General

Chillers: In addition to the requirements of *0792 Mechanical maintenance*, conform to YANMAR's recommendations. Record results.

Engine: Provide YANMAR approved maintenance at intervals recommended by YANMAR.

4 SELECTIONS

Schedules are a way of documenting a selection of proprietary or generic products or systems by their properties. Indicate their locations here and/or on the drawings. Refer to NATSPEC TECHnote GEN 024 for guidance on using and editing schedules.

4.1 CHILLERS

Gas powered chiller schedule

Property	CH1	CH2	CH3
Chiller: Type			

Property	CH1	CH2	CH3
Chiller: Gas type			
Chiller: Modular connection			
Chiller: Net refrigerating capacity at full load (kW(r))			
Chiller: Minimum part load capacity (kW(r))			
Chiller: Minimum heat recovery heating capacity (kW)			
Chiller: Minimum hot water recovery heating capacity (kW)			
Chilled water: Flow rate (L/s)			
Chilled water: Entering temperature (°C)			
Chilled water: Leaving temperature (°C)			
Liquid cooler: Maximum water velocity (m/s)			
Liquid cooler: Maximum water pressure drop at design flow rate (kPa)			
Liquid cooler: Fouling factor (m ² K/kW)			
Condenser: Air flow rate (L/s)			
Condenser: Fan external static pressure (Pa)			
Condenser: Entering air dry bulb temperature (°C)			
Condenser: Maximum condensing temperature (°C)			
Condenser: Altitude above sea level			
Condenser: Condenser fan type			
Condenser: Fan construction			
Condenser: Maximum speed (rev/s)			
BMS interface protocol			
Factory performance testing			
Integrated lifting facilities for water box covers			
Maximum sound pressure level measured at 1.5 m horizontally at			

Property	CH1	CH2	CH3
any point around the chiller in free field at 100% capacity:			
- 63 Hz			
- 125 Hz			
- 250 Hz			
- 500 Hz			
- 1000 Hz			
- 2000 Hz			
- 4000 Hz			
- 8000 Hz			

CH1, CH2, CH3: These designate each instance or type or location of the item scheduled. Edit to align with the project's codes or tags.

Edit codes in the **Schedule** to match those on drawings.

Chiller

Chiller: Type: e.g Heat pump, Heat pump with hot water recovery.

Chiller gas type: e.g. Natural gas, LPG.

Modular connection: Insert Yes or No. Document the modular arrangement including the number of interconnected chillers. If none in the project, delete row.

Net refrigerating capacity at full load (kW(r)): This must agree with the value calculated from the chilled water flow rate and temperatures. Condenser and evaporator surface area per kW of refrigeration may be specified for conservative designs but are normally not required.

Minimum part load capacity (kW(r)): Alternatively, specify turndown, e.g. to 25%.

Minimum heat recovery heating capacity (kW): Delete if heat recovery not used.

Minimum hot water recovery heating capacity (kW): Delete if hot water recovery heating option not used.

Liquid cooler

Fouling factor (m²K/kW): Insert value if AHRI 551/591(SI) values are not suitable, otherwise delete row.

Condenser

Air flow rate (L/s): Include if relevant e.g. ducted discharge.

Fan external static pressure (Pa): For ducted discharge including the effect of additional acoustic treatment if applicable.

Altitude above sea level. (For non-sea level locations to enable manufacturer to de-rate condenser performance.)

Condenser fan type: e.g. propeller, axial flow aerofoil, centrifugal.

Fan construction: e.g. impeller materials. See *0731 Fans* for details.

Other

BMS interface protocol: Consider specifying protocol, e.g. ANSI/ASHRAE 135 (BACnet) to facilitate control system standardisation and flexibility but ensure that chiller suppliers and controls suppliers can provide what you specify. Make sure that this is coordinated with an equivalent requirement in *0771 Automatic controls*.

Factory performance testing: Insert either Required or Not required. This may have significant cost implications since it will be done overseas. See **SUBMISSIONS** for more *Guidance*.

Integrated lifting facilities for water box covers: Insert either Required or Not required.

Other issues to be considered for possible inclusion in the schedule

Liquid cooler:

- Insulation type and thickness.
- Fouling factor: The value use by AHRI 551/591(SI) for liquid coolers is 0.01761 m².K/kW based on ASHRAE research. A higher value may be required to suit project circumstances.
- Minimum water side working pressure (kPa) if the pressure at the chiller exceeds standard manufacturer's values (e.g. chiller located in a basement of a tall building). Select to suit operating conditions for, e.g. location of pump relative to chiller, height of building and AS 1210.

Adapting the Gas powered chiller schedule for design and construct projects

If the contractor is to calculate the required performance and to select the equipment, the **SELECTIONS** schedules can be used to set generic selection parameters. Note that the documents should include sufficient information for items to be determined by the contractor, for example from documented performance parameters and drawing information. For these items, insert suitable text, e.g. To the documented requirements. The **Gas powered chiller schedule** can then form the basis of the contractor's submissions with the text replaced by design values:

- Chiller: Net refrigerating capacity at full load (kW(r)): Specify the capacity split between the chillers in each column, e.g. 50% of the combined chiller capacity.
- Chilled water: Flow rate (L/s).
- Fan external static pressure (Pa).
- Maximum sound pressure level measured at 1.5 m horizontally at any point around the chiller in free field at 100% capacity (and following rows).

REFERENCED DOCUMENTS

The following documents are incorporated into this worksection by reference:

AS 1210	2010	Pressure vessels
AS 1432	2004	Copper tubes for plumbing, gasfitting and drainage applications
AS/NZS 1571	1995	Copper - Seamless tubes for airconditioning and refrigeration
AS 1572	1998	Copper and copper alloys - Seamless tubes for engineering purposes
AS 2784	2002	Endless wedge belt and V-belt drives
AS 2848		Aluminium and aluminium alloys - Compositions and designations
AS 2848.1	1998	Wrought products
AS/NZS 3666		Air-handling and water systems of buildings - Microbial control
AS/NZS 3666.1	2011	Design, installation and commissioning
AS 4506	2005	Metal finishing - Thermoset powder coatings
AS/NZS 5149		Refrigerating systems and heat pumps – Safety and environmental requirements.
AS/NZS 5149.1	2016	Definitions, classification and selection criteria (ISO 5149-1:2014, MOD)
AS/NZS 5149.2	2016	Design, construction, testing, marking and documentation (ISO 5149-2:2014, MOD)
AS/NZS 5149.3	2016	Installation site (ISO 5149-3:2014)
AS/NZS 5149.4	2016	Operations, maintenance, repair and recovery (ISO 5149-4:2014, MOD)
AS/NZS 5601		Gas installations
AS/NZS 5601.1	2013	General installations
SA/SNZ HB 32	1995	Control of microbial growth in air-handling and water systems of buildings
AHRI 460	2005	Performance rating of remote mechanical-draft air-cooled refrigerant condensers
ANSI Z21.40.4	1996	Performance testing and rating of gas-fired, air conditioning and heat pump appliances
ANSI/ASHRAE 15	2016	Safety Standard for Refrigeration Systems
ASTM A240/A240M	2018	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM B117	2018	Standard practice for operating salt spray (fog) apparatus
UL 984	1996	Standard for hermetic refrigerant motor-compressors
EN 16905		Gas-fired endothermic engine driven heat pumps
EN 16905-1	2017	Terms and conditions

The following documents are mentioned only in the **Guidance** text:

AS/NZS ISO 817	2016	Refrigerating systems - Refrigerant classification
BCA J5.8	2019	Energy efficiency - Air-conditioning and ventilation systems - Pipework insulation
NATSPEC DES 003	2006	Fire hazard properties of insulation and pliable membranes
NATSPEC DES 010	2015	Atmospheric corrosivity categories for ferrous products
NATSPEC DES 022	2010	Microbial control
NATSPEC DES 031	2014	Specifying R-Values
NATSPEC GEN 006	2007	Product specifying and substitution
NATSPEC GEN 010	2009	Mechanical commissioning strategies
NATSPEC GEN 020	2018	Building commissioning
NATSPEC GEN 024	2015	Using NATSPEC selections schedules
NATSPEC PRO 007	2016	Refrigerant options
NATSPEC TR 01	2018	Specifying ESD
NATSPEC TR 03	2018	Specifying Design and Construct for Mechanical services
PCA	2019	National Construction Code Series Volume 3 - Plumbing Code of Australia
AHRI 551/591(SI)	2018	Performance rating of water chilling and heat pump water-heating packages using the vapor compression cycle
ANSI/ASHRAE 135	2016	BACnet: A data communication protocol for building automation and control networks
ISO 5149 series		Refrigeration systems and heat pumps - Safety and environmental requirements