



STEAM TURBINE CENTRIFUGAL LIQUID CHILLERS

INSTALLATION INSTRUCTIONS

Supersedes: 160.67-N1 (504)

Form 160.67-N1 (814)

MODEL YST UNITS MANUFACTURED BEFORE DECEMBER 2006 DESIGN LEVEL F



LD12189



Metric Conversions

Issue Date:
August 29, 2014



IMPORTANT!

READ BEFORE PROCEEDING!

GENERAL SAFETY GUIDELINES

This equipment is a relatively complicated apparatus. During installation, operation maintenance or service, individuals may be exposed to certain components or conditions including, but not limited to: refrigerants, materials under pressure, rotating components, and both high and low voltage. Each of these items has the potential, if misused or handled improperly, to cause bodily injury or death. It is the obligation and responsibility of operating/service personnel to identify and recognize these inherent hazards, protect themselves, and proceed safely in completing their tasks. Failure to comply with any of these requirements could result in serious damage to the equipment and the property in

which it is situated, as well as severe personal injury or death to themselves and people at the site.

This document is intended for use by owner-authorized operating/service personnel. It is expected that these individuals possess independent training that will enable them to perform their assigned tasks properly and safely. It is essential that, prior to performing any task on this equipment, this individual shall have read and understood this document and any referenced materials. This individual shall also be familiar with and comply with all applicable governmental standards and regulations pertaining to the task in question.

SAFETY SYMBOLS

The following symbols are used in this document to alert the reader to specific situations:



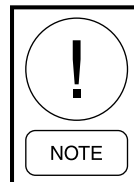
Indicates a possible hazardous situation which will result in death or serious injury if proper care is not taken.



Identifies a hazard which could lead to damage to the machine, damage to other equipment and/or environmental pollution if proper care is not taken or instructions are not followed.



Indicates a potentially hazardous situation which will result in possible injuries or damage to equipment if proper care is not taken.



Highlights additional information useful to the technician in completing the work being performed properly.



External wiring, unless specified as an optional connection in the manufacturer's product line, is not to be connected inside the control cabinet. Devices such as relays, switches, transducers and controls and any external wiring must not be installed inside the micro panel. All wiring must be in accordance with Johnson Controls' published specifications and must be performed only by a qualified electrician. Johnson Controls will NOT be responsible for damage/problems resulting from improper connections to the controls or application of improper control signals. Failure to follow this warning will void the manufacturer's warranty and cause serious damage to property or personal injury.

CHANGEABILITY OF THIS DOCUMENT

In complying with Johnson Controls' policy for continuous product improvement, the information contained in this document is subject to change without notice. Johnson Controls makes no commitment to update or provide current information automatically to the manual owner. Updated manuals, if applicable, can be obtained by contacting the nearest Johnson Controls Service office or accessing the Johnson Controls QuickLIT website at <http://cgproducts.johnsoncontrols.com>.

Operating/service personnel maintain responsibility for the applicability of these documents to the equipment. If there is any question regarding the applicability of

these documents, the technician should verify whether the equipment has been modified and if current literature is available from the owner of the equipment prior to performing any work on the chiller.

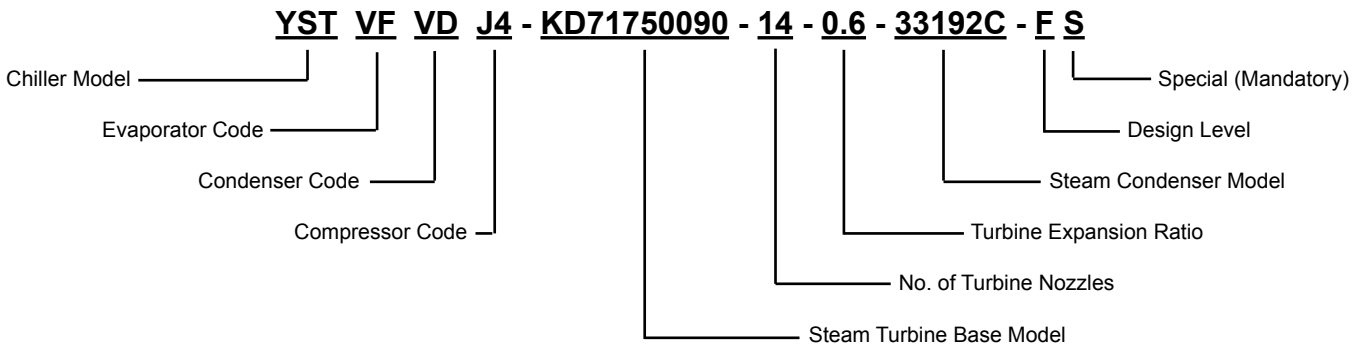
CHANGE BARS

Revisions made to this document are indicated with a line along the left or right hand column in the area the revision was made. These revisions are to technical information and any other changes in spelling, grammar or formatting are not included.

ASSOCIATED LITERATURE

MANUAL DESCRIPTION	FORM NUMBER
Operating & Maintenance	160.67-O2
Wiring Diagram - Model YST (Style F)	160.67-PW1
Wiring Diagram - Model YST (Style F) Auto Start	160.67-PW3
Renewal Parts - Unit	160.67-RP1
Renewal Parts - OptiView Control Center	160.67-RP2
Engineering Guide	160.67-EG1

NOMENCLATURE



ALLOWABLE COMPRESSOR/EVAPORATOR/ CONDENSER/TURBINE/AND STEAM CONDENSER COMBINATIONS

COMPRESSOR CODE	EVAPORATOR CODE	CONDENSER CODE	TURBINE MODEL	STEAM CONDENSER MODEL
H6, H7	GB, GC, GD	GB, GD	K2G51000090	29168A
			K2G51000125	29168B
J1	HF, HH	GB, GD	K2G71000090	29168C
			K2G71000125	29168D
J2	HF, HH	GB, GD HB, HD	KG81250090	31168B
			K2G71250125	31168C 31168D
J3	JF, JG, JH	JB, JD	KG81620090	35168B
			K2G71620125	35168C
			KD71620090	35168D
			KD71620125	
J4	TF, TG, TH	TB, TD	KD71620090	33192B
	VF, VH	VB, VD	KD71620125	33192C
	WF, WH	VB, VD	KD71750090	33192D
			KD71750125	

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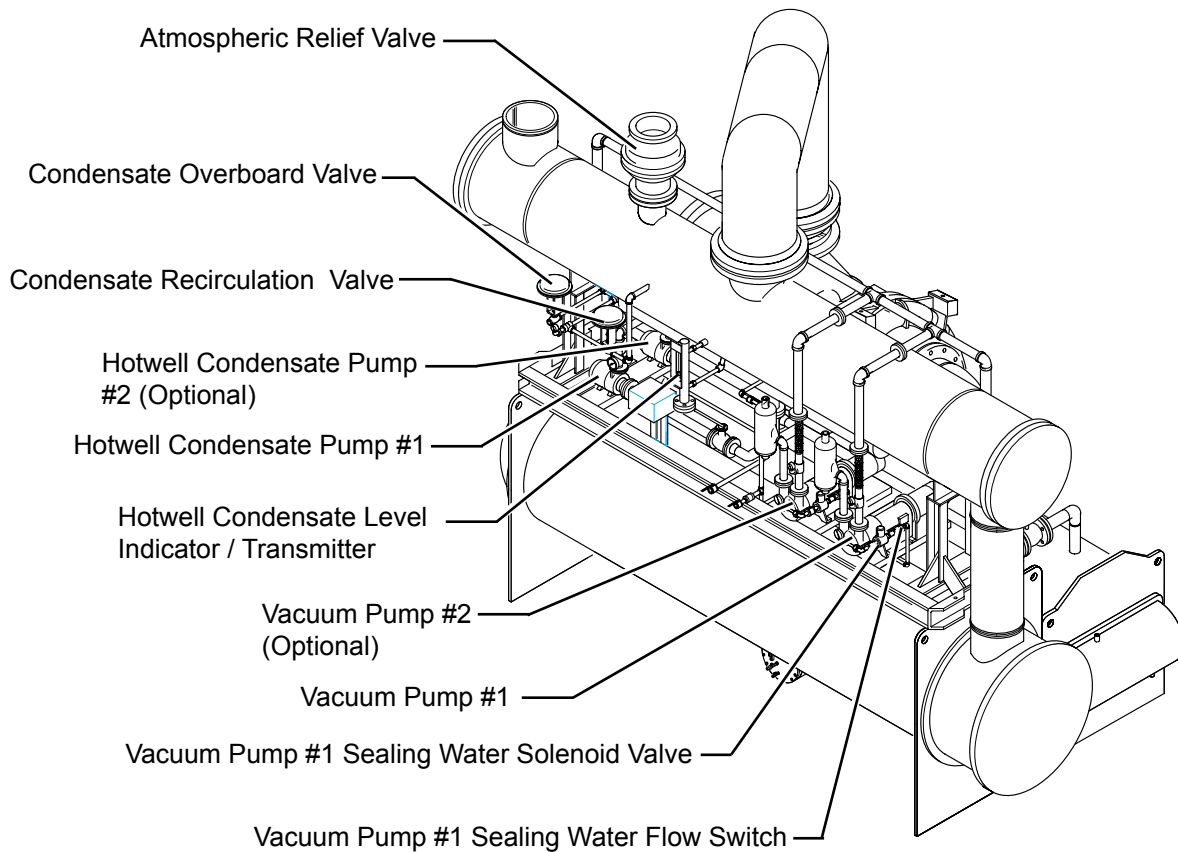
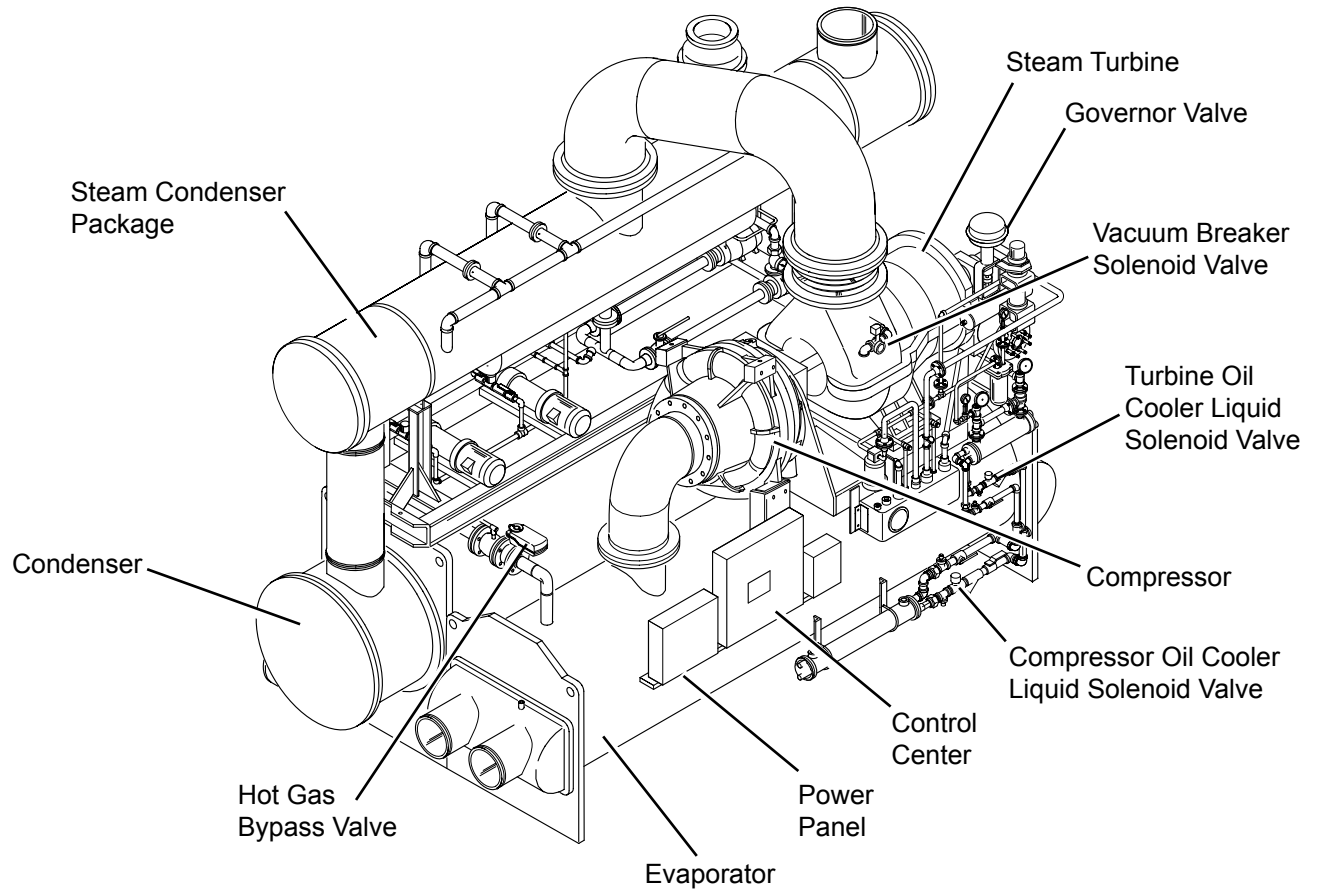


FIGURE 1 - MODEL YST CHILLER

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SECTION 1 - INTRODUCTION

GENERAL

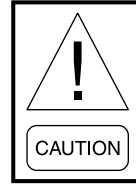
This instruction describes the installation of the Model YST Centrifugal Liquid Chiller Unit. This unit is completely factory-packaged including; the evaporator, refrigerant condenser, compressor, steam turbine, lubrication systems, power panel, control center, and all interconnecting unit piping and wiring. The steam condenser package is shipped separately and suitable for direct mounting onto the chiller or mounting along side the chiller. (Refrigerant and oil charges shipped separately unless optional refrigerant condenser isolation valves are ordered.)

Chillers can also be shipped dismantled when required by rigging conditions, but generally it is more economical to enlarge access openings to accommodate the factory assembled unit. Chillers shipped dismantled **MUST** be field assembled under the supervision of a Johnson Controls representative, but otherwise installation will be as described in this instruction.

FIELD ASSEMBLED UNITS ONLY

Use the reference instructions listed in the beginning of this manual in conjunction with this manual for more detailed installation instructions. This manual will be furnished with all units that are to be field assembled. Extra copies may be ordered from the Johnson Controls Publication Distribution Center.

The services of a Johnson Controls representative will be furnished to check the installation, supervise the initial start-up and operation of all chillers installed within Continental United States.



The Johnson Controls Warranty may be voided if the following restrictions are not adhered to:

- 1. No valves or connections should be opened under any circumstances because such action will result in loss of the factory nitrogen charge.*
- 2. Do not dismantle or open the chiller for any reason except under the supervision of a Johnson Controls representative.*
- 3. When units are shipped dismantled, notify the nearest Johnson Controls office in ample time for a Johnson Controls representative to supervise rigging the unit to its operating position and the assembly of components.*
- 4. Do not make final power supply connections to the power panel.*
- 5. Do not charge the compressor with oil.*
- 6. Do not charge the unit with refrigerant.*
- 7. Do not attempt to start the system.*
- 8. Do not run hot water (110°F / 43°C max) or steam through the evaporator or refrigerant condenser at any time.*

SHIPMENT

The chiller may be ordered and shipped in any of the following forms:

Form 1 – Factory Assembled Unit. (steam condenser package shipped separately) refrigerant and oil are factory charged.

1. The compressor/turbine driveline assembly mounted, with all necessary interconnecting piping assembled. OptiView™ Control Center is mounted on the unit. Complete unit factory leak tested, evacuated and charged with R-134A.
2. Miscellaneous material – Partial pre-fabricated steam exhaust piping and four (4) neoprene isolation pads.

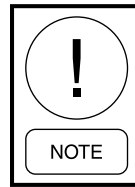
Form 2 – Factory Assembled Unit. (steam condenser package shipped separately.) Refrigerant and oil charges shipped separately.

1. The compressor/turbine driveline assembly mounted, with all necessary interconnecting piping assembled. OptiView™ Control Center is mounted on the unit. Complete unit factory leak tested, evacuated and charged with holding charge of nitrogen.
2. Miscellaneous material – Partial pre-fabricated steam exhaust piping and four (4) neoprene isolation pads.

Form 3 – The compressor/turbine driveline assembly is separate from the shells – Shipped as three major assemblies. Unit first factory assembled, refrigerant piped, wired and leak tested; then dismantled for shipment. The compressor/turbine driveline assembly is removed from the shells and skidded. Evaporator/Refrigerant Condenser is not skidded. The Steam Condenser package is shipped separately.

All wiring integral with compressor is left on it, and all conduit is left on shell. Turbine lube system/piping remains on the driveline skid. All openings on compressor, oil separator, and shells are closed and charged with dry nitrogen (2 to 3 PSIG) (14-21 kPa).

Miscellaneous packaging of control center, tubing, water temperature controls, wiring, oil, etc.; refrigerant charge shipped separately. Partial pre-fabricated steam exhaust piping and neoprene isolation pads are shipped loose.



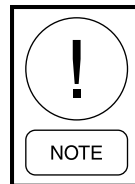
Units shipped dismantled MUST be re-assembled by, or under the supervision of, a Johnson Controls representative.

Form 7 – Split Shells – Shipped as four major assemblies. Unit first factory assembled, refrigerant piped, wired and leak tested; then dismantled for shipment. Compressor/turbine driveline assembly removed from shells and skidded. The Steam Condenser package is shipped separately.

Evaporator and refrigerant condenser shells are separated at tube sheets and are not skidded. Refrigerant lines between shells are flanged and capped, requiring no welding.

All wiring integral with compressor is left on it. All wiring harnesses on shells are removed. Turbine lube system/piping remains on driveline skid. All openings on compressor and shells are closed and charged with dry nitrogen (2 to 3 PSIG) (14-21 kPa).

Miscellaneous packaging of control center, tubing, water temperature controls, wiring, oil, etc; refrigerant charge shipped separately. Partial pre-fabricated steam exhaust piping and neoprene isolation pads are shipped loose.



Units shipped dismantled MUST be re-assembled by, or under the supervision of, a Johnson Controls representative.

When more than one chiller is involved, the major parts of each unit will be marked to prevent mixing of assemblies.

INSPECTION – DAMAGE – SHORTAGE

The unit shipment should be checked on arrival to see that all major pieces, boxes and crates are received. Each unit should be checked on the trailer or rail car when received, before unloading, for any visible signs of damage. Any damage or signs of possible damage must be reported to the transportation company immediately for their inspection.

JOHNSON CONTROLS WILL NOT BE RESPONSIBLE FOR ANY DAMAGE IN SHIPMENT OR AT JOB SITE OR LOSS OF PARTS. (Refer to Shipping Damage Claims, Form 50.15-NM)

When received at the job site all containers should be opened and contents checked against the packing list. Any material shortage should be reported to Johnson Controls immediately. (Refer to Shipping Damage Claims, Form 50.15-NM)

CHILLER DATA PLATE

A unit data plate is mounted on the control center assembly of each unit, giving unit model number; design working pressure; water passes; refrigerant charge; serial numbers; and connection diagrams.

LOCATION

Chillers are furnished with neoprene vibration isolator mounts for basement or ground level installations. Units may be located on upper floor levels providing the floor is capable of supporting the total unit operating weight. See *Figure 4 on page 14*.



Sufficient clearance to facilitate normal service and maintenance work must be provided all around and above the unit and particularly space provided at either end to permit cleaning or replacement of evaporator and refrigerant condenser tubes – see CLEARANCE. A doorway or other sufficiently large opening properly located may be used. The chiller should be located in an indoor location where temperatures range from 40°F to 110°F (4.4°C to 43.3°C).

RIGGING

The complete standard chiller is shipped without skids. (When optional skids are used it may be necessary to remove the skids so riggers skates can be used under the unit end sheets to reduce overall height.)

Each unit has four (4) lifting holes (two in each end) in the end sheets which should be used to lift the unit.

Care should be taken at all times during rigging and handling of the chiller to avoid damage to the unit and its external connections. Lift the unit only using spreader bars and the holes in the endsheets as shown in *Figure 2 on page 12*.



Do not lift the unit with slings around compressor or by means of eyebolts in the tapped holes of the compressor. Do not turn a unit on its side for rigging. Do not rig vertically without factory supplied vertical rigging option.



The chiller package and Steam Condenser package must be rigged separately. Never attempt to rig the entire YST package with the Steam Condenser chiller installed. The Steam Condenser package must be mounted on the chiller after the chiller package has been installed in its final location.

The rigging and operating weights and overall dimensions are given in form 160.67-EG1 as a guide in determining the clearances required for rigging. Add 6" (15 cm) to overall height for optional skidded unit.

FOUNDATION

A level floor, mounting pad or foundation must be provided by others, capable of supporting the operating weight of the unit.

CLEARANCE

Sufficient clearance to permit normal service and maintenance work should be provided all around and above the unit. Additional space should be provided at one end of the unit to permit cleaning of evaporator, refrigerant condenser and steam condenser tubes, as required. A doorway or other properly located opening may be used.

Clearances should be adhered to as follows:

Rear and above unit – 2 ft (61 cm).

Front of unit – 3 ft (91 cm).

Tube Removal – 14 ft.* (4.3 m) (either end)

* 16 ft. (4.9 meters) on shell codes T-T, V-V & W-V.

STEAM CONDENSER PACKAGE

The Steam Condenser package is shipped separately as a completely packaged assembly. The Steam Condenser package consists of a skid mounted surface condenser with piped accessories for the condensate and vacuum systems. The atmospheric relief valve is shipped loose for field assembly.

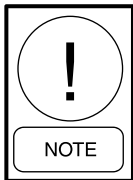
The Steam Condenser package shipment should be checked on arrival to see that all major pieces, boxes and crates are received. Each Steam Condenser package should be checked on the trailer or rail car when received, before unloading, for any visible signs of damage. Any damage or signs of possible damage must be reported to the transportation company immediately for their inspection.

JOHNSON CONTROLS WILL NOT BE RESPONSIBLE FOR ANY DAMAGE IN SHIPMENT OR AT JOB SITE OR LOSS OF PARTS. (Refer to Shipping Damage Claims, Form 50.15-NM)

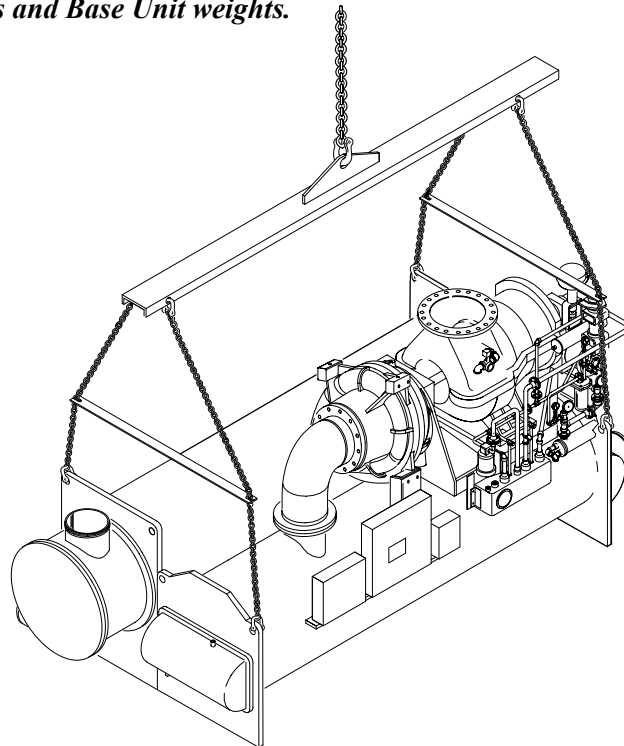
When received at the job site all containers should be opened and contents checked against the packing list. Any material shortage should be reported to Johnson Controls immediately. (Refer to Shipping Damage Claims, Form 50.15-NM)

Steam Condenser Package Rigging

Lifting lugs are provided at the four corners of the structural steel skid and lifting eyes are provided on the condenser shell. Use chains or equalizing cables and spreader bars, as necessary, to prevent contact with the piped accessories. See *Figure 3 on page 13* for Steam Condenser package rigging recommendations.



Refer to Engineering Guide 160.67-EG1 for dimensions and Base Unit weights.



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All lifting should be performed slowly with frequent inspection from level. All lifting should be performed slowly with frequent inspection of cables or chains which may apply pressure on piping or accessories.

The condenser skid can be lifted or moved with fork-lift trucks. Keep load bearing surfaces isolated on the structural steel only.

If necessary, the condenser and accessory items may be separated from the skid base. Disconnect bolting, piping and wiring as required.

Optional Steam Exhaust Trunk

Repair or maintenance requiring removal of the turbine upper casing will first require the removal of the steam exhaust trunk piping. When the optional factory piping kit is ordered for the steam exhaust trunk, lifting lugs are provided loose with the piping to be located and welded at the job site, in a suitable location to enable the rigging of the major piping assemblies. The optional piping kit is provided as partial pre-fabricated to be final trimmed/fitted and welded at the site. Welding back-up rings are provided with the piping kit.

FIGURE 2 - RIGGING

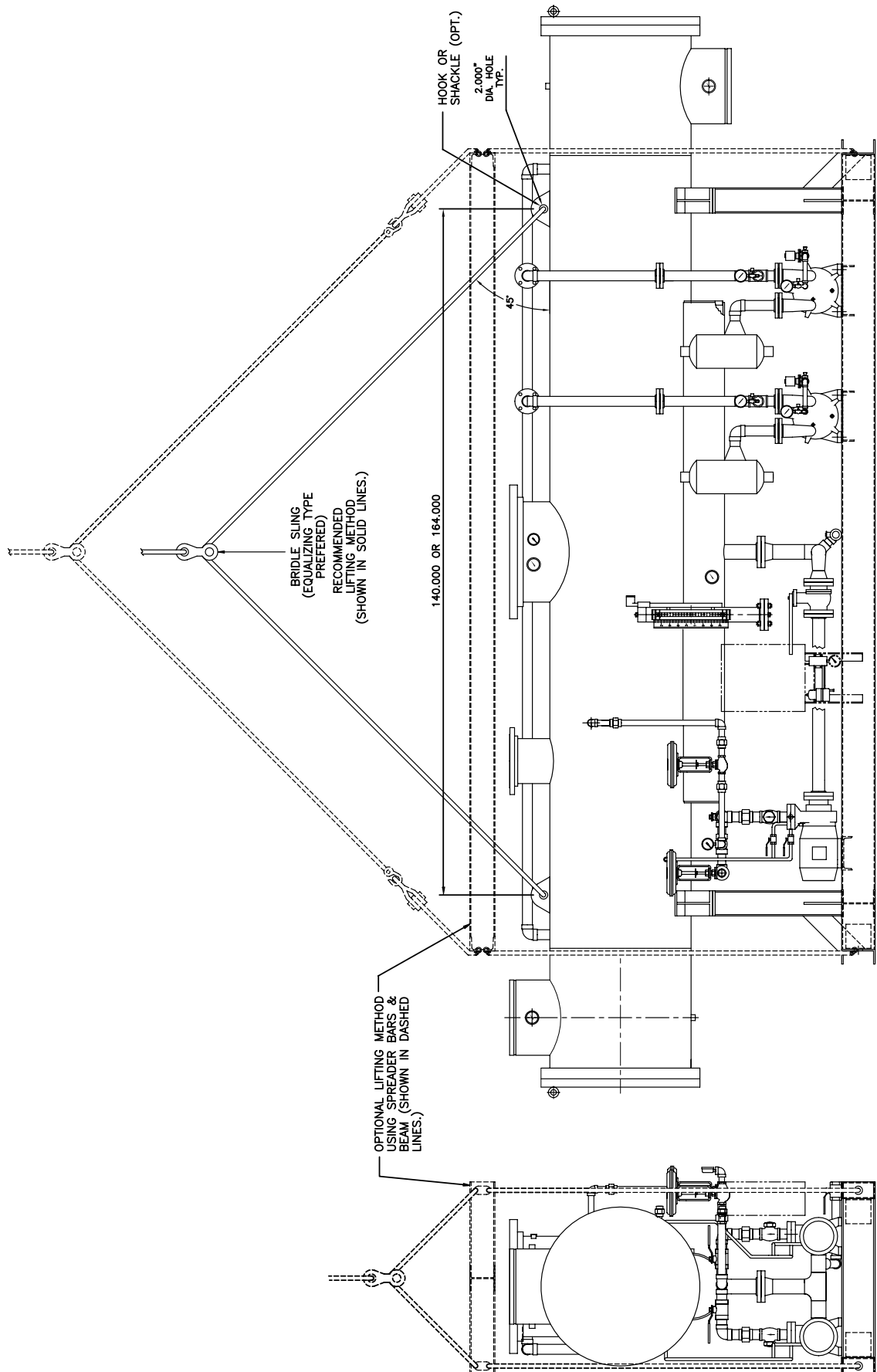
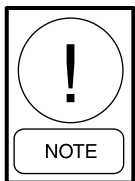
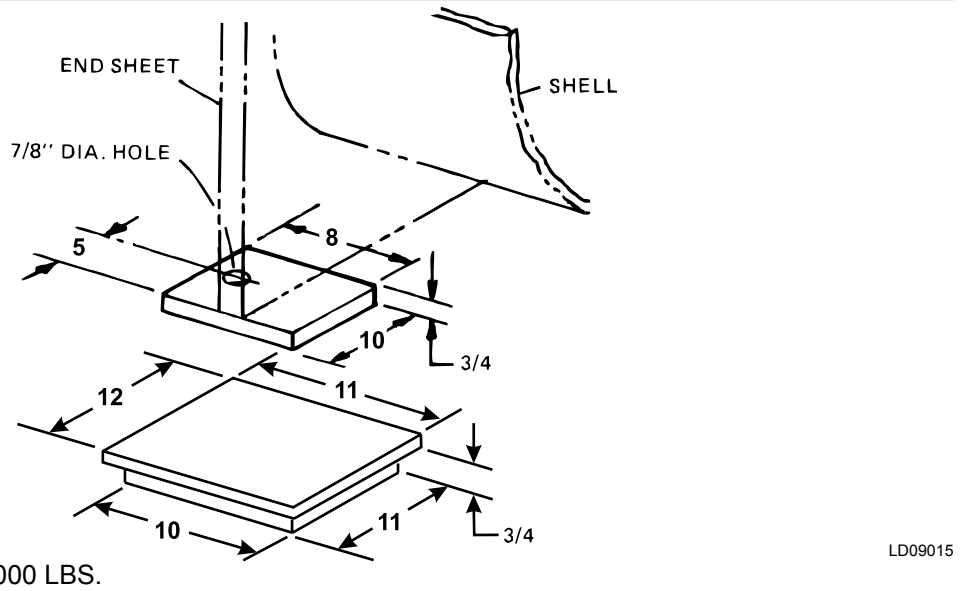
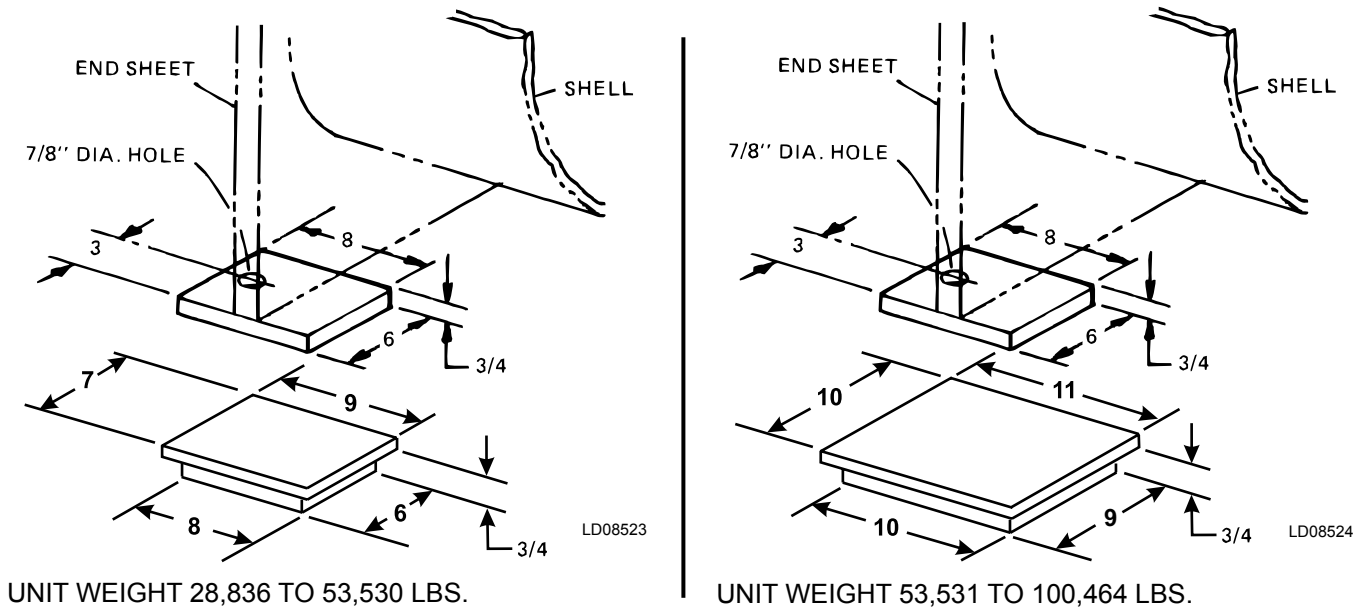


FIGURE 3 - STEAM CONDENSER PACKAGE RIGGING

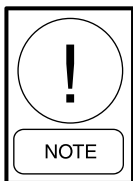
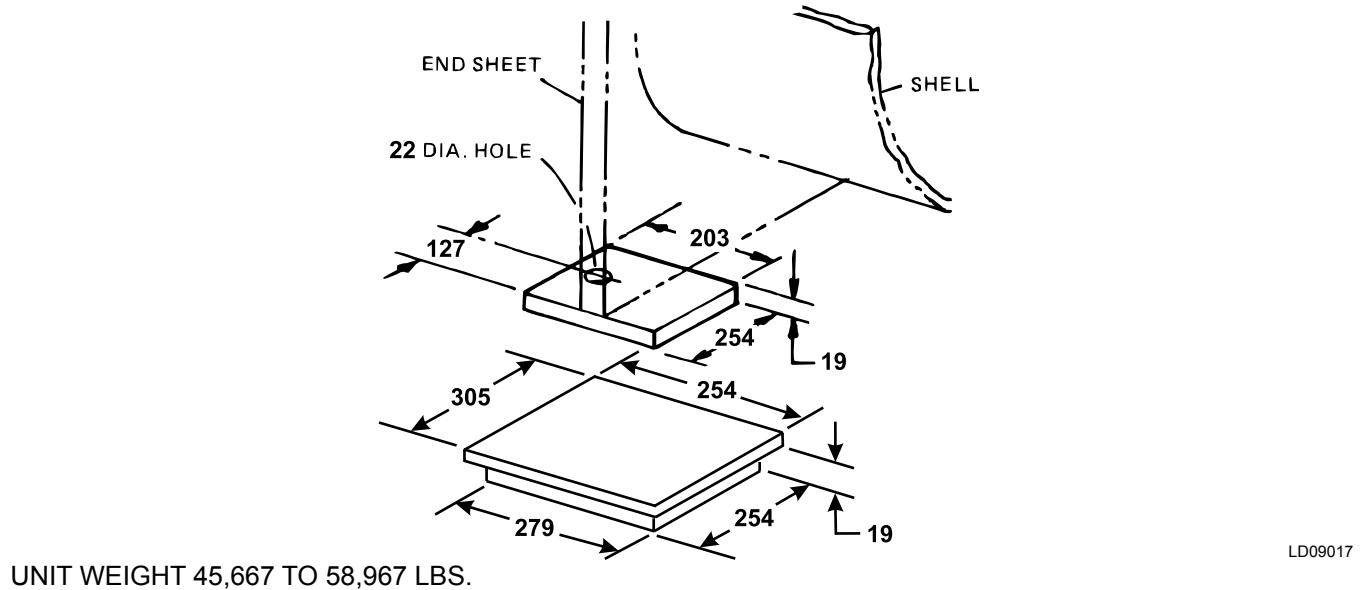
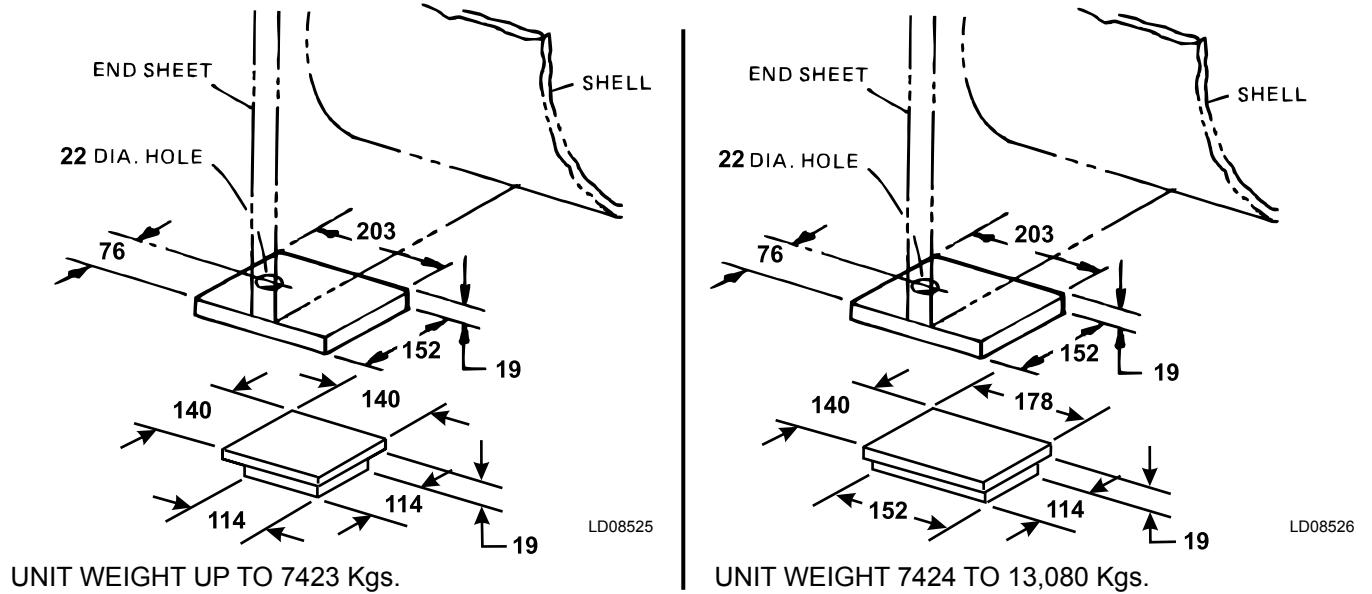
ALL DIMENSIONS ARE IN INCHES



See York standard arrangement drawings for floor layout of Neoprene Isolators by model.

FIGURE 4 - NEOPRENE ISOLATORS (STANDARD DIMENSIONS)

ALL DIMENSIONS ARE IN MILLIMETERS



See York standard arrangement drawings for floor layout of Neoprene Isolators by model.

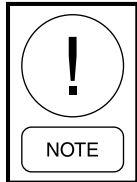
FIGURE 5 - NEOPRENE ISOLATORS (METRIC DIMENSIONS)

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SECTION 2 - INSTALLATION

RIGGING UNIT TO FINAL LOCATION

Rig the chiller package to its final location on the floor or mounting pad, lift the unit (or shell assembly) by means of an overhead lift and lower the unit to its mounting position. (If optional shipping skids are used, remove them before lowering the chiller to its mounting position.)



At this point units shipped dismantled should be assembled under the supervision of a Johnson Controls representative.



The chiller package and Steam Condenser package must be rigged separately. Never attempt to rig the entire YST package with the Steam Condenser chiller installed. The Steam Condenser package must be mounted on the chiller after the chiller package has been installed in its final location.

LOCATING AND INSTALLING ISOLATOR PADS

The isolator pad mounts are to be located as shown in Figure 4 or 5 starting on page 14.

After the isolator pads have been placed into position on the floor, lower the chiller onto the pads. When the unit is in place, remove the rigging equipment and check that the unit is level. The unit should be level within 1/4" (6 mm) from one end to the other end and from front to the rear. If the chiller is not level within the amount specified, lift it and place shims between the isolation pad and the chiller tube sheets. (Shims are included with the isolator kit.) Lower unit again and recheck to see that it is level.

CHECKING THE ISOLATION PAD DEFLECTION

All isolation pads should be checked for the proper deflection while checking to see if the unit is level. Each pad should be deflected approximately 0.10 inches (2.5 mm) to 0.20 inches (5 mm). If an isolation pad is under-deflected, shims should be placed between the unit tube sheet and the top of the pad to equally deflect all pads.

LEVELING THE UNIT

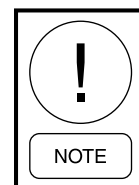
The longitudinal alignment of the unit should be checked by placing a level on the top center of the evaporator shell under the compressor assembly. Transverse alignment should be checked by placing a level on top of the shell tube sheets.

After the Steam Condenser package has been installed in place, care should be taken in leveling the condenser package, shimming at the skid/tubesheet, if necessary.

PIPING CONNECTIONS

Water/Drains

- Refrigerant condenser inlet/outlet**
- Evaporator inlet/outlet
- Turbine/Compressor cooling water manifold inlet/outlet and piping drains
- Steam condenser inlet**/outlet
- Steam condenser vacuum pump seal water: 3.5 gpm (0.2 L/s) @ approx. 60°F (15.6 °C)
- Steam condenser vacuum pump discharge separator drain
- Steam condenser relief valve seal water: trickle flow
- Steam condenser relief valve seal water drain
- Steam turbine casing drain
- Steam turbine gland leak off drain and steam trap drain
- Steam turbine steam ring drain
- Steam condenser condensate overboard valve:



Approx. 20 psig (138 kPa) discharge pressure available at outlet of overboard valve. If downstream pressure requirements exceed this, a custom condensate pump selection is required.

- Steam condenser hotwell level system drain
- Water box drains - evaporator, refrigerant condenser and steam condenser.

**York provided pre-fabricated piping for these connections. When the Steam Condenser Package is located remotely all power and control wiring is supplied and installed by others.



External piping loads to the steam inlet and cooling water outlet connections should be minimized. Allowable nozzle loads are available upon request if any concerns develop.

Steam/Vents

- Steam turbine steam inlet
- Steam turbine steam exhaust**
- Steam condenser steam inlet**
- Steam condenser relief valve vent
- Steam turbine gland sealing steam: 150 psig (1030 kPa) max. steam supply
- Steam turbine gland seal relief valve.

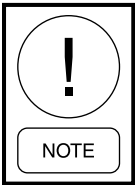
**York provided pre-fabricated piping for these connections.

Refrigerant Vents

- Refrigerant condenser relief valves(s)
- Evaporator relief valve(s)

Air (Instrument Quality Air Source - ISA S7.3)

- Steam turbine governor air supply and bearing seal air purge: 80-150 psig (552 - 1030 kPa), approx. 13 SCFM (22 sm³/h).
- Steam condenser level control system: 20-150 psig (138 - 1030 kPa), approx. 0.5 SCFM (0.9 sm³/h).



Additional air is required for the YST auto-start option. See York Flow Diagrams for details.

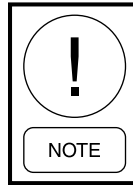
Power

- 460V single point power connection, approximately 28.6 KVA (KD turbine) or 24.2 KVA (KG turbine).

Required Auxiliary Components (customer supplied)

- Steam inlet strainer: Full flow strainer with fine [3/64" (1.2 mm) perforations], stainless steel mesh, suitable for steam service.

- Steam inlet moisture separator: Steam supply to turbine must be dry & saturated for optimum efficiency.
- Steam inlet throttling valve: Manual globe valve for inlet steam isolation and throttling (during start up). Note: This valve is York supplied when the system auto-start option is ordered.
- Steam turbine casing drain. The steam turbine casing must be provided with a means of draining during operation (while under vacuum). Available factory options for this function are an automatic pressure powered pump, a manual condensate drain tank or an automatic condensate drain tank.

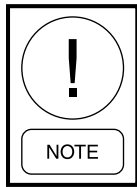


An automatic pressure powered pump is York supplied when the system auto-start option is ordered.

A suitable piping arrangement with flexible type joints and piping supports/hangers, as required, must be provided for the steam inlet line to the turbine. It is recommended that a piping analysis be performed by a qualified engineer to verify the design adequately protects the steam turbine from excessive strains due to system/thermal loads. Maximum allowable loads on steam connections are governed by NEMA SM23-1991 Steam Turbines for Mechanical Drive Services.

After the unit is leveled the piping connections may be made; chilled water, condenser water and refrigerant relief. The piping should be arranged with offsets for flexibility, and adequately supported and braced independently of the unit to avoid strain on the unit and vibration transmission. Hangers must allow for alignment of pipe. Isolators (by others) in the piping and hangers are highly desirable, and may be required by specifications, in order to effectively utilize the vibration isolation characteristics of the vibration isolation mounts of the unit.

Check for piping alignment – Upon completion of piping, a connection in each line as close to the unit as possible should be opened, by removing the flange bolts or coupling and checked for piping alignment. If any of the bolts are bound in their holes, or if the connection springs are out of alignment, the misalignment must be corrected by properly supporting the piping or by applying heat to anneal the pipe.



If the piping is annealed to relieve stress, the inside of the pipe must be cleaned of scale before it is finally bolted in place.

WATER PIPING

Flow Rate - For normal water chilling duty, evaporator and refrigerant condenser flow rates are permitted at water velocity levels in the heat exchangers tubes of between 3 ft/sec and 12 ft/sec (0.9 m/s and 3.7 m/s). Variable flow applications are possible, however, chiller selections must be made using a water velocity within the range noted above. Variable flow in the refrigerant condenser is not recommended, as it generally raises the energy consumption of the system by keeping the refrigerant condenser pressure high in the chiller. Additionally, the rate of fouling in the refrigerant and steam condensers will increase at lower water velocities associated with variable flow, raising system maintenance costs. Cooling towers typically have narrow ranges of operation with respect to flow rates and will be more effective with full design flow.

EVAPORATOR AND REFRIGERANT CONDENSER WATER PIPING

The evaporator and refrigerant condenser water boxes have nozzles which are grooved, suitable for welding 150 PSIG DWP flanges or the use of Victaulic couplings. Factory mounted flanges are optional.

The nozzles and water pass arrangements are furnished in accordance with the job requirements (see Product Drawings) furnished with the job. Standard units are designed for 150 PSIG DWP on the water side. If job requirements are for greater than 150 PSIG DWP, check the unit data plate before applying pressure to evaporator or refrigerant condenser to determine if the chiller has provisions for the required DWP.

Inlet and outlet connections are identified by labels placed adjacent to each nozzle.

Chilled Water

Foreign objects which could lodge in, or block flow through, the evaporator and refrigerant condenser tubes must be kept out of the water circuit. All water piping must be cleaned or flushed before being connected to the chiller, or other equipment.

Permanent strainers (supplied by others) - are recommended in both the evaporator and refrigerant condenser water circuits to protect the chiller as well as the pumps, tower spray nozzles, chilled water coils and controls, etc. The strainer must be installed in the entering chilled water line, directly upstream of the chiller.

Water piping circuits should be arranged so that the pumps discharge through the chiller, and should be controlled as necessary to maintain essentially constant chilled and refrigerant condenser water flows through the unit at all load conditions.

If pumps discharge through the chiller, the strainer may be located upstream from pumps to protect both pump and chiller. (Piping between strainer, pump and chiller must be very carefully cleaned before start-up.) If pumps are remotely installed from chiller, strainers should be located directly upstream of the chiller.

Refrigerant Condenser Water Circuit

The chiller is engineered for maximum efficiency at both design and part load operation by taking advantage of the colder cooling tower water temperatures which naturally occur during the winter months. Appreciable power savings are realized from these reduced heads.

The minimum entering refrigerant condenser water temperature for other full and part load conditions is provided by the following equation:

$$\text{Min. ECWT} = \text{LCHWT} - \text{C RANGE} + 17^{\circ}\text{F}$$

$$\text{Min. ECWT} = \text{LCHWT} - \text{C RANGE} + 9.4^{\circ}\text{C}$$

where:

ECWT = entering refrigerant condensing water temperature

LCHWT = leaving chilled water temperature

C RANGE = refrigerant condensing water temperature range at the given load condition.

At initial startup, entering condensing water temperature may be as much as 25°F (14°C) colder than the standby chilled water temperature as long as it is above the minimum ECWT allowed.

Stop Valves

Stop valves may be provided (by others) in the evaporator and refrigerant condenser water piping adjacent to the unit to facilitate maintenance. Thermometer wells and pressure taps should be provided (by others) in the piping as close to the unit as possible to facilitate operating check.

Flow Switches

Thermal type water flow switches are factory mounted in the chilled and condensed water nozzles and are factory wired to the OptiView control panel. These solid-state flow sensors have a small internal heating element and use the cooling effect of the flowing fluid to sense when an adequate flow rate has been established.

Optional Remote Steam Turbine Gaugeboard (Field Installed)

A remote steam turbine gaugeboard can be purchased when the unit is planned to be manually started and has a steam throttling valve that is not within view of the micropanel. When required, the remote turbine gaugeboard will be mounted on a freestanding station.

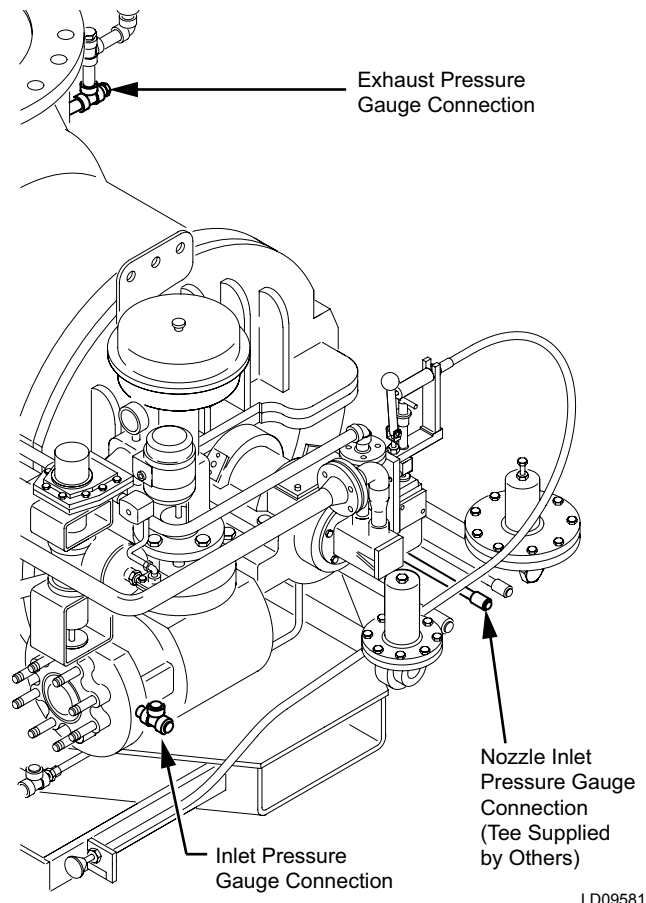


FIGURE 6 - OPTIONAL TURBINE GAUGEBOARD CONNECTIONS

The gaugeboard is provided with three pressure gauges (steam inlet, nozzle ring, and exhaust) and a tachometer. The remote gaugeboard is shipped loose for installation at the job site. All the piping between the instrumentation on the gaugeboard and turbine shall be provided and installed by others. (Stainless steel is recommended) See *Figure 6 on page 20*.

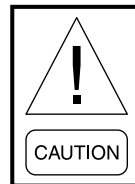
The remote turbine gaugeboard is recommended if there is manual start and the steam inlet throttling valve location makes it impossible to view panel during slowroll.

Drain and Vent Valves

Drain and vent valves (by others) should be installed in the connections provided in the evaporator and refrigerant condenser waterboxes. These connections may be piped to drain if desired.

Checking Piping Circuits and Venting Air

After the water piping is completed, but before any water box insulation is applied, torque the waterbox flange nuts to 30 and 60 ft. lbs. (41 and 81 N·m). Gasket shrinkage and handling during transit cause waterbox flange nuts to loosen. If water pressure is applied before tightening is done, the gaskets may be damaged and need to be replaced. Check the steam condenser piping connection for leaks. Pipe unions and flanges may loosen during shipment and installation. Re-tighten, if necessary.



Before the initial operation of the pumps both water circuits should be thoroughly vented of all air at the high points. Failure to do so will result in pass baffle damage.

Fill both the chilled and condenser water circuits, and vent any air from the chiller water boxes. Operate the pumps manually and carefully check the evaporator, refrigerant and steam condenser waterboxes and piping for leaks. Repair leaks as necessary.

REFRIGERANT RELIEF PIPING

Each unit is equipped with pressure relief valves located on the refrigerant condenser and on the evaporator for purpose of quickly relieving excess pressure of the refrigerant charge to the atmosphere as a safety precaution in case of an emergency, such as fire.

Refrigerant relief vent piping (by others), from the relief valves to the outside of the building, is required by code in most areas and should be installed on all chillers. The vent line should be sized in accordance with the ANSI/ASHRAE-15, or local code. The vent line must include a dirt trap in the vertical leg to intercept and permit clean out and trap any vent stack condensation. The piping MUST be arranged to avoid strain on the relief valves, using a flexible connection, if necessary. See *Figure 7 on page 21* for a typical piping arrangement.

STEAM TURBINE CASING DRAIN OPTIONS

The steam turbine casing must be provided with a means of draining during operation (while under vacuum). Factory available options are:

- Automatic pressure powered pump (standard option)
- Manual condensate drain tank (by special quote)
- Automatic condensate drain tank (by special quote)

When the factory casing drain option is supplied, the equipment is shipped loose for installation at the jobsite.

STEAM PIPING

Inlet and exhaust piping for the steam turbine should be designed and installed by knowledgeable persons experienced in turbine work.

The size of steam inlet line is based upon velocities in the piping generally accepted as being good practice for runs of straight pipe up to 200 feet, or the equivalent in valves and fittings. The piping contractor must ensure that the steam supply is available at the turbine flange at the temperature and pressure required to achieve the design capacity of the chiller. JOHNSON CONTROLS ASSUMES NO RESPONSIBILITY IN REGARD TO PRESSURE OR TEMPERATURE DROPS. THE PERFORMANCE OF THE TURBINE SPECIFIED IS BASED UPON THE INLET PRESSURE AND TEMPERATURE AS MEASURED AT THE TURBINE STEAM INLET FLANGE.

Steam inlet piping for the standard YST condensing turbines should include a fullsize throttle valve in the main steam inlet line and a smaller throttling valve in the bypass line to be used for slow rolling the turbine (See *Figure 8 on page 27*). The smaller valve is required to allow the steam flow to be reduced to the point where the governor valve must be open to at least 25-35% in order to achieve slow roll speed. This will provide optimum speed control during the slow roll warm-up of the turbine.

Exhaust piping is available as an optional kit for field installation. The relief valve to protect the turbine exhaust casing and surface condenser is provided on the steam condenser package for standard YST chillers.

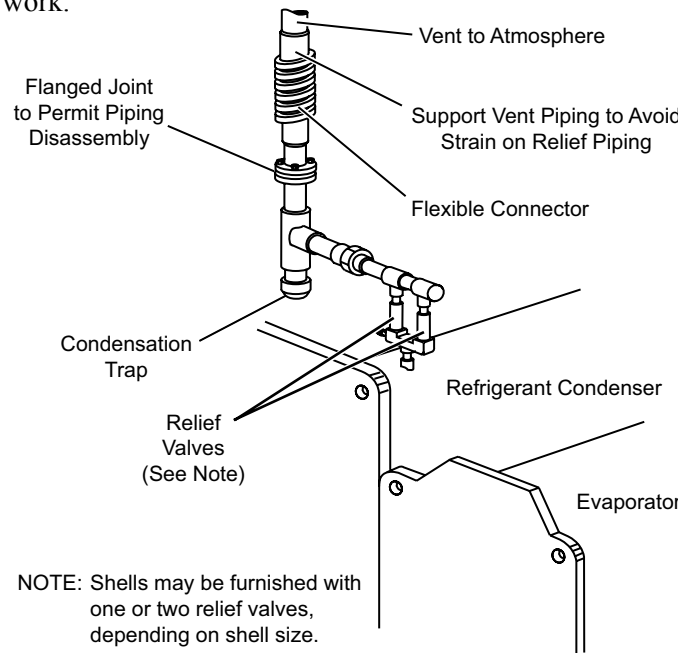


FIGURE 7 - TYPICAL REFRIGERANT VENT PIPING

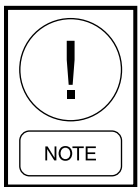
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Piping for special back pressure turbines should include a throttle valve in the steam inlet line and a stop valve in the exhaust line. A suitable relief valve to protect the turbine exhaust casing must be provided between the turbine exhaust flange and the exhaust stop valve. The exhaust relief valve or the rupture disc should correspond in size to those indicated for steam and exhaust lines in APPENDIX-A, NEMA SM23-8, Steam Piping Systems. These relief valves serve to protect the turbine casing against overpressurization in case the turbine is started with the exhaust valve closed or the backpressure rises for any reason during operation. The relief valve should be of sufficient capacity to relieve the rated steam flow of the turbine at the maximum operating pressure specified when all hand valves are opened. Contact Tuthill Energy Systems for specifications on sizing the valve, relieving capacity, and overpressurization limits.

Steam inlet and exhaust piping (if not supplied by YORK) must be properly designed and supported so that its weight and thermal expansion will not produce excessive strains on the turbine inlet or exhaust flanges, either when cold or when at normal operating temperature. The piping must be designed so that it does not have to be sprung into position for bolting to the turbine flanges when cold. Likewise, the piping must not be spring out of position when everything is at running temperature.

FORCE DUE TO THERMAL EXPANSION CAN BE VERY GREAT IF NOT PROVIDED FOR BY EXPANSION AND SUPPORT OF PIPING.

These forces can cause misalignment. The maximum allowable forces and moments, per NEMA standards are indicated on the outline drawings. See APPENDIX A, NEMA SM23, Part 8 (Steam Piping Systems) for additional information.



Factory supplied STANDARD steam exhaust piping does NOT require additional support or pipe hangers.

Moisture in the inlet steam not only increases the steam consumption but causes rapid wear of the valve seats, nozzles and turbine blades. A moisture separator and steam trap must be installed at the low point of the inlet piping to ensure that the turbine receives dry steam.

Where exhaust piping bends upward after leaving the turbine, steam traps must be provided to keep the ex-

haust line drained to prevent water from building up in the exhaust pipe and turbine casing. **FAILURE TO KEEP THE EXHAUST LINE DRAINED MAY RESULT IN A RESTRICTION IN THE EXHAUST LINE, CAUSING A LOSS OF POWER AND DAMAGE TO THE TURBINE ROTOR.**

Connecting the steam line should always begin at the header or other source, the turbine connection being made last. If an expansion joint is used in either line it must be securely anchored to prevent axial strain on the turbine.

BE SURE TO BLOW OUT AND CLEAN ALL STEAM LINES BEFORE CONNECTING TO THE TURBINE. FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE STEAM STRAINER SCREEN AND OTHER INTERNAL PARTS.

JOHNSON CONTROLS ACCEPTS NO RESPONSIBILITY FOR DAMAGE RESULTING FROM THE ENTRANCE OF FOREIGN MATERIALS

Recommended blow-down procedure (per turbine manufacturer)

Newly constructed steam piping should be blown-down to remove scale, weld beads and any other foreign material. Such material can cause severe damage if it enters the steam turbine.

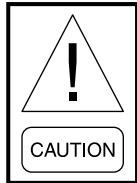
The blow-down connection should be as close to the turbine as possible. The diameter of the blow-down connection should be a minimum of one half the diameter of the line being blown-down to ensure that steam velocity in the piping is high enough to break loose and carry away any foreign material stuck to the inside of the piping.

Blow-down should be done before the piping is insulated. Steam at full temperature and pressure should be bled through the piping.

After the piping has been warmed up, the valve in the blow-down connection should be opened wide for about 15 seconds to allow live steam to blow out any loose material in the piping. Piping should then be allowed to cool down to room temperature, about 6-8 hours.

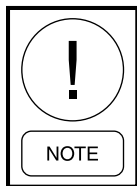
Thermal expansion and contraction which occurs during warming up and cooling down, helps break loose the foreign material inside the piping. Hammering around any welded joints in the piping will also help to break loose foreign material

The above procedures of warm-up, blow-down and cool-off should be repeated as many times as necessary to clean all foreign materials out of the piping. To check for clean piping, a target should be placed about two feet away from the blow-down opening so that the steam will hit the target, and any solids in the steam will become embedded in the target. Plywood, aluminum and polished stainless steel are commonly used target materials. Piping can be considered clean when no embedded particles and indentations are found in the target after a 15 second blow-down.



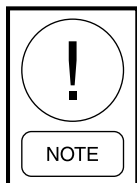
Removal of foreign material from the piping is the responsibility of the party installing the piping. The turbine warranty does not cover damage due to the entrance of foreign material.

Turbine supply steam and condensate piping connections to the chiller are to be supplied and installed by the site piping contractor.



A suitable piping arrangement with flexible type joints and piping supports/hangers, as required, must be provided for the steam inlet line to the turbine. It is recommended that a piping analysis be performed by a qualified engineer to verify the design adequately protects the steam turbine from excessive strains due to system/thermal loads. Maximum allowable loads on steam connections are governed by NEMA SM23-1991 Steam Turbines for Mechanical Drive Services.

The turbine exhaust piping to the steam condenser shall be installed by the piping contractor, however, the design and supply of the exhaust piping and components may be supplied by YORK depending on the options chosen. Piping should be adequately supported and braced independently of the chillers. Hangers must allow for piping alignment at the operation temperature.

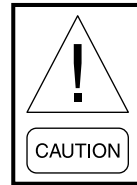


Factory supplied STANDARD steam exhaust piping does NOT require additional support or pipe hangers.

The piping contractor is responsible for the form and fit of turbine steam piping. The piping must be installed with the flanges and bolt holes properly aligned. The

bolts should be able to be inserted without any difficulty and no force should be applied to allow the bolts to be inserted or flanges aligned. When the flange bolts are tightened, they must not impose any force or moment on the turbine flanges. Contact your local Johnson Controls office for any additional information.

All steam piping must be arranged so that strains will not be imposed on the turbine. The total resultant force and total resultant moment at any connection should not exceed the limits defined by NEMA SM23-1991 for steam turbine systems.



Failure to minimize strain on the turbine from steam piping can result in misalignment between the turbine and refrigerant compressor. Misalignment can cause significant damage to the compressor/turbine bearings and/or coupling.

Gland Seal Leak-Off Piping

Where the rotor shaft passes through the turbine casing, packing glands of the segmented carbon ring or labyrinth type are provided. These have leak-off connections piped to a common point shown in *Figure 8 on page 27*. FROM THIS POINT, THE CUSTOMER MUST PROVIDE SUITABLE PIPING OF A SIZE INDICATED ON THE OUTLINE DRAWING.

If it is necessary to run the pipe for a long distance the size should be increased so that back pressure does not build up on the packing gland. This pipe must slope down from the connection point to avoid forming a water trap and must not contain a shut-off valve.

On non-condensing turbines, a small amount of steam will pass through this line at all times. The amount of steam passing through the line will depend upon the amount of back pressure.

The leak-off steam is commonly piped to a sewer or open header. If this line becomes partially clogged, or the back pressure builds up for any reason, steam will blow about the shaft at the packing gland.

Some machines may be equipped with an optional gland condenser which condenses the gland leakage as well as steam leaking from other leak-off connections. The condensate from this gland condenser can be returned to the feed water system.

Gland Leak-Off Condenser - Optional Supply by Special Quotation

This equipment may be specified for use on high back-pressure applications, those turbines operating with a high pressure differential across the glands, and which must operate for long periods of time between shut-downs (some low pressure turbines may also use this equipment).

The condenser is piped to the outer leak-off connections of the glands. It creates a slight vacuum on the outer leak-off areas, assuring that leakage will leave through leak-off piping and not past inactive seals.

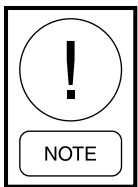
The most common configuration is the gland condenser and ejector. The gland condenser is a shell-and-tube type heat exchanger in which cooling water is used to condense steam leakage from the glands. The ejector is a steam nozzle which creates a low pressure area to remove any air which has leaked into the system and thus maintains the vacuum in the leak-off areas.

This equipment is available for all types of leak-off flows, large or small. The condensed leakage steam and cooling water can be recovered and returned to the boiler. Note that the condenser tubes and ejector both require periodic cleaning.

Steam Turbine Casing Drains

YST chillers are provided with tapped drain openings that can be piped to a sewer or any other low point that permits the water to drain off by gravity. The location of these openings is shown in *Figure 8 on page 27* and the outline drawing.

A steam ring drain connection is provided to on all YST chillers for getting rid of excess moisture the accumulates in the steam ring when the turbine casings is cold at startup. This drain must be fitted with a valve that can be opened when steam is first admitted to the turbine and remains open during the slow roll warm-up of the turbine. The operation of the steam ring drain is explained in SECTION 2 - *Sequence of Operation*.



The steam ring drain valve must be kept closed during normal operation after the slow roll warm-up of the turbine. This is done automatically on chillers supplied with optional "Auto-Start".

On standard YST chillers with up-discharge turbine exhaust, an exhaust casing drain connection is supplied. The turbine must be supplied with a means of drain-

ing the casing during operation (While under vacuum). The standard Factory supplied option is an automatic pressure powered pump. Also available by special quotation is a condensate drain tank (manual or automatic). When either option is supplied, it is shipped loose for installation at the job site.

On non-condensing turbines with side-discharge turbine exhaust, there is no need for an exhaust casing drain since condensate cannot collect in the turbine exhaust end.

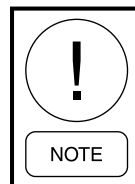
On any application where the exhaust piping bends upward after leaving the turbine, steam traps must be provided to keep the exhaust line drained to prevent water from building up in the exhaust pipe and turbine casing.



Failure to keep the exhaust line drained may result in a restriction in the exhaust line, causing a loss of power and damage to the turbine rotor.

Pressure Powered Pump - Optional Supply

When ordered, a Factory supplied automatic pressure powered pump is provided for draining condensate from the steam turbine casing, during operation. The pressure power pump is shipped loose and all piping and installation is provided by others.



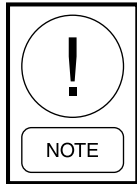
An automatic pressure powered pump is York supplied when the system auto-start option is ordered.

Liquid enters the pump body through the inlet check valve causing the float to rise. As the chamber fills the valve changeover linkage is engaged opening the motive supply valve and closing the equalizing valve. As motive pressure is above the total back pressure, condensate is forced out through the outlet check valve into the return system.



Motive pressure for automatic pressure powered pumps cannot exceed a maximum of 200 PSIG (steam or air may be used). Application with higher pressure motive supply must use custom selected condensate drain equipment suitable for higher pressures.

As the liquid level falls within the pump, the float re-engages the valve changeover linkage causing the motive supply valve to close and the equalizing valve to open allowing condensate to re-enter through the inlet check valve and the cycle is repeated. Refer to York standard flow diagram for typical pressure pump piping installation.



All the piping associated with the installation of the Automatic Pressure Powered Pump is field provided and installed.

Condensate Drain Tank - Optional Supply by Special Quotations

When ordered, a Factory supplied condensate drain tank is provided for draining the condensate from the exhaust end of the steam turbine during operation. The tank is shipped loose and all piping and installation is provided by others.

The tank is provided with a high level alarm switch which is connected to the OptiView Control Center to signal the operator that the tank must be manually drained by closing and opening the appropriate valves to isolate the tank from the turbine during the draining process and allow the condensate to drain into the sewer. If the tank is automated, the tank provided with a self contained control panel, float switches, and solenoid valves to control the draining isolation/draining process.

Steam Relief

Each steam condenser is equipped with an atmospheric relief valve, sized to relieve all the steam which can be exhausted from a turbine under maximum possible full throttle conditions. The atmospheric relief valve is designed/selected per HEI (Heat Exchange Institute) standards for steam condensers and provides protection for the steam turbine exhaust and exhaust trunk, as well as the steam condenser shell. The discharge of the atmospheric relief valve should be piped to direct a large volumetric flow of hot steam to a safe area outside, away from all personnel.

STEAM CONDENSER PACKAGE HYDROSTATIC TEST

After the installation is complete, the entire condensing system and piping on the exhaust steam side should be tested to prove the tightness of all connections. This

can be completed by filling the condensing package with water to the top of the steam inlet flange. If possible, put the Condensing Package under 15 psi of pressure. Inspect all connections, valves, gauges, fittings, pumps and other accessories for leaks.

CONTROL WIRING

On units shipped disassembled, after installation of the control center, control wiring must be completed between unit components and power panel, using wiring harness furnished.

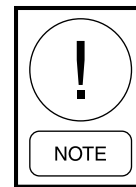
Field wiring connections for commonly encountered control modifications (by others) if required, are shown on Form 160.67-PW2.



No deviations in unit wiring from that shown on drawings furnished shall be made without prior approval of the Johnson Controls representative.

POWER WIRING

A 460V-3-50/60 Hertz single point supply is standard. DO NOT make final power connections to power panel until approved by Johnson Controls representative.



When the steam condenser package is located remotely all power and control wiring between the condenser and chiller is supplied and installed by others.

INSULATION

(See Product Drawings)



DO NOT field insulate until the unit has been leak tested under the supervision of the Johnson Controls representative.

Insulation of the type specified for the job, or minimum thickness to prevent sweating of 30°F (-1°C) surfaces should be furnished (by others) and applied to the evaporator shell, end sheets, liquid feed line to flow chamber, compressor suction connection, and evaporator waterboxes and connections. The waterbox flange insulation must be removable, to allow waterbox removal for the tube maintenance. Details of areas to be insulated are given on the Product Drawing.

Units are furnished factory anti-sweat insulated on order at additional cost. This includes all low temperature surfaces except the evaporator waterbox/returnheads.

FLOOR MOUNTED STEAM CONDENSER

As an alternative to the standard YST arrangement, the steam condenser package can be ordered for floor mounting adjacent to the chiller package. Prefabricated piping kits for the steam trunk, water piping and wiring between chiller package and steam condenser are not included with a floor mounted arrangement. These interconnecting components must be designed, supplied and installed by others.



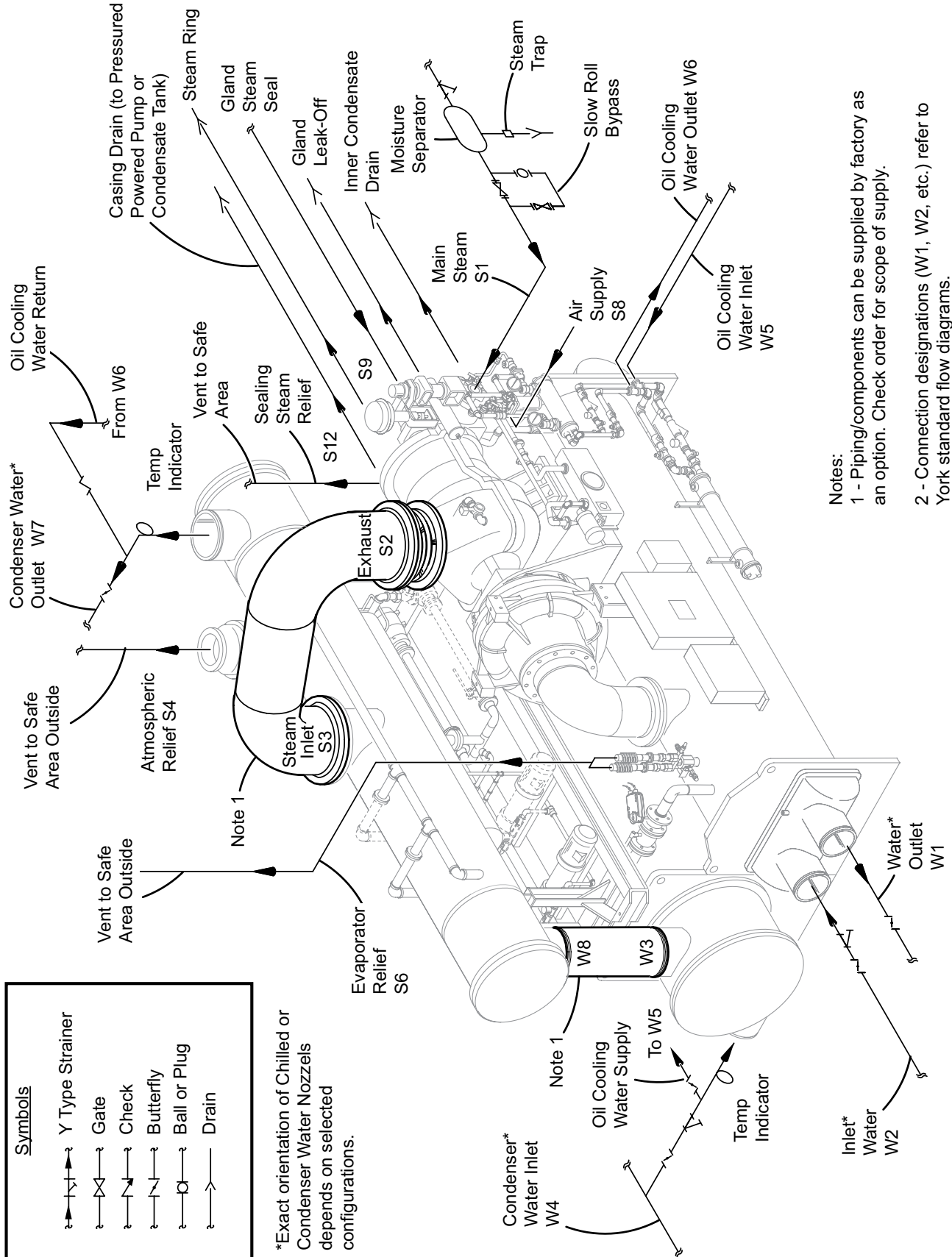
External piping loads to the steam inlet and water box connections should be minimized. Allowable nozzle loads are available upon request if any concerns develop.

INSTALLATION CHECK – REQUEST FOR START-UP SERVICE

The services of a Johnson Controls representative will be furnished to check the installation and supervise the initial start-up and operation on all chillers installed within the Continental United States.

After the unit is installed, piped and wired as described in this Instruction, but before any attempt is made to start the unit, the Johnson Controls District Office should be advised so that the start-up service, included in the contract price, can be scheduled. Notification to the Johnson Controls office should be by means of completing the Installation Check List and Request Forms in the back of the 160.67-O2 manual.

MANUAL START



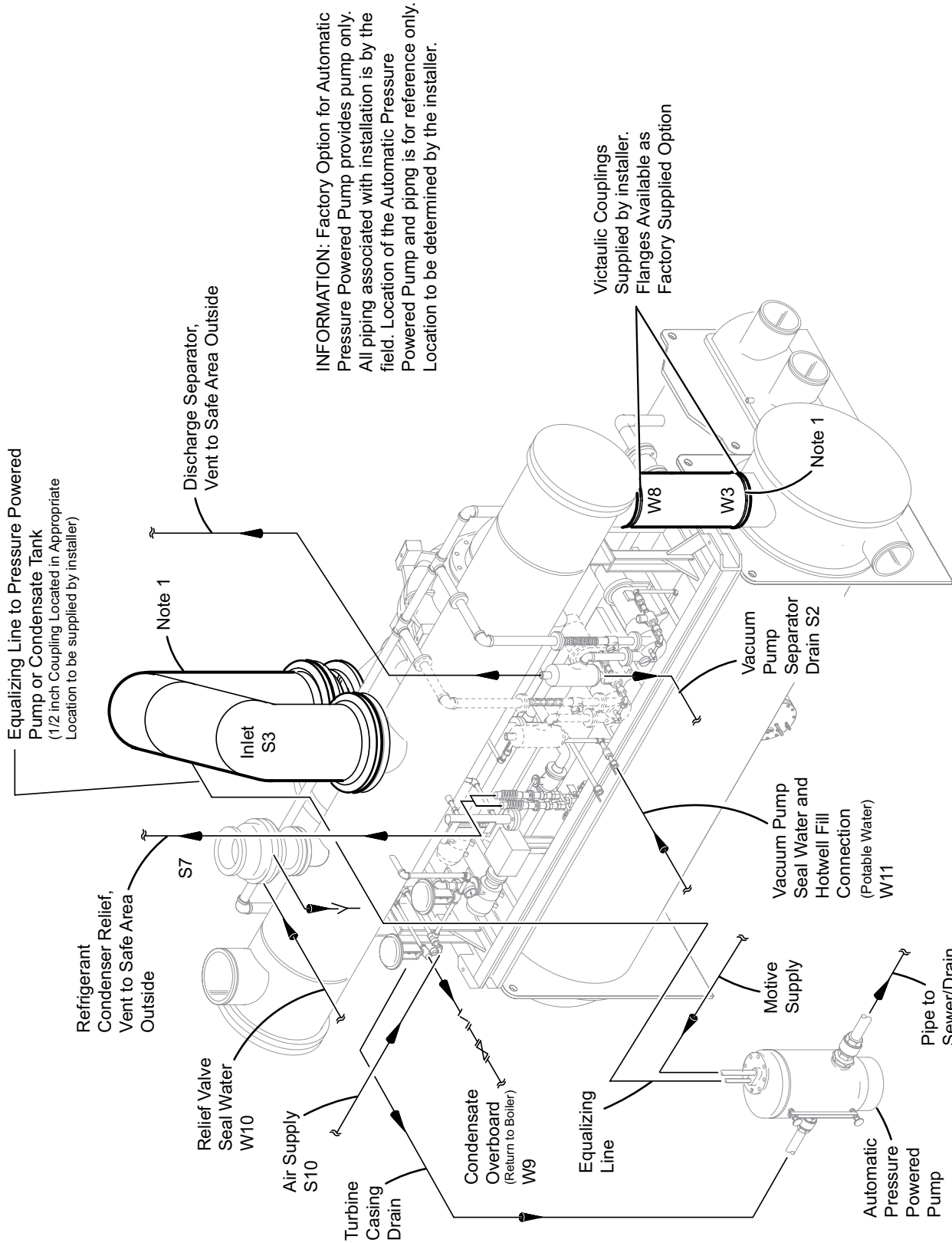
Notes:
 1 - Piping/components can be supplied by factory as an option. Check order for scope of supply.
 2 - Connection designations (W1, W2, etc.) refer to York standard flow diagrams.

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FIGURE 8 - TYPICAL MANUAL START PIPING ARRANGEMENT

MANUAL START

LD09347



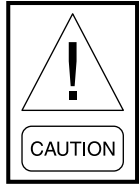
INFORMATION: Factory Option for Automatic Pressure Powered Pump provides pump only. All piping associated with installation is by the field. Location of the Automatic Pressure Powered Pump and piping is for reference only. Location to be determined by the installer.

Victaulic Couplings
Supplied by installer.
Flanges Available as
Factory Supplied Option

FIGURE 8 – TYPICAL MANUAL START PIPING ARRANGEMENT (CONT'D)

ALIGNMENT

Alignment refers to the proper relationship between the centerlines and distance between the turbine shaft and compressor. Factory assembled packages are aligned prior to shipment and must be re-checked prior to startup.



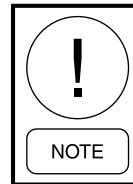
Inaccurate alignment can result in destructive vibration, loosening of grout, failure of bearings, coupling failure, bent shaft, and other conditions that could lead to catastrophic equipment damage.

Alignment Data

The following instructions and suggestions are made for guidance in alignment of newly installed equipment and under the presumption that:

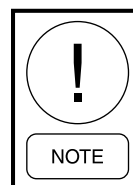
- The persons reading this are familiar with high speed turbomachinery and that they are aware of the basic principles of alignment.
- It is understood that the various procedures suggested for checking completed portions of the system are in no way a substitution for proper design, engineering, and construction. Additionally, the suggestions made represent only one of several acceptable alternatives.
- In the case of turbomachinery, many of the items vital to a good alignment have been done well ahead of the actual “cold alignment” of the equipment. Unless the person responsible for the alignment has first-hand knowledge that the preparations have been done properly, it is best to verify these items. Some areas that warrant specific attention would be:
 - Piping. Assure that the piping is installed in accordance with design criteria, that it is complete, and that it is in its functional state. Look for proper placement and adjustment of guides, anchors, and supports; proper adjustment of tie-bolts on expansion joints; correct positioning of spring hangers; complete make-up of flanges with gaskets in place and bolts tightened; absence of slip-blinds which may have been installed for pressure testing of pipelines; and proper orientation of check valves and other control devices.
 - Check the grouting to assure it is complete and supports the structure of the unit.
 - Check all foundation bolts to assure tightness.

- Check all shim packs for rust, improperly cut shims, folds and wrinkles, burrs, hammer marks, and dirt etc. Shims are a vital link between the machine and the foundation and are essential to the maintenance of alignment over long periods. Good practice dictates that as few shims as possible be used if changes are required, replace many thin shims with fewer shims of greater thickness. Shims of stainless steel should be used wherever possible. Also it is important to make sure the equipment supports and soleplate/baseplate are clean and in good condition.



If field mounting the turbine is required make sure to complete the following item.

- Check for misalignment of machine supports relative to the soleplate, this is sometimes referred to as a “soft foot” condition. Mounting a dial indicator on the machine support with the indicator stem resting on the soleplate can make a simple test for this condition. Watch the indicator as the hold-down bolts are loosened. If the movement of the indicator is more than .002”, it is an indication of a problem which must be rectified. It is also appropriate to remove the shim pack and check with feeler gauges to assure that the machine support is parallel with the soleplate.



The goal of proper alignment is to provide the most accurate collinear alignment during the majority of operating conditions.

- Check for piping strain. This can be accomplished by placing dial indicators on the machine to monitor both vertical and horizontal movement of the casing or shaft. Then loosen all of the compressor hold-down bolts. If the machine moves more than the average observed in checking individual supports, it is obviously the result of an external force and probably the piping.



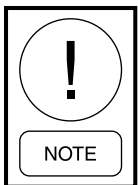
Piping strain can cause problems with alignment and must be corrected before operating the unit.

- Remove the mylar protection that may be used to stabilize the turbine shaft during shipment. Make sure that the bearings have been properly installed in the machines, are lubricated, and bearing covers are properly tightened.

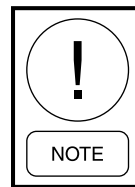
The term "Cold Alignment" refers to the position of the centerline of the shaft of one piece of equipment relative to the centerline of the shaft of an adjoining machine to which it is connected, as well as the distance between the two shafts, with the machines in a non-operating temperature stabilized or "cold" condition. The term implies both offset and angularity. The importance of this cold alignment is that it is usually the only check made to ascertain directly the relative position of the two shafts. The result of this check is the basis for determining shaft alignment of the equipment during operation. It is the fundamental benchmark and must be accurately done and properly recorded.

There are various methods which can be utilized to perform the alignment. The method described in this manual will be that of using dial indicators. While the method of employing dial indicators is an old and well-established technique, these are precautions which the technician should already be aware of.

The most widely used of the traditional alignment methods is commonly referred to as the "Face-O.D." method as illustrated in *Figure 9 on page 30*. As shown in the figure, a bracket is attached to one shaft and extends to the proximity of the coupling hub on the adjacent shaft. Dial indicators are affixed to this bracket with the stem of one indicator resting on the face of the coupling hub and the stem of the other indicator resting on the outside diameter of the same hub. The "parallel" offset of the shafts is determined by the "O.D." readings, while angularity of the shafts is determined by the "face" readings. It is required that the proper distance between the shafts be established before any alignment method is used. This spacing dimension can be found on the outline drawing and/or the coupling drawing for the specific application.



Dial indicators which are anti-magnetic are strongly recommended.



Make sure the indicator stem is near the center of travel before taking readings and will remain in contact with the flange surface. Rotate the shaft to insure the indicators will not be impacted or obstructed when rotated.

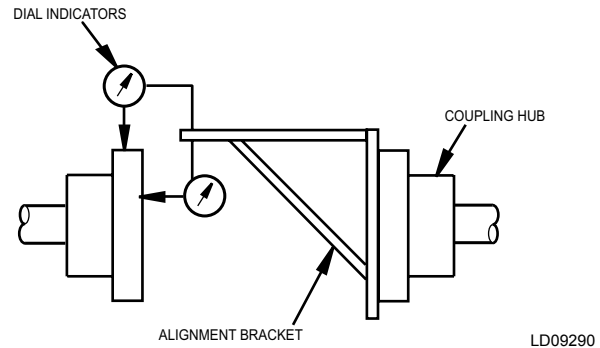


FIGURE 9 - TYPICAL ARRANGEMENT FOR "FACE - O.D." READINGS TO DETERMINE COLD ALIGNMENT OF SHAFTS

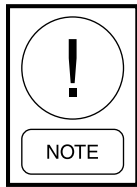
To eliminate inaccuracies in geometry of the coupling hub, turning of both shafts simultaneously such that the indicator readings are taken always at the same place on the hub will give more precision. This precaution can be difficult on larger equipment and may not be possible. Face measurements taken by this method must have the axial float of the two shafts accounted for.

Axial movement must be taken into account when turning the shafts on equipment with hydrodynamic thrust bearings or no thrust bearings. (Small machinery utilizing ball bearings may not encounter any axial float.) The shafts must have axial positions rechecked each time a reading is taken. One additional element that must be accounted for is the difference between the exhaust end shaft rise and the steam end shaft rise. Typically, the steam end will rise more than the exhaust end due to higher temperatures. This will result in cold misalignment offsets that have the coupling face "open" at the top.

Care must also be taken in the brackets that are used to hold the dial indicators. "Universal" or makeshift brackets contrived on the spur of the moment can give inaccurate readings, which can lead to improper alignments. Refer to the following, "Checking for Sag" section in this manual. Especially when the spans between the shafts are quite long, care must be taken to assure that the bracket being utilized is stiff enough that it will not deflect under its own weight.

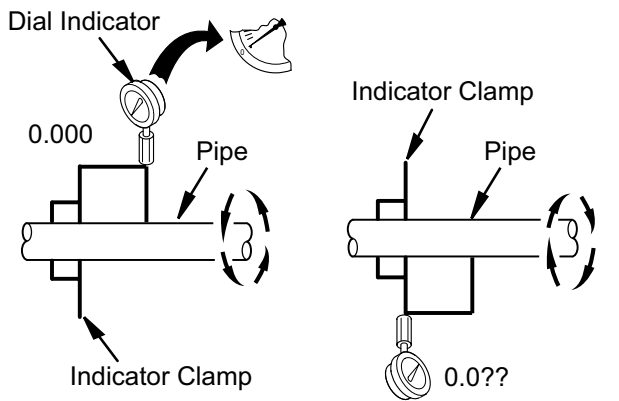
Checking for Sag

Clamp the indicator system onto a piece of pipe (1-1/2 - 2 inch diameter).



Make sure the indicator/clamp system measures the same distance as the coupling span.

Zero the indicator while on top. Rotate to the bottom and record any change in reading on the indicator. This is the amount of "Sag" due to gravity. If Sag measures more than 0.003 inches the brackets should be reinforced or modified. See *Figure 10 on page 31*.



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FIGURE 10 - MEASURING "SAG" OF INDICATOR/CLAMP SYSTEM

An alternative method is sometimes preferred because of the elimination of some of the problems mentioned above with the "Face O. D." method would be to utilize the "Reverse Indicator" method as illustrated in *Figure 11 on page 31*.

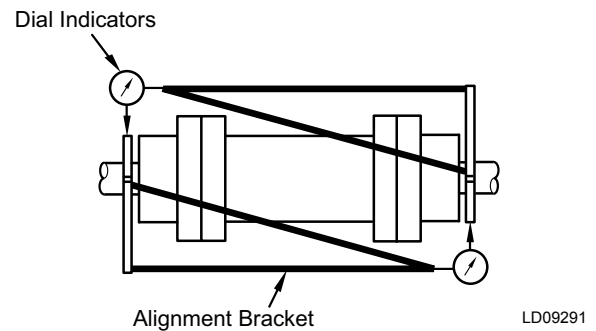
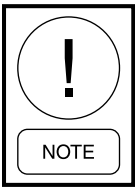


FIGURE 11 - TYPICAL "REVERSE INDICATOR" TO DETERMINE COLD ALIGNMENT OF SHAFTS

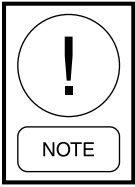
This method employs indicator readings taken on the outside diameter of the coupling hubs or shaft only. The sketch indicates two brackets used simultaneously, which is normally the preferred method. One bracket could be utilized by switching back and forth for each set of readings but this is far less convenient and may affect accuracy.

Use of the "Reverse Indicator" method eliminates the requirement for removing the coupling spacer in a majority of cases. This reduces the wear and tear on the coupling. The error caused by coupling hub run-out is entirely eliminated since both shafts turn as a unit (with spacer installed), and angular misalignment is greatly magnified as the hub separation is increased and more precisely diagnosed. Since face readings are eliminated, there is limited concern about axial float.

One precaution that carries over to the "Reverse Indicator" method which was present in the "Face O.D." method is that of deflection or Sag in the alignment bracket. This problem can be minimized by building the bracket with substantial material to prevent SAG or by determining the deflection in the alignment fixture and making the appropriate corrections in the alignment data. (See the checking for Sag section previously discussed in this manual)



Dial indicator readings will be 2X the actual shaft centerline measurement.



Make sure the indicator stem is perpendicular and near the center of its travel before taking any readings.

In recent years people have questioned the value of the traditional "Hot Check Alignment". Not only is it costly and time-consuming to bring a machine up to temperature, stop it, break couplings, and attempt to determine alignment before it cools off, but the re-

sults are highly questionable. It is normally not possible to make the check quickly enough to accurately determine the thermal growth of the equipment. Also any hydraulic forces and torque reactions, which can be significant, are never revealed by the traditional check methods because the forces disappear immediately upon stopping the machine. One alternative is to use the cold position of the shafts as a benchmark, and deduce the hot alignment by monitoring the movement of the machine casings, shafts, or bearing centerlines from the cold position to the hot position. There are several methods used for this monitoring. A variety of techniques can be applied to the actual determination of casing or shaft movement, which includes optical or electronic (laser) techniques. In any event, a "Hot Alignment" check of the driveline alignment at operating temperatures is required.

The following factors can be used to convert from English to the most common SI Metric values.

TABLE 1 - SI METRIC CONVERSION

MEASUREMENT	MULTIPLY ENGLISH UNIT	BY FACTOR	TO OBTAIN METRIC UNIT
Capacity	Tons Refrigerant Effect (ton)	3.516	Kilowatts (kW)
Power	Horsepower	0.7457	Kilowatts (kW)
Flow Rate	Gallons / Minute (gpm)	0.0631	Liters / Second (l/s)
Length	Feet (ft)	0.3048	Meters (m)
	Inches (in)	25.4	Millimeters (mm)
Weight	Pounds (lbs)	0.4538	Kilograms (kg)
Velocity	Feet / Second (fps)	0.3048	Meters / Second (m/s)
Pressure Drop	Feet of Water (ft)	2.989	Kilopascals (kPa)
	Pounds / Square Inch (psi)	6.895	Kilopascals (kPa)

TEMPERATURE

To convert degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32° and multiply by 5/9 or 0.5556.

Example: $(45.0^{\circ}\text{F} - 32^{\circ}) \times 0.5556 = 27.2^{\circ}\text{C}$

To convert a temperature range (i.e., a range of 10°F) from Fahrenheit to Celsius, multiply by 5/9 or 0.5556.

Example: $10.0^{\circ}\text{F range} \times 0.5556 = 5.6^{\circ}\text{C range}$



P.O. Box 1592, York, Pennsylvania USA 17405-1592
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Form 160.67-N1 (814)
Issue Date: August 29, 2014
Supersedes: 160.67-N1 (504)

800-861-1001
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