CATERPILLAR®

3600 Marine Engine Application and Installation Guide

● **Piping**

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Diesel Engine Systems - Piping

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General Requirements

The requirements included for diesel main propulsion and generator set installations are not intended to replace applicable regulatory agency requirements. Their requirements should be reviewed prior to initiating system design or evaluation.

Piping should be direct with minimum bends and sufficient joints for ready accessibility and removal. It must not interfere with walkways, doors or hatches, and permit unrestricted access in walk areas and designated work spaces. Piping should clear areas required for operation and machinery control, and should be routed around machinery or tank access openings, and access openings used for shipping or receiving machinery and equipment.

Expansion joints must be used at bulkheads and decks to prevent piping damage from structure movement due to ship flexing. Use removable piping when it obstructs equipment requiring dismantling for periodic overhaul. Provide isolating valves to minimize system disruption.

Keep piping close to bulkheads, behind framing, and along the underside of decks. Leave sufficient space between pipes and spool all pipes from decks or bulkheads to permit easy maintenance and painting. Galvanizing of ferrous piping should be done only after fabrication.

Minimize piping in control rooms or over electrical equipment. When this is not possible, fix the pipe in one length with all flanges or screwed connections kept away from electrical switch gear or cabinets.

Support piping to prevent vibration damage. If subject to mechanical damage it should be adequately protected by removable metal guards. The guards must allow for inspection and painting. When subject to movement from expansion or other causes, specially designed hangers or supports must be provided. Spring type hangers should be provided when required for main engine exhaust gas pipes. Heavy items such as valves and fittings must be supported to prevent overloading the attached piping. Revise the number of supports provided, the type selected, and the location to eliminate excessive vibration of piping under all normal operating conditions.

Use flexible connections for all piping connected to the engine or other reciprocating machinery. The length and weight of piping mounted on the engine must be kept to a minimum, and the flexible connection should be placed right at the engine connection flange whenever possible. Provide pipe support on the hull side of the system piping to minimize pipe movement and flex connection loading. Flexible connections installed in piping systems for fuel oil, flammable liquids, and high pressure containment may require approval by the classification society and/or other applicable regulatory bodies.

Avoid piping arrangements with excessive turbulence, such as tee connections. High and low points should not occur. Use plugs or valves for draining in unavoidable low points. Fit high points with vent valves.

The integrity of water and oil tight areas in the ship's structure must not be disrupted by piping design. Use flange type welded connections on either side of bulkheads to permit pipe dismantling for service. Vent connections to the weather deck should have a flanged joint just above the deck to facilitate service of the vent terminal. Do not use heat sensitive material, such as PVC piping in piping systems penetrating water or oil tight division bulkheads, or for systems transporting flammable materials such as fuel oil, diesel oil and lube oil. PVC or other such piping material must also meet all applicable classification society approval.

Valves should normally be gate or globe type, except for throttling purposes where globe type valves should be used. Pay special attention to the selection of seat, stem and trim materials. Improper material application may result in the accelerated corrosion and failure of salt water service valves, and deterioration of seat materials in ball and butterfly valves used in fuel oil and lube oil transfer systems. The substitution of butterfly or ball valves can be made where permitted by classification societies. Do not use butterfly or ball valves where close, controllable throttling is mandatory. Hand wheels or operating levers of valves should be easily operated from a walkway or deck. Unless obvious, provide valves with nameplates clearly stating their purpose. Valves attached to the ships hull or oil tanks should be selected and arranged based on classification society requirements.

Safety or relief valve inlet piping should be as short as possible. Where discharging to atmosphere, direct the open end of pipes away from machinery, electrical equipment, or operating personnel. Discharge oil system relief valves to the low pressure side of the system.

System monitoring gauges, thermometers, etc. should be visible from operating areas. Thermometers should have separate wells. Pressure gauges should have test tees. Locate isolating valves close to the main piping run. Pressure gauges, pressure switches, or similar instrumentation used in heated fuel oil piping systems, should be the filled or electric transmitter type.

Vent tanks containing flammable fluids and the engine crankcase to atmosphere with a gooseneck ventilator and flame screens and closures. Air vent discharges must not enter ventilation air inlets, openings to accommodations or work spaces, discharge on machinery, electrical equipment, or personnel. Thoroughly clean all piping and equipment after fabrication and prior to ship installation. After installation, each system must be cleaned and flushed with the applicable system's medium, or an approved substitute. The process should be reviewed by the owner, regulatory body's inspector and the engine builder. Conduct each flushing at the system's maximum operating pressure and temperature, and above normal line velocity. Remove, bypass, or blank-off heat exchangers, control valves, and other in-line components which could trap debris during the flushing process. Refer to Caterpillar procedure 3L0492 for further details on pipe flushing and pickling.

Visually inspect combustion air and exhaust gas piping systems to ensure weld slag and debris is removed prior to installation.

Piping Sizes

The following table is a pipe selection guide for suggested fluid velocities. To avoid erosion, water hammer, or the possibility of noise, the upper velocity limits should not be exceeded. The final pipe sizes should be selected based on considerations of piping layout, number of fittings, valves, viscosity of fluid passing through the pipe, and pressure drop. Head loss on the suction side of pumps should be carefully analyzed. Compare the losses in the suction piping to the net positive suction head available with the specific pump selected.

Fluid Design Velocities

Service	Nominal[a] m/sec (ft/sec)	Limit m/sec (ft/sec)
Hot water suctions	0.06√d (√d)	.9 (3)
Hot-water discharge	0.18√d (3√d)	2.4 (8)
Cold fresh water suction	0.18√d (3√d)	4.6 (15)
Cold fresh water discharge	0.30√d (5√d)	6.1 (20)
Lube oil service pump suction	0.06√d (√d)	1.2 (4)
Lube oil discharge	0.12√d (2√d)	1.8 (6)
Fuel oil service suction	0.06√d (√d)	1.2 (4)
Fuel oil service discharge	0.09√d (1.5√d)	1.8 (6)
Fuel oil transfer suction	0.06√d (√d)	1.8 (6)
Fuel oil transfer discharge	0.12√d (2√d)	4.6 (15)
Diesel oil suction	0.12√d (2√d)	2.1 (7)
Diesel oil discharge	0.30√d (5√d)	3.7 (12)
Hydraulic oil suction	0.09√d (1.5√d)	2.4 (8)
Hydraulic oil discharge	0.48√d (8√d)	6.1 (20)
Seawater suctions[b]	0.18√d (3√d)	4.6 (15)
Seawater discharge[b]	0.30√d (5√d)	4.6 (15)
Steam	3.00√d (50√d)	61.0 (200)
Steam exhaust, 14 800 kPag (215 psig)	4.54√d (75√d)	76.2 (250)
Steam exhaust, high vacuum	4.54√d (75√d)	100.6 (300)

[a] d is the pipe internal diameter in mm (inches)
[b] 2.7 m/sec (8.8 ft/sec) nominal velocity for galvanized steel pipe

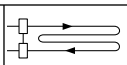
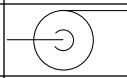
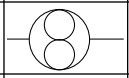
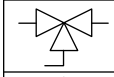
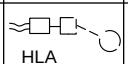
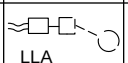
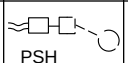
Schedule of Piping

Figure 1 is a guide for preparing piping schedules. It is not intended to replace specific requirements of applicable classification societies or regulatory bodies.

Abbreviations

ASTM	American Society of Testing and Materials	CuNi	copper-nickel
		Galv.	galvanized
Brz.	bronze	Sch	schedule
Cu.	copper	Std.	standard
		Wt.	weight

Piping Symbol

Symbol	Description	Symbol	Description	Symbol	Description
	Gate Valve		Un-Insulated Pipe		Tank Heating Coil
	Gate Valve with Remote Operating Gear Attached		Insulated Pipe		Gauge Glass (Automatic Closure)
	Locked "Open" Valve		Air Vent with Flame Screen		Plate Heat Exchange
	Locked "Closed" Valve		Air Vent w/Flame Screen & Closure		Shell and Tube Heat Exchanger
	Globe Valve		Air Vent w/Flame Screen, Check Valve & Closure		Centrifugal Pump
	Screw Down Non-Return Valve		Drip Pan		Positive Displacement Pump
	Lock Shut Valve		Thermometer		Manhole in Tank
	Swing Check Valve		Thermometer		Flow Meter
	Three -way Cock		High Temperature Alarm		Pipe Return to Tank
	Air Operated Three-Way Cock (or Valve)		Low Temperature Alarm		Pump Suction Bell
	Relief Valve		High Level Alarm		Filter
	Angle Valve		Low Level Alarm		Differential Pressure Indicator
	Pressure Control Valve		Pump Start		Pressure Switch
	Self-Contained Temperature Control Valve w/ Manual Override		Pump Stop		Alarm
	Butterfly Valve		Pressure Switch		Motor
	Ball Valve		Steam Blow-Out		
	In-Line Relief Valve		Sounding Valve with Lever		
	Diverting Valve with Manual Lever		Simplex Strainer		
	Temperature Control Valve		Duplex Strainer		
	Air Operated Butterfly Valve		Orifice Plate		
	Flexible Connector		Pressure Gauge		
	Flexible Connector		Level Indicator		

Schedule of Piping

SYSTEM		PIPING		TAKE DOWN JOINTS		BOLTS	NUTS	GASKETS	VALVES				FITTINGS		GENERAL NOTES
##	SERVICE	SIZE	TYPE	SIZE	TYPE				SIZE	PRESS	MATERIAL	TRIM	SIZE	TYPE	
1	Cooling Fresh Water	Above 10mm (.5 in.)	Seamless, ASTM A106, Sch. 40 Grade A or B	Above 10mm (.5 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve	ASTM A307 Grade B	ASTM A307 Grade B	Inserted Rubber Sheet	50mm (2 in.) and above	125#	Cast Iron or Forged Steel Flanged	Brass	50mm (2 in.) and Above	Forged Steel Std. Wt.,Butt Welded ends, ASTM A-234	
		10mm (.5 in.) and Below	Seamless Copper, ASTM B88, Type K or L	Below 10mm (.5 in.)	Brass Unions, Bite Joint or Sleeve				40mm (1-.5 in.) and below	200#	Bronze	Brass	40mm (1.5 in.) and Below	Ductile Iron, Forged Steel, or Brz., Screwed	
2	Cooling Sea Water	Above 10mm (.5 in.)	90 / 10 CuNi Pipe	Above 10mm (.5 in.)	Bronze Flanges, Brazed.	ASTM A307 Galv.	ASTM A307 Galv.	Inserted Rubber Sheet	50mm (2 in.) and above	125# 150#	Cast Iron, Flanged Cast Steel, Flanged	Brass or Monel	Above 10mm (.5 in.)	Bronze, Brazed; or Built-up Cu, Flanged	Or use ## 3 which is acceptable substitute
		10mm (.5 in.) and Below	Seamless Copper, ASTM B88, Type K or L	Below 10mm (.5 in.)	Brass Unions, Bite Joint or Sleeve				40mm (1-1/2 in.) and below	200#	Bronze, Flanged or Screwed	Brass or Monel	10mm (.5 in.) and Below	Brass Joints	
3	Sea Chest, Overboard, Air Vent, and Blow-Out Conn.	All	Seamless, ASTM A106, Sch. 80 Grade A or B, Galvanized	Above 10mm (.5 ft.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve	ASTM A307 Galv.	ASTM A307 Galv.	Inserted Rubber Sheet	50mm (2 in.) and above	150#	Cast Steel, Flanged	Brass or Monel	50mm (2 in.) and Above	Butt Welded Galvanized	
				Below 10mm (.5 ft.)	Brass Unions, Bite Joint or Sleeve				40mm (1-.5 in.) and below	200#	Bronze, Flanged	Brass or Monel	40mm (1.5 in.) and Below	Ductile Iron or Forged Steel, Galv. Screwed	
4	Oil & Fuel-Filling,Transfer, and Service	Above 10mm (.5 in.)	Seamless, ASTM A106, Sch. 40 Grade A or B	Above 10mm (.5 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve	ASTM A307 Galv.	ASTM A307 Galv.	Nitrile	50mm (2 in.) and above	125# 150# *	Cast Iron or Forged Steel, Flanged Cast Steel, Flanged	Brass	50mm (2 in.) and Above	Forged Steel Std. Wt.,Butt Welded ends, ASTM A-234	*Valves on Oil & Fuel tanks will be Cast Steel Flanged
		10mm (.5 in.) and Below	Seamless Copper, ASTM B88, Type K or L	Below 10mm (.5 in.)	Brass Unions, Bite Joint or Sleeve				40mm (1.5 in.) and below	200#	Bronze, Flanged or Screwed	Brass	40mm (1.5 in.) and Below	Ductile Iron or Forged Steel Screwed or Socket Weld	
5	Exhaust Gas	All	Steel Resistance Welded, ASTM A53*	All	Steel Plate Flanges	ASTM A307 Galv.	ASTM A307 Galv.	Hi-Temp., Asbestos Free					All	Forged Steel, Butt Welded Flngd. (Flex conns. to be Stainless Steel)	*Pipe to be at least 7mm (.25 in.) thick
6	Exhaust Gas - Open Drains	All	Steel Resistance Welded, ASTM A53 Sch.40						50mm (2 in.) and above	200#	Bronze, Flanged or Screwed	Brass	All	Forged Steel, Butt Welded	
									40mm (1.5 in.) and below	200#	Bronze, Flanged or Screwed	Brass	All	Forged Steel, Butt Welded	
7	Starting Air and Control Air	Above 10mm (.5 in.)	Seamless, ASTM A106, Sch. 40 Grade A or B	Above 10mm (.5 in.)	Steel Slip-on Welded Flanges, Butt Welded or Sleeve	ASTM A307 Galv.	ASTM A307 Galv.	Nitrile	50mm (2 in.) and above	150#	Cast Iron or Forged Steel, Flanged	Brass	50mm (2 in.) and Above	Forged Steel, Flanged or Butt Welded	
		10mm (.5 in.) and Below	Seamless Copper, ASTM B88, Type K or L	Below 10mm (.5 in.)	Brass Unions, Bite Joint or Sleeve				40mm (1.5 in.) and below	200#	Bronze, Flanged or Screwed	Brass	40mm (1.5 in.) and Below	Forged Steel, Screwed or socket weld	

Figure 1

Materials and specifications are
subject to change without notice.

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