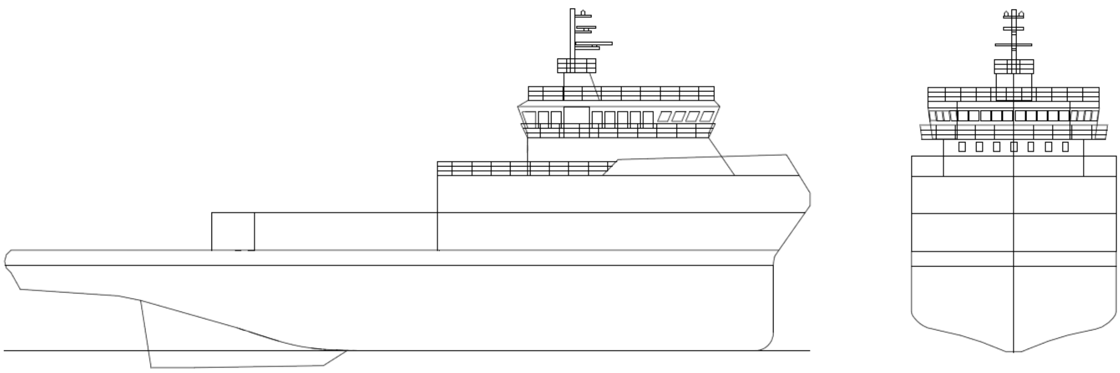
REMOLCADOR DE ALTURA POLIVALENTE

ESCUELA POLITÉCNICA SUPERIOR

UNIVERSIDAD DE A CORUÑA

PROYECTO FIN DE GRADO 2014/2015

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE



CUADERNO 10: DEFINICIÓN DE LA PLANTA PROPULSORA Y SUS AUXILIARES

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DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

CURSO 2.014-2015

PROYECTO NÚMERO

TIPO DE BUQUE: Remolcador de Altura Polivalente, escolta, lucha contra incendios y lucha contra la contaminación.

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: American Bureau of Shipping, Solas, Marpol.

CARACTERÍSTICAS DE LA CARGA: 130 toneladas de tiro a punto fijo, 700 toneladas de carga en cubierta.

VELOCIDAD Y AUTONOMÍA: 15 nudos al 85 % de la MCR, 15 % de margen de mar, autonomía de 8000 millas.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA: Maquinillas de remolque en proa y popa, gancho giratorio y articulado, los habituales en este tipo de buques.

PROPULSIÓN: Propulsión diésel-eléctrica, propulsores azimutales tipo Schottel.

TRIPULACIÓN Y PASAJE: 14 tripulantes, 60 supervivientes.

OTROS EQUIPOS E INSTALACIONES: Hélice transversal en proa,

Ferrol, 23 de Marzo de 2.015

ALUMNO: D. Mario Teijeiro Prieto.

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1. INTRODUCCIÓN

En este cuaderno se definirá la configuración de la planta propulsora. Esta tiene la finalidad de alimentar a los motores eléctricos para la propulsión que han sido definidos en el cuaderno 6, y satisfacer las necesidades eléctricas del buque, las cuáles han sido descritas en el cuaderno 11.

Una vez definidos los generadores del buque se estimará el consumo total de combustible y se comprobará la autonomía.

Además se diseñarán los sistemas auxiliares según los requerimientos del reglamento de la sociedad de clasificación ABS, el reglamento SOLAS y los requerimientos del fabricante. Los sistemas auxiliares definidos serán los sistemas de combustible, refrigeración y aceite.

Por último se realizará un plano de disposición preliminar de la cámara de máquinas.

2. JUSTIFICACIÓN DE LA ELECCIÓN DEL EQUIPO PROPULSOR

La propulsión planteada es de tipo diésel – eléctrica ya que es uno de los requisitos del proyecto en su RPA.

Además este tipo de propulsión es de los más empleados en este tipo de buques. A continuación se describirán las principales ventajas e inconvenientes de este tipo de propulsión con respecto a la propulsión convencional para justificar su aplicación al proyecto:

Ventajas generales:

- Reducción del ruido y las vibraciones.
- Disminución de los costes operacionales debido a la reducción en el consumo de combustible si existen grandes variaciones de demanda.
- Mejora de la maniobrabilidad y capacidad de posicionamiento al utilizar propulsores azimutales.

Ventajas en la propulsión:

- Se reduce al mínimo la longitud de la línea de ejes.
- Permite operar con velocidades variables.
- Se alcanza un par máximo a bajas velocidades.

Ventajas de generación de energía:

- La operación puede producirse en elevadas cargas con gran eficiencia del motor.
- La fiabilidad es mayor al contar con múltiples generadores.
- La planta posee una gran flexibilidad de distribución.
- Descarga de CO2 y NOx reducidos debido a la optimización del régimen de carga de los generadores.

Desventajas principales:

- La inversión inicial es mayor al ser mayor su coste de adquisición.
- Aumento de pérdidas mecánicas entre el generador y el propulsor al haber un mayor número de equipos y componentes eléctricos.
- Necesidad de una mayor formación de la tripulación.

3. ELECCIÓN DE LOS GENERADORES.

3.1 Generación principal de energía eléctrica

La potencia total que se instalará en el buque se determinará para la condición con mayores necesidades eléctricas. Para ello se ha realizado una primera aproximación de la potencia necesaria en cada condición de navegación del buque en el cuaderno 11. En esta aproximación no se han tenido en cuenta los equipos de los servicios para la propulsión ya que estos se calcularán en el presente cuaderno. Estos servicios son el servicio de combustible, el sistema de lubricación, el sistema de refrigeración, máquinas auxiliares para el arranque, etc.

Los resultados obtenidos en el cuaderno 11 en esta primera aproximación muestran que la condición de mayor demanda eléctrica es la condición de remolque:

$$Potencia\ remolque = 9191{,}578\ kW$$

A partir de este valor de potencia necesaria se estudiarán las distintas alternativas de generadores que permitan obtener esta potencia a un régimen aceptable en todas las condiciones eléctricas estudiadas. Este régimen se tomará entre un 80 y un 98 % de la potencia máxima de los generadores.

Como primera opción se ha estudiado la combinación de dos generadores del mismo modelo ya que sería la mejor opción respecto a la reducción de costes de mantenimiento, piezas de repuesto y simplicidad de diseño.

Configuración con dos motores		
Motores	Engine(kW)	Generator (kW)
W9L32	5220	5037,3
Condición	Demanda (kW)	% Utilización
Remolque	9191,578	91,2
Navegación libre	2466,916	49
Anti contaminación	3335,116	66,2
Contra incendios	4872,874	96,7
Rescate	2338,181	46,4

Como puede verse esta opción no es viable en la mayoría de condiciones de navegación por lo que ha sido descartada.

A continuación se comprueba la opción de disponer 3 generadores iguales para conseguir las mismas ventajas que la anterior ocasión:

Configuración con tres motores iguales		
Motores	Engine(kW)	Generator (kW)
W6L32	3480	3358,2
Condición	Demanda (kW)	% Utilización
Remolque	9191,578	91,2
Navegación libre	2466,916	73,5
Anti contaminación	3335,116	99,3
Contra incendios	4872,874	72,6
Rescate	2338,181	69,6

Esta opción tampoco resulta viable ya que existen 3 condiciones en las que el % de utilización de los generadores baja del 80 %.

Por último se ha estudiado la opción de instalar 3 generadores con potencias distintas para poder tener una mayor flexibilidad operativa:

Configuración con tres motores		
Motores	Engine (kW)	Generator (kW)
W9L32	5220	5037,3
8L 26	2720	2625
6L 26	2040	1969
Condición	Demanda (kW)	% Utilización
Remolque	9191,578	95,4
Navegación libre	2466,916	94
Anti contaminación	3335,116	72,6
Contra incendios	4872,874	96,7
Rescate	2338,181	89,1

Finalmente se ha optado por esta opción ya que es en la que se obtiene un mayor % de utilización en la condición de navegación libre que es la que más tiempo ocupará en la operación del buque. El resto de condiciones de navegación se encuentran en un rango aceptable de % de utilización que en comparación con las otras opciones valoradas se acerca mucho más al rango óptimo buscado.

3.2 Generador de emergencia

Además del conjunto de generadores que alimentan la red eléctrica, se dispondrá un generador de emergencia independiente. Para su definición se utilizará la potencia obtenida en el balance eléctrico realizado en el cuaderno 11 en la condición de emergencia:

$$Potencia\ de\ emergencia = 129{,}737\ kW$$

El generador de emergencia instalado cumplirá con los siguientes requerimientos del SOLAS:

La fuente de energía eléctrica de emergencia, el correspondiente equipo transformador, la fuente transitoria de energía de emergencia, el cuadro de distribución de emergencia y el cuadro de distribución de alumbrado de emergencia estarán situados por encima de la cubierta corrida más alta y tendrán acceso fácil desde la cubierta expuesta. No estarán situados a proa del mamparo de colisión.

La ubicación de estos equipos será tal que un incendio o cualquier siniestro sufridos en el espacio que contenga la fuente de energía principal, el correspondiente equipo transformador y el cuadro de distribución principal, o en cualquier espacio de categoría A para máquinas, no dificultarán el suministro y distribución de energía eléctrica de emergencia.

En la medida de lo posible, el espacio que contenga los equipos de emergencia no será contiguo a los mamparos límite de los espacios de categoría A para máquinas o de los espacios que contengan la fuente de energía eléctrica principal, transformador y cuadro eléctrico principal.

Si la fuente de energía eléctrica es un generador:

Estará accionado por un motor eléctrico apropiado con alimentación independiente de combustible.
Arrancará automáticamente en menos de 45 segundos en el momento que falle el suministro de la fuente de energía eléctrica principal, a menos que haya instalada una fuente transitoria de energía eléctrica de emergencia. Si el generador de emergencia arranca automáticamente, quedará conectado automáticamente al cuadro de distribución de emergencia.
A menos que el generador de emergencia tenga un segundo dispositivo de arranque independiente, la fuente única de energía acumulada estará protegida de modo que no la pueda agotar completamente el sistema de arranque automático.

El local donde será ubicado el generador de emergencia se ha definido en la cubierta 2 por lo que se cumplen todos los requisitos citados por el SOLAS.

El generador diésel de emergencia elegido es de la marca comercial CAT y cuenta con las siguientes características:

Modelo	CAT C12
Potencia (kW)	254 kW
Rpm	1800
Peso (kg)	1174
Frecuencia (Hz)	50

4. ESTIMACIÓN DEL CONSUMO DE LOS GENERADORES

4.1 Consumo de combustible

Una vez determinada la necesidad eléctrica del buque y los motores diésel - generadores que se instalarán se calculará el consumo total de combustible en la condición de navegación libre:

$$Consumo = \frac{Consumo_{específico}\left(\frac{g}{kW * h}\right) * Horas\ servicio * Potencia\ (kW)}{10^6}$$

Primero se calcularán las horas de servicio a partir de la autonomía y la velocidad de servicio que son requisitos del proyecto en su RPA:

$$Horas\ de\ servicio = \frac{Autonomía\ (millas)}{V_s\ (nudos)} = \frac{8000}{15}$$

$$Horas\ de\ servicio = 533{,}33\ h$$

	Navegación libre		
	W9L32	8L 26	6L 26
Nº motores utilizados	0	1	0
Consumo específico 100% (g/kWh)	184	190	187
Potencia (kW)	5037,3	2625	1969
% Utilización	0	94%	0
Potencia consumida (kW)	0	2467,5	0
Consumo (ton)	0	250,038	0
Consumo total (ton)	250,038		
Consumo (m3)	280,94		

4.2 Capacidad de los tanques de combustible

La capacidad de los tanques de combustible estará definida por el cálculo realizado en el apartado anterior para la condición de navegación libre.

Los tanques definidos son los siguientes:

Tanque	Tipo de tanque	Capacidad (m3)
Sedimentación	Sedimentación	25,02
Uso diario ER	Uso diario	37,38
Uso diario BB	Uso diario	37,38
D.O.1	Almacén	69,51
D.O.2.	Almacén	69,51
D.O.3.	Almacén	55,815
D.O.4.	Almacén	55,815
D.O.5.	Almacén	26,025
D.O.6.	Almacén	26,025
D.O.7.	Almacén	53,34
D.O.8.	Almacén	53,34

La capacidad de los tanques es estimada al realizarse sin tener en cuenta las formas del buque. El volumen real de los tanques sería inferior a este y por esto se ha dejado un margen suficiente de capacidad.

4.3 Consumo de aceite lubricante

El cálculo del consumo de aceite lubricante se ha realizado de la misma forma que el cálculo para el consumo de combustible.

	Navegación libre		
	W9L32	8L 26	6L 26
Nº motores utilizados	0	1	0
Consumo específico 100% (g/kWh)	0,35	0,5	0,5
Potencia (kW)	5037,3	2625	1969
% Utilización	0	94%	0
Potencia consumida (kW)	0	2467,5	0
Consumo (ton)	0	0,658	0
Consumo total (ton)	0,658		
Consumo (m3)	0,741		

4.4 Capacidad de los tanques de aceite lubricante

Los tanques definidos son los siguientes:

Tanque	Capacidad (m3)
Aceite C -1	12,57
Aceite C-2	12,57

La capacidad de aceite se ha definido muy por encima del consumo calculado de los generadores en la condición de navegación libre ya que el aceite es también necesario para los demás equipos consumidores de aceite.

5. SISTEMAS AUXILIARES DE LA PROPULSIÓN

5.1 Sistema de combustible

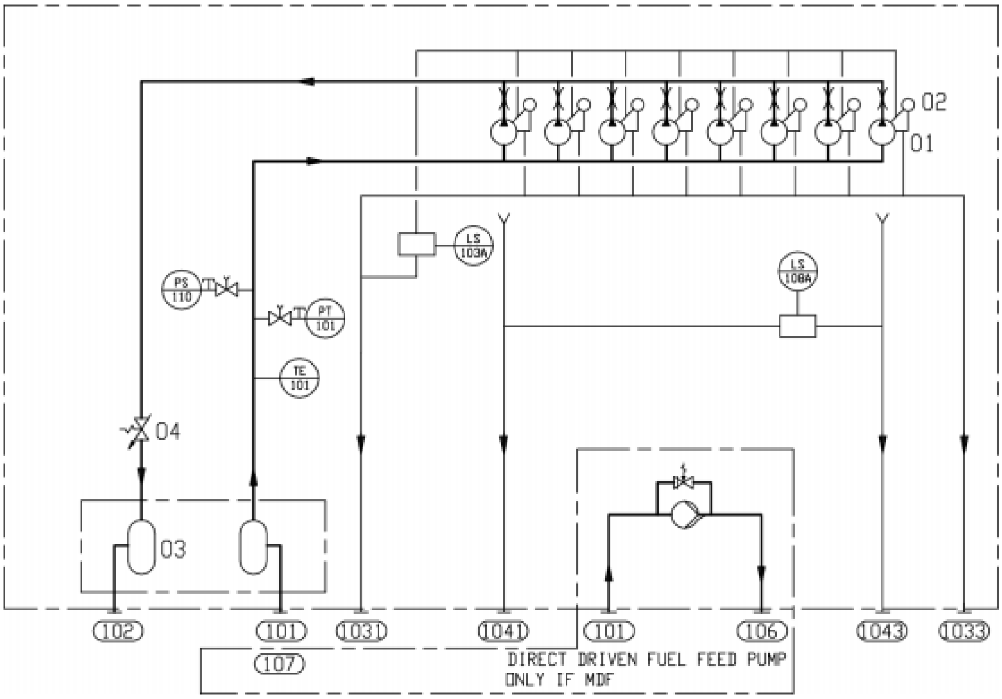
El sistema de combustible se utilizará para controlar la temperatura para mantener el grado adecuado y estable de viscosidad del combustible antes de las bombas de inyección. Este sistema incluirá al menos un tanque de sedimentación y dos separadoras.

Según los requerimientos del SOLAS, en instalaciones de múltiples motores que se encuentren conectados al mismo circuito de combustible, debe ser posible cerrar el suministro de combustible y retornar las líneas conectadas al motor individualmente.

El sistema de combustible se divide en el sistema interno del propio motor y el sistema exterior al motor:

Sistema interno del motor

Motor W9L32:



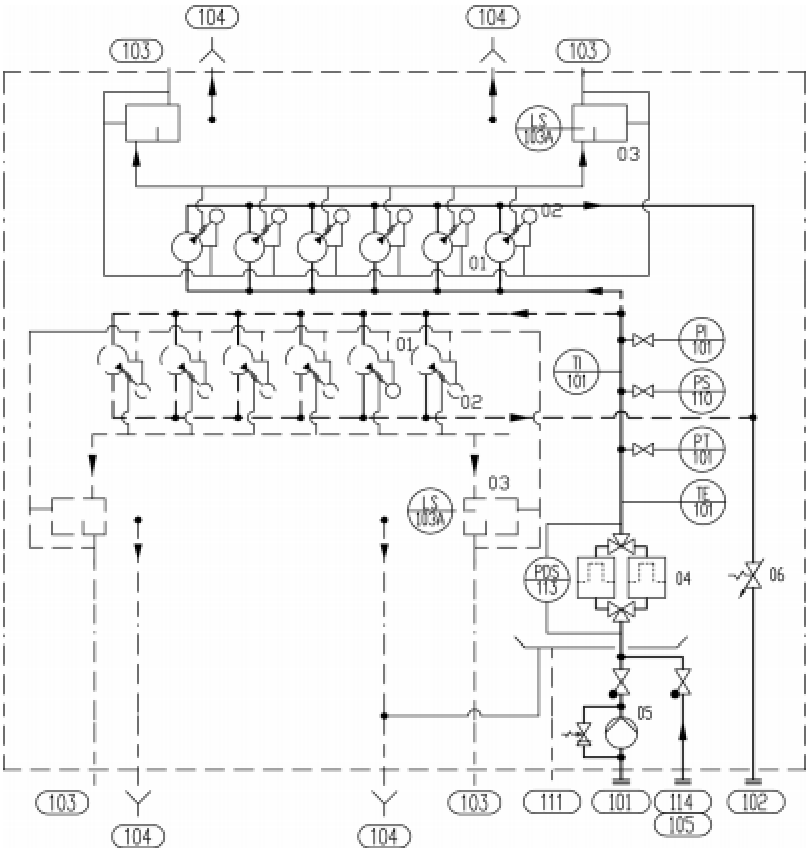
System components:					
01	Injection pump	03	Pulse damper (for 500 kW/cyl)	Option A: Option B:	Pressure relief valve Without pressure relief valve
02	Injection valve	04	Pressure relief valve		

Sensors and indicators:			
LS103A	Fuel oil leakage, injection pipe A-bank	PT101	Fuel oil pressure, engine inlet
LS108A	Fuel oil leakage, dirty fuel A-bank	TE101	Fuel oil temperature, engine inlet
PS110	Fuel oil stand-by pump start (if stand-by)		

Pipe connections:		Size	Pressure class	Standard
101	Fuel inlet	DN32 (DN40)*	PN40	ISO 7005-1
102	Fuel outlet	DN32	PN40	ISO 7005-1
1031	Clean fuel leakage, outlet	OD28		DIN 2353
1033	Clean fuel leakage, outlet	OD28		DIN 2353
1041	Dirty fuel leakage, outlet	OD18		DIN 2353
1043	Dirty fuel leakage, outlet	OD28		DIN 2353
106	Fuel to external filter	DN32	PN40	ISO 7005-1
107	Fuel from external filter	DN32	PN40	ISO 7005-1

) DN40 if engine driven fuel feed pump

Motores 8L26 y 6L26:



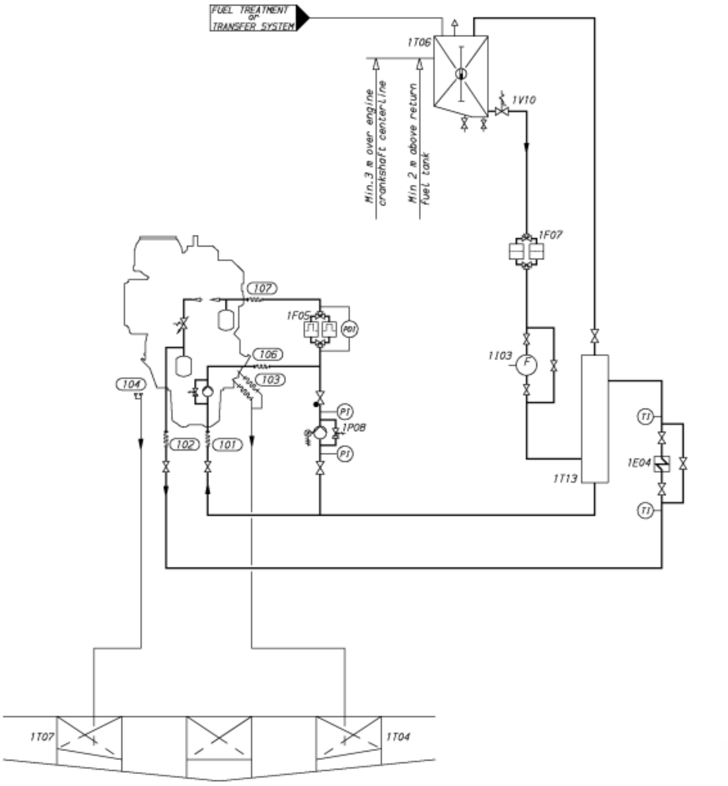
System components					
01	Injection pump	03	Fuel oil leakage collector	05	Engine driven fuel feed pump
02	Injection valve	04	Duplex fine filter	06	Pressure regulating valve

Sensors and indicators			
PT101	Fuel oil pressure, engine inlet	TI101	Fuel oil temperature, engine inlet
TE101	Fuel oil temperature, engine inlet	PI101	Fuel oil pressure, engine inlet (if GL)
LS103A/B	Fuel oil leakage, injection pipe	PS110	Fuel oil stand-by pump start (if stand-by pump)
PDS113	Fuel oil filter, pressure difference		

Pipe connections		Size	Pressure class	Standard
101	Fuel inlet	DN32	PN16	DIN2633/DIN2513 R13
101	Fuel inlet, 16V	DN40	PN16	DIN2633/DIN2513 R13
102	Fuel outlet	L26: DN32 V26: DN25	PN16	DIN2633/DIN2513 V13
103	Leak fuel drain, clean fuel	OD22	PN250	DIN2353
104	Leak fuel drain, dirty fuel	OD22	PN250	DIN2353
105	Fuel stand-by connection, in-line engines	L26: DN32 V26: DN25	PN16	DIN2633
111	Drain from fuel filter drip tray, V-engines only	OD22	PN250	DIN2353
114	Fuel from starting/day tank, in-line engines	L26: DN32 V26: DN25	PN16	DIN2633

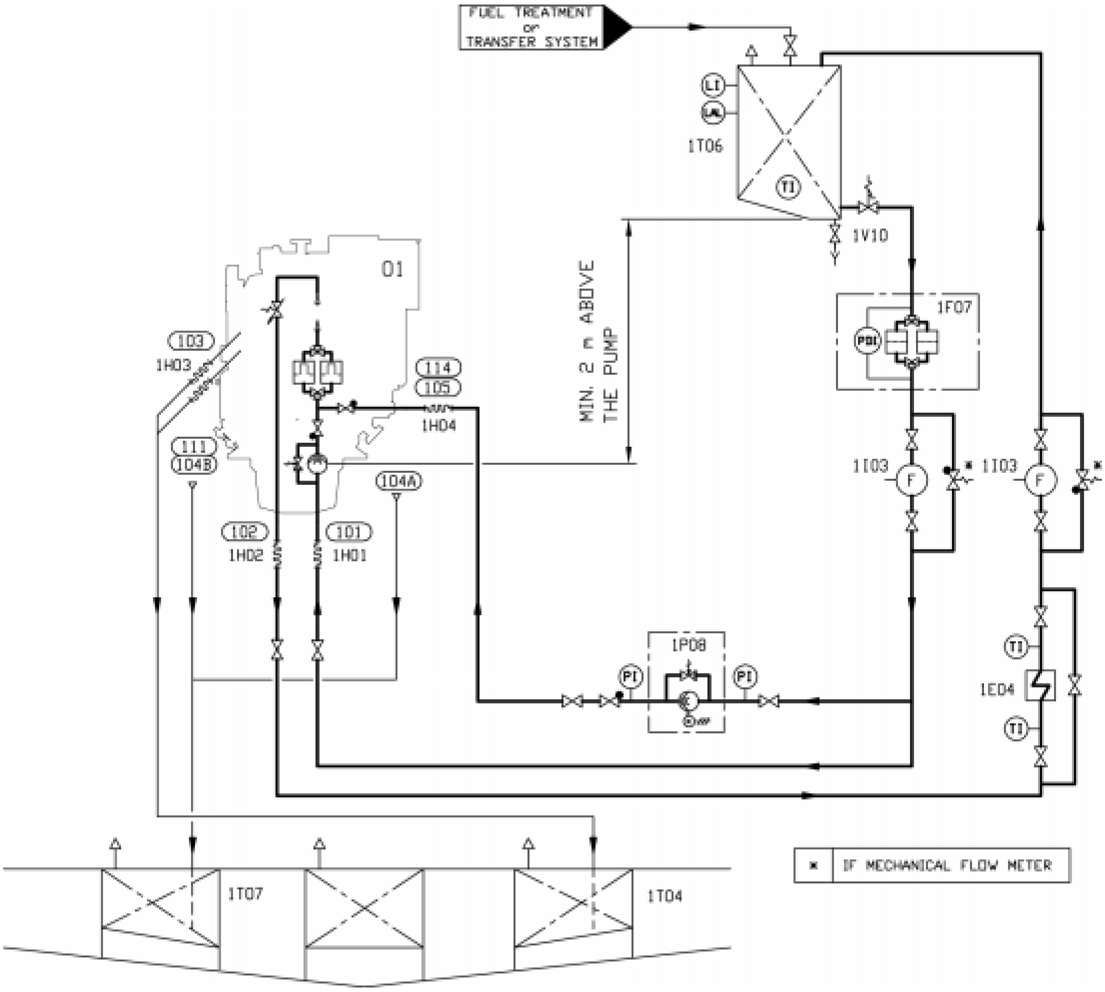
Sistema externo de combustible

Motor W9L32:



System components		Pipe connections	
1E04	Cooler (MDF)	101	Fuel inlet
1F05	Fine filter (MDF)	102	Fuel outlet
1F07	Suction strainer (MDF)	103	Leak fuel drain, clean fuel
1I03	Flow meter (MDF)	104	Leak fuel drain, dirty fuel
1P08	Stand-by pump (MDF)	106	Fuel to external filter
1T04	Leak fuel tank (clean fuel)	107	Fuel from external filter
1T06	Day tank (MDF)		
1T07	Leak fuel tank (dirty fuel)		
1T13	Return fuel tank		
1V10	Quick closing valve (fuel oil tank)		

Motores 8L26 y 6L26:



System components			
01	Diesel engine Wärtsilä L26	1P08	Stand-by pump, MDF
1E04	Cooler (MDF)	1T04	Leak fuel tank, clean fuel
1F07	Suction strainer, MDF	1T06	Day tank, MDF
1H0X	Flexible pipe connection	1T07	Leak fuel tank, dirty fuel
1I03	Flow meter	1V10	Quick closing valve (fuel oil tank)

Pos	Pipe connections	Size
101	Fuel inlet	DN32
102	Fuel outlet	DN32
103	Leak fuel drain, clean fuel	2 * OD22
104A	Leak fuel drain, dirty fuel	Plug R3/4"
104B	Leak fuel drain, dirty fuel	OD22
105	Fuel stand-by connection	DN32
111	Drain fuel from fuel filter drip tray	OD22
114	Fuel from starting/day tank	DN32

5.1.1 Dimensionamiento de los tanques de combustible

Almacén, uso diario y sedimentación

El combustible almacenado en los tanques almacén, se transfiere a los tanques de sedimentación donde se produce una separación inicial de lodos y agua del combustible. De estos se transfiere el combustible a los tanques de uso diario y estos suministran el combustible a los motores.

Para el dimensionamiento del tanque de sedimentación se recurrirá a la guía técnica del motor. Según ella el tanque de sedimentación deberá poseer una capacidad suficiente para 24 h de operación con el consumo máximo de combustible, de forma que se asegura un tiempo suficiente para la sedimentación. Al tratarse de MDF los tanques de sedimentación no necesitan un sistema de calefacción.

Para el dimensionamiento de los tanques de uso diario se requiere de un tanque con capacidad suficiente para asegurar el suministro de combustible durante 8 horas. La temperatura del interior de los tanques deberá de encontrarse entre los 20 y los 40ºC. Además, deberá asegurarse una presión estática positiva en la succión de las bombas de alimentación del combustible.

La capacidad que los tanques de uso diario tendrían que tener como mínimo para el suministro de 24 h de combustible sería:

Consumo 24 h	11,2518

Los tanques de uso diario que se han definido tienen una capacidad mayor a la calculada para dejar un margen de seguridad:

Tanque	Tipo de tanque	Capacidad (m3)
Uso diario ER	Uso diario	37,38
Uso diario BB	Uso diario	37,38

La capacidad mínima del tanque de sedimentación será la suficiente para 24 h de operación:

Consumo 24 h	11,2518

De la misma forma que los tanques de uso diario, el tanque de sedimentación también tendrá una capacidad mayor a la mínima necesaria:

Tanque	Capacidad (m3)
Sedimentación	25,02

Por último, los tanques almacén tendrán la capacidad suficiente como para alcanzar la autonomía requerida para el buque proyecto de 8000 millas. La capacidad total de combustible necesario ya ha sido calculada en el apartado 4.1 de este cuaderno. La capacidad de los tanques de uso diario, más la capacidad del tanque de sedimentación y de los tanques almacén tendrá que ser como mínimo igual a la capacidad calculada.

La capacidad mínima necesaria para los tanques de uso diario es la siguiente:

Capacidad mínima (m3)	181,16

La capacidad estimada al realizar la disposición general del buque está muy por encima de la capacidad requerida por lo que se ha definido una nueva disposición de tanques cuyas capacidades son las siguientes:

Tanque	Tipo de tanque	Capacidad (m3)
D.O.3.	Almacén	55,815
D.O.4.	Almacén	55,815
D.O.7.	Almacén	53,34
D.O.8.	Almacén	53,34
		218,31

Tanques de lodos

Según los requerimientos del reglamento MARPOL Anexo I. Reglas para prevenir la contaminación por hidrocarburos, todos los buques con GT > 400 deben ir equipados con un tanque o tanques con adecuada capacidad para la recepción de los residuos oleaginosos tales como los que resultan de la depuración de combustibles y aceites de lubricación y de filtraciones en espacios de máquinas.

El volumen mínimo requerido por estos tanques se define de la siguiente forma:

$$V_1 = K_1 * C * D \; m3$$

Donde:

K_1 = Constante igual a 0,05.

C = Consumo diario de fuel oil (ton)

D = Tiempo máximo entre puertos donde los residuos oleaginosos pueden ser descargados (días). Se estimará un valor de 30 días.

$$V_1 = 0{,}05 * 11{,}252 * 30$$

$$V_1 = 16{,}87 \; m3$$

Se han definido dos tanques de lodos con las siguientes capacidades:

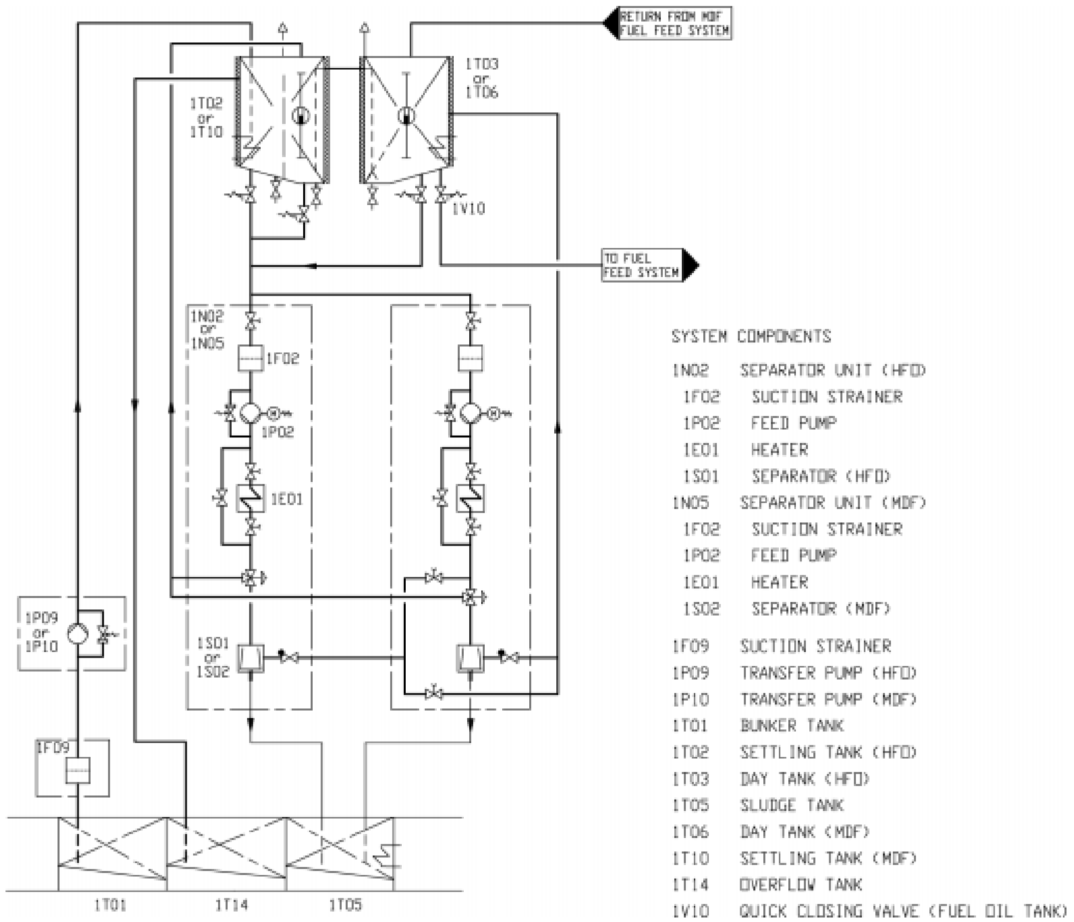
Tanque	Capacidad (m3)
Lodos 1	10,095
Lodos 2	10,095
	20,19

5.1.2 Unidad de separación

Se instalará una unidad de separación al tratarse de una instalación MDF. Esta se utilizará para la eliminación de agua y posibles contaminantes.

La capacidad de la separadora será suficiente para garantizar el suministro de fuel a máximo consumo. Los módulos de separación contarán con los siguientes componentes:

- Filtro de succión.
- Bomba de alimentación.
- Precalentador.
- Tanque de lodos.
- Separadora.
- Bomba de lodos.
- Monitorización del sistema.



Separadora

A continuación se calculará el caudal Q necesario para la separadora a partir de la fórmula especificada en la guía del motor:

$$Q = P * b * \frac{24}{\rho * t} \ kW$$

Donde:

P = Potencia máxima continua de los motores (kW).

b = Consumo específico de combustible +15% de margen de seguridad (g/kWh).

ρ = Densidad del combustible (kg/m^3)

t = Tiempo diario de separación = 23,5 h según la guía del motor.

Al aplicar esta fórmula a los tres generadores que se han definido se obtiene lo siguiente:

	W9L32	8L 26	6L 26
P (kW)	5037,3	2625	1969
b (g/kW.h)	211,6	218,5	215,05
ρ (kg/m3)	890	890	890
t (h)	23,5	23,5	23,5
Q (l/h)	**1223,114**	**658,164**	**485,891**

Al haber definido un motor de cada tipo, el caudal necesario para la separación será la suma de los anteriores:

$$\boldsymbol{Caudal\ separadora = 2,367\ m3/h}$$

El modelo comercial elegido es del fabricante Hutchison Hayes Separation Inc.:

Modelo	HH 219 MO
Capacidad (m3/h)	2,5

Bomba de alimentación de la separadora

Las características que poseerá esta bomba están definida en la guía del motor y son las siguientes:

Caudal (m3/h)	2,5
Presión de diseño (bar)	0,5
Temperatura de diseño (ºC)	50

Precalentador de la separadora

A continuación se definirá la capacidad de calor requerida para el precalentador a partir de la siguiente fórmula proporcionada por el fabricante del motor:

$$P = \frac{Q * \Delta T}{1700}\ kW$$

Donde:

Q = Capacidad de la bomba de alimentación de la separadora (l/h).

ΔT = Incremento de temperatura en el precalentador (ºC).

La temperatura recomendada después del precalentado es de entre 20 y 40 ºC para el MDF.

Q (l/h)	2367,168
T salida (ºC)	40
T entrada (ºC)	20
ΔT (ºC)	20
P (kW)	27,849

5.1.3 Bombas de trasiego de combustible

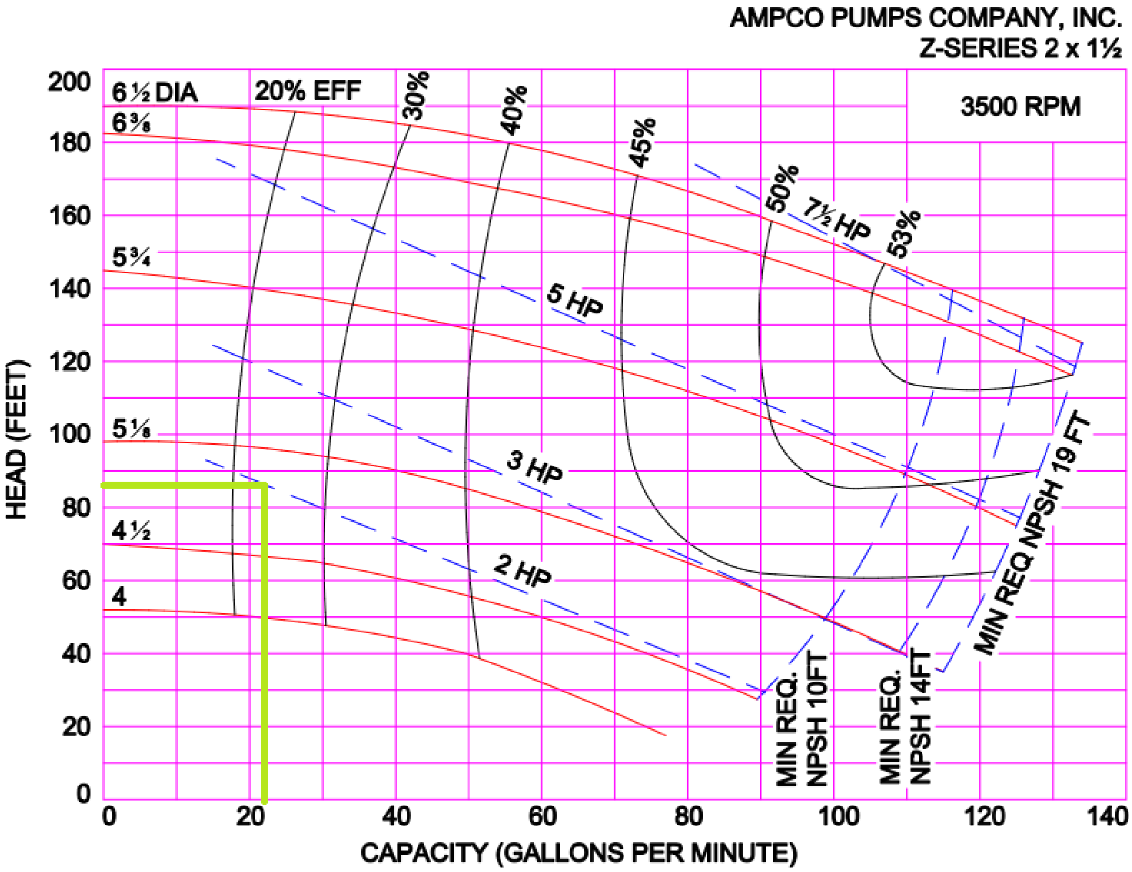
Se instalarán dos bombas de este tipo para llenar los tanques de sedimentación y se estimará el tiempo de llenado en 5 horas. A partir de la capacidad de los tanques de sedimentación se obtiene el caudal necesario para las bombas:

Capacidad tanques sedimentación (m3)	25,02
Tiempo (h)	5
Caudal (m3/h)	5
Presión (bar)	2,5
Número de bombas	2 (1 reserva)

Se utilizará una bomba para el llenado del tanque de sedimentación y se dejará otra igual de reserva.

La bomba comercial elegida tiene las siguientes características:

Marca comercial	AMPCO
Modelo	Z series 2x1 1/2
Potencia (kW)	1,5
RPM	3500



Existirá también una bomba de trasiego de combustible entre el tanque de sedimentación y los tanques de uso diario. Fijando un tiempo de llenado igual de 5 h y suponiendo un caudal equivalente:

Tiempo (h)	5
Caudal (m3/h)	5
Presión (bar)	2,5
Número de bombas	3 (1 reserva)

Se utilizarán dos bombas una para alimentar cada tanque y existirá una más de reserva. La bomba comercial elegida es la misma ya que poseerá las mismas características:

Marca comercial	AMPCO
Modelo	Z series 2x1 1/2
Potencia (kW)	1,5
RPM	3500

5.1.4 Bomba de circulación de combustible

La bomba de circulación de combustible mantiene la presión en las bombas de inyección y hace circular el combustible por el sistema. Según la guía del motor esta bomba debe de cumplir lo siguiente:

- Capacidad: 5 veces el consumo total de todos los motores conectados.
- Presión de diseño: 16 bar.
- Temperatura de diseño: 50 ºC.

	W9L32	8L 26	6L 26
Potencia (kW)	5037,3	2625	1969
Consumo específico 85% (g/kWh)	181	185	185
Consumo (m3/h)	0,9117513	0,485625	0,364265
5 x Consumo (m3/h)	4,5587565	2,428125	1,821325

Se ha definido que existirá una bomba para alimentar a cada motor y existirá otra de repuesto para cada una de las anteriores. Con esto, las características principales de las bombas de cada motor serán:

	W9L32	8L 26	6L 26
Caudal (m3/h)	4,559	2,428	1,821
Presión (bar)	16	16	16

El modelo de bomba comercial elegido es igual para los tres casos:

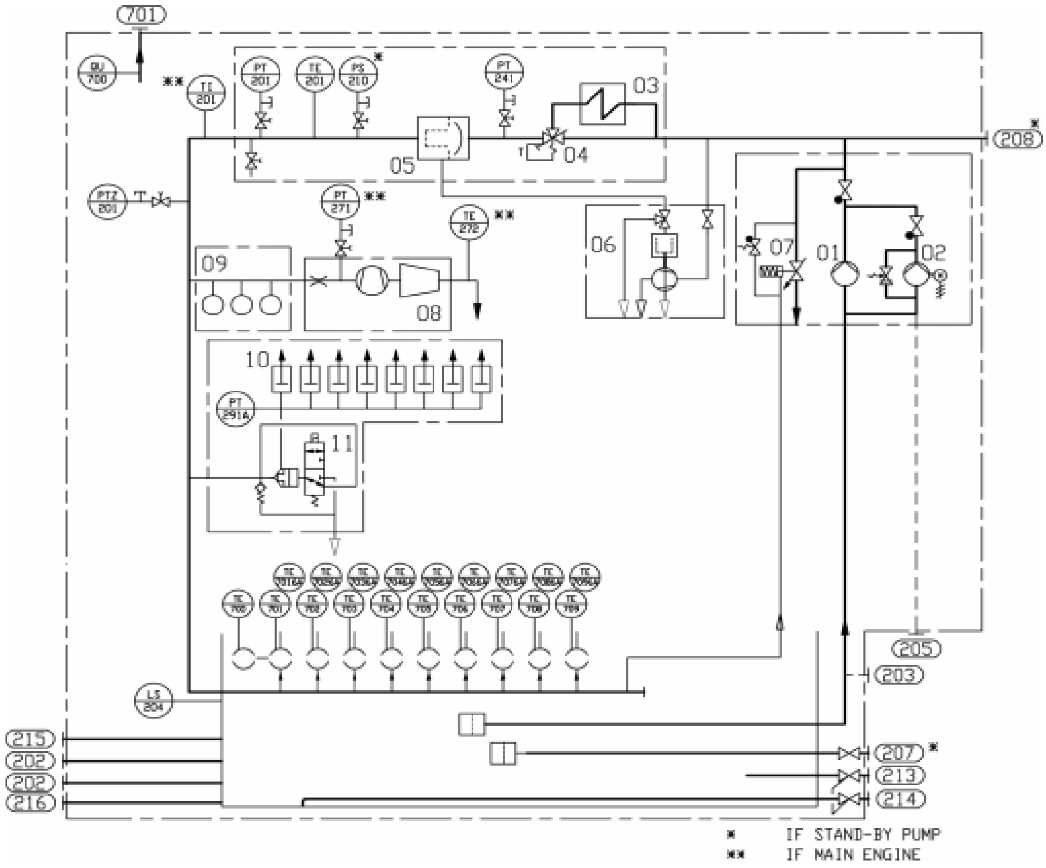
Modelo	ITUR KSB RPH mdp 25-230
Potencia máxima (kW)	32,77
Rpm	1450

5.2 Sistema de lubricación

El sistema de lubricación se dividirá también en un sistema interno y uno externo:

Sistema interno del motor

Motor W9L32:

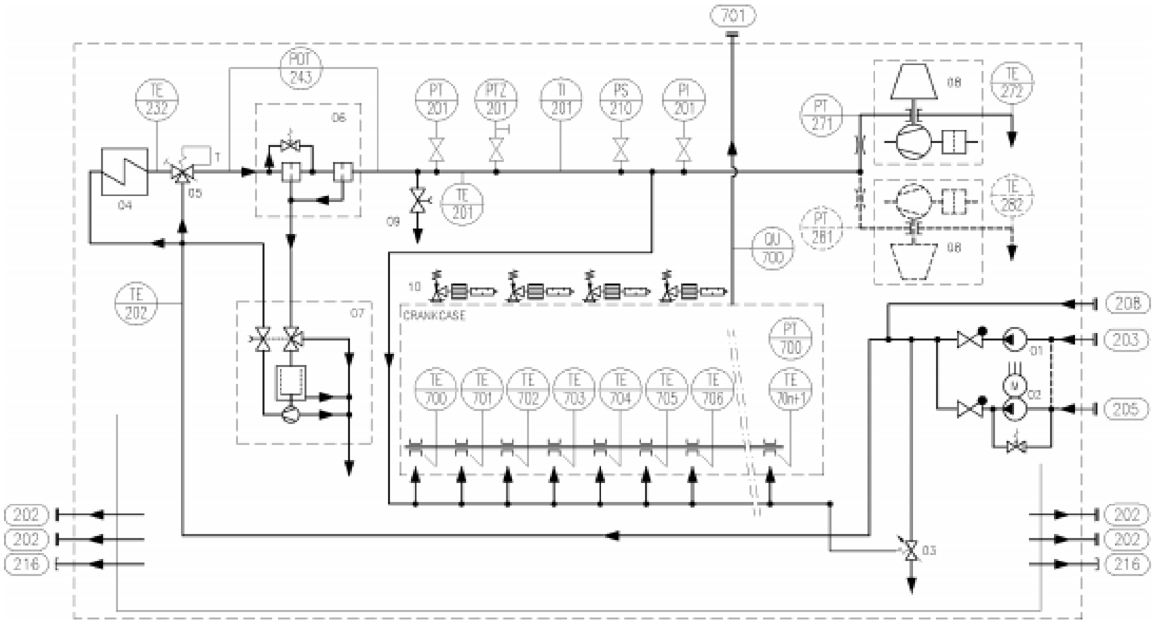


System components:			
01	Lubricating oil main pump	07	Pressure control valve
02	Prelubricating oil pump	08	Turbocharger
03	Lubricating oil cooler	09	Camshaft bearings and cylinder head lubrication
04	Thermostatic valve	10	Guide block
05	Automatic filter	11	Control valve
06	Centrifugal filter		

Sensors and indicators:			
LS204	Lubricating oil low level, wet sump	TE272	Lubricating oil temperature, TC A outlet
PS210	Lubricating oil stand-by pump start (if stand-by)	PT291A	Control air pressure after VIC valve, A-bank
PT201	Lubricating oil pressure, engine inlet	TE7#	Main bearing temperature
PT271	Lubricating oil pressure, TC A inlet (not if TPS61 turboc.)	TE70#6A	Big end bearing temp, cyl 0#A (optional)
PT241	Lubricating oil pressure, filter inlet	QU700	Oil mist detector
PTZ201	Lubricating oil pressure, engine inlet	TI201	Lubricating oil temperature, engine inlet (if ME)
TE201	Lubricating oil temperature, engine inlet		

Pipe connections:		Size	Pressure class	Standard
202	Lubricating oil outlet (dry sump)	DN150	PN16	ISO 7005-1
203	Lubricating oil to engine driven pump (dry sump)	DN200	PN16	ISO 7005-1
205	Lubricating oil to priming pump (dry sump)	DN80	PN16	ISO 7005-1
207	Lubricating oil to el. driven pump (stand-by pump)	DN150	PN16	ISO 7005-1
208	Lubricating oil from el. driven pump (stand-by pump)	DN100	PN16	ISO 7005-1
213	Lubricating oil from separator and filling (wet sump)	DN40	PN40	ISO 7005-1
214	Lubricating oil to separator and drain (wet sump)	DN40	PN40	ISO 7005-1
215	Lubricating oil filling (wet sump)	DN40		ISO 7005-1
216	Lubricating oil drain (wet sump)	M22 x 1.5		
701	Crankcase ventilation	DN100	PN16	ISO 7005-1

Motores 8L26 y 6L26:



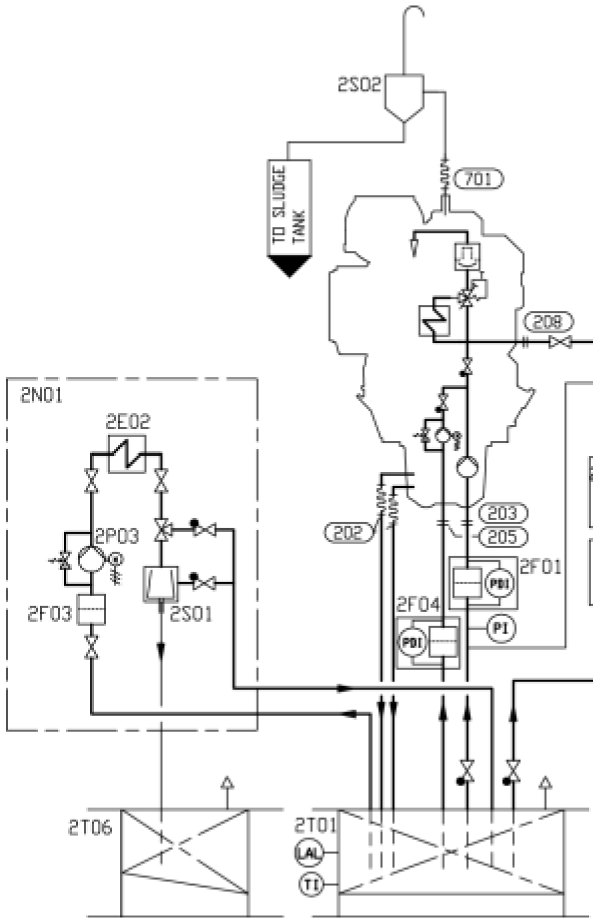
System components, dry sump					
01	Main lubricating oil pump	05	Thermostatic valve	08	Turbocharger
02	Pre-lubricating oil pump	06	Automatic filter	09	Sample valve
03	Pressure control valve	07	Centrifugal filter	10	Crankcase safety relief valves
04	Lubricating oil cooler				

Sensors and indicators, dry sump			
PT201	Lubricating oil pressure, engine inlet	TE272/TE282	Lubricating oil temp. TC A/B outlet (if ME)
PT271/PT281	Lubricating oil pressure TC A/B inlet	TE70n	Main bearing temperature (optional), cyl. n
PTZ201	Lubricating oil pressure, engine inlet	PI201	Lubricating oil pressure, engine inlet (if GL)
PDT243	Lubricating oil filter pressure difference	PS210	Lubricating oil stand-by pump start
TE201	Lubricating oil temp. engine inlet	PT700	Crankcase pressure (if FAKS)
TI201	Lubricating oil temp. engine inlet	TE202	Lubricating oil temp. before cooler (if FAKS)
QU700	Oil mist detector (optional)	TE232	Lubricating oil temp. LOC outlet (if FAKS)

Pipe connections, dry sump		Size	Pressure class	Standard
202	Lubricating oil outlet	DN150	PN6	DIN2573
203	Lubricating oil to engine driven pump	DN150	PN10	DIN2576
205	Lubricating oil to priming pump, in-line engines	PCD125 - 4xØ14	PN10	-
208	Lubricating oil from el. driven pump	L26: DN80 V26: DN100	PN10	DIN2576
216	Lubricating oil drain	L26: Plug G 1 1/2" V26: Plug G 3/4"		DIN910
701	Crankcase ventilation	L26: DN80 V26: DN100	PN16 PN6	DIN2577 DIN2573

Sistema externo de lubricación

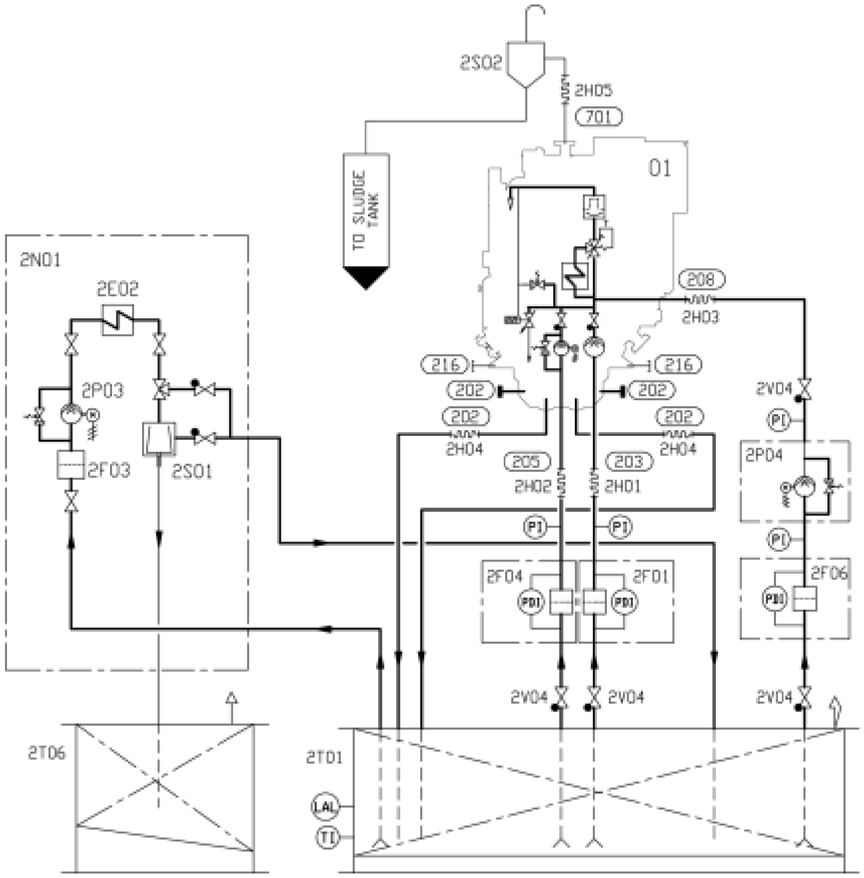
Motor W9L32:



System components:			
2E02	Heater (separator unit)	2P03	Separator pump (separator unit)
2F01	Suction strainer (main lubricating oil pump)	2P04	Stand-by pump
2F03	Suction filter (separator unit)	2S01	Separator
2F04	Suction strainer (Prelubricating oil pump)	2S02	Condensate trap
2F06	Suction strainer (stand-by pump)	2T01	System oil tank
2N01	Separator unit	2T06	Sludge tank

Pipe connections:		Size L32	Size V32
202	Lubricating oil outlet	DN150	DN150
203	Lubricating oil to engine driven pump	DN200	DN250
205	Lubricating oil to priming pump	DN80	DN125
208	Lubricating oil from electric driven pump	DN100	DN125
701	Crankcase air vent	DN100	DN125

Motores 8L26 y 6L26:



System components:			
01	Diesel engine Wärtsilä L26	2N01	Separator unit
02	Diesel engine Wärtsilä V26	2P03	Separator pump (separator unit)
2E02	Heater (separator unit)	2P04	Stand-by pump
2F01	Suction strainer (main LO pump)	2S01	Separator (separator unit)
2F03	Suction filter (separator unit)	2S02	Condensate trap
2F04	Suction strainer (pre lubricating oil pump)	2T01	System oil tank
2F06	Suction strainer (stand-by pump)	2T06	Sludge tank
2H0#	Flexible pipe connections	2V04	Non-return valve

Pos	Pipe connections	L26	V26
202	Lube oil outlet (from oil sump)	4 * DN150	
203	Lube oil to engine driven pump	DN200	DN150
205	Lube oil to priming pump	DN65	
208	Lube oil from el. driven pump	DN80	DN100
216	Lube oil drain	2 * plug G 3/4"	
701	Crankcase air vent	DN80	DN100

5.2.1 Dimensionamiento de los sistemas de lubricación

Bombas principales

Las bombas se dimensionarán para abastecer un caudal suficiente incluso a bajas velocidades. Serán de engranajes y estarán equipadas con una válvula para controlar la presión.

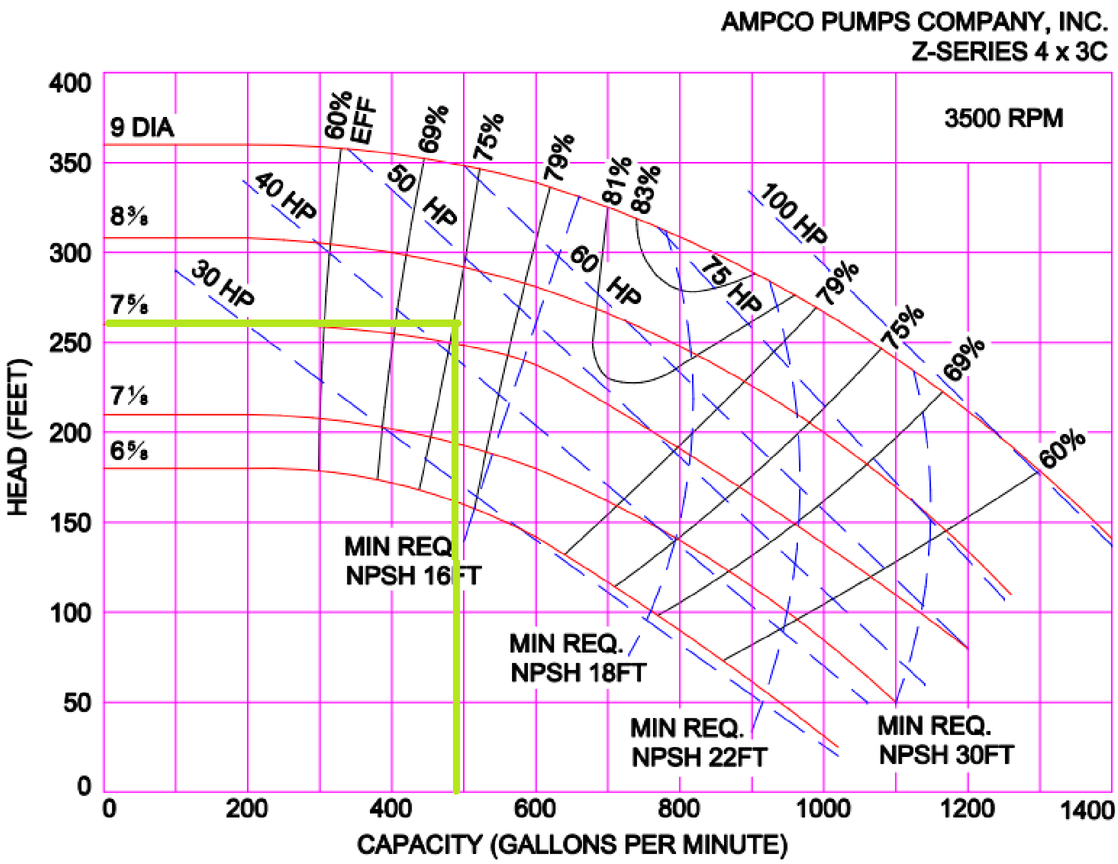
Los datos del fabricante para estas bombas son los siguientes:

	W9L32	8L 26	6L 26
Caudal (m3/h)	112	81	60
Presión (bar)	8	8	8

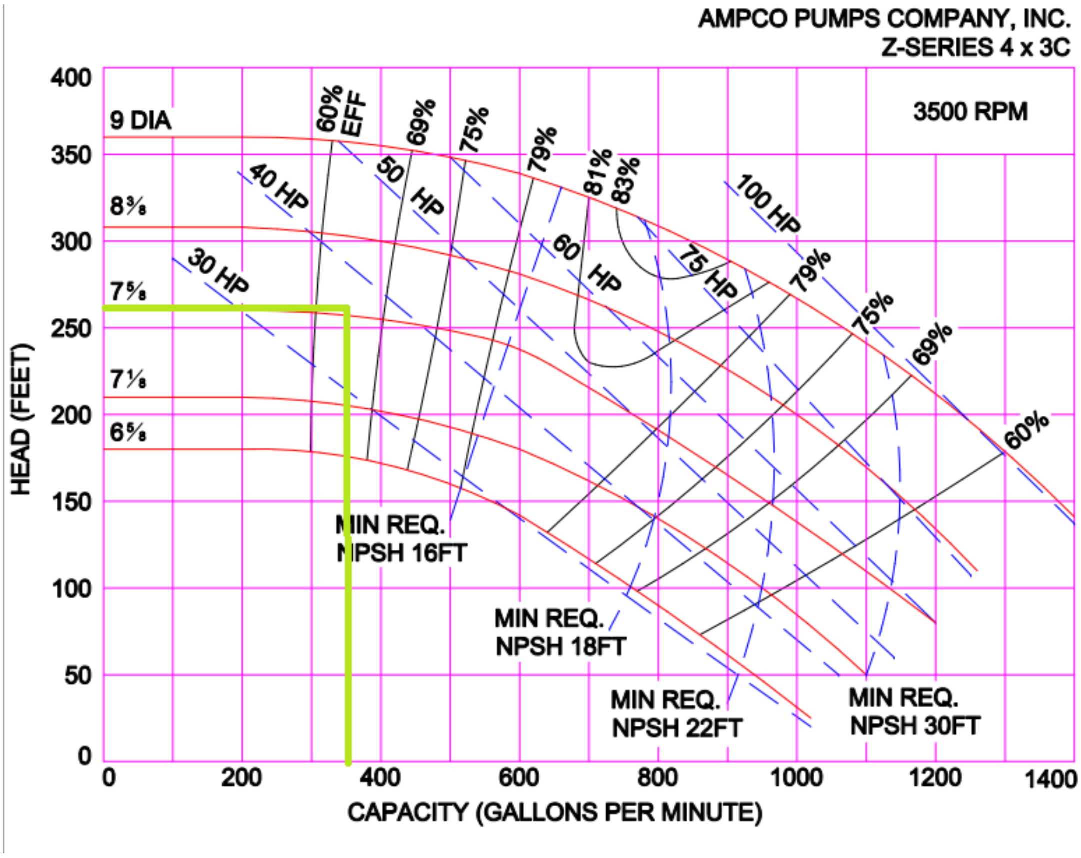
Las bombas comerciales elegidas son las siguientes:

	W9L32	8L 26	6L 26
Modelo	AMPCO Z 4x3C	AMPCO Z 4x3C	AMPCO Z 3x2
Potencia (kW)	32	26	22,3
Rpm	3500	3500	3500

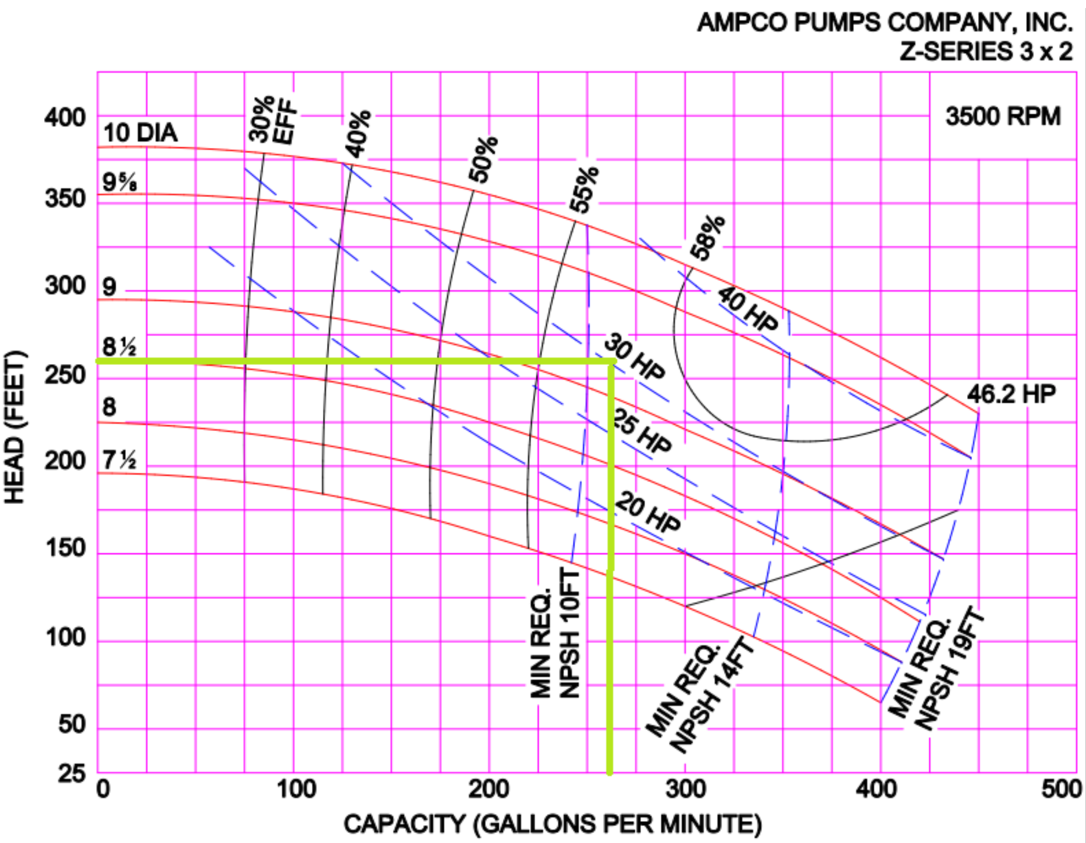
Bomba W9L32:



Bomba 8L26:



Bomba 6L26



Bombas de prelubricación

Estas bombas se encontrarán en funcionamiento siempre que el motor se encuentre en stand-by. Serán de accionamiento eléctrico y llevarán una válvula de seguridad. Los datos del fabricante en cuanto a presión y caudal son los siguientes:

	W9L32	8L 26	6L 26
Caudal (m3/h)	100	75	55
Presión (bar)	8	8	8

Las bombas elegidas son las mismas que para las bombas principales pero tendrán una potencia distinta:

	W9L32	8L 26	6L 26
Modelo	AMPCO Z 4x3C	AMPCO Z 4x3C	AMPCO Z 3x2
Potencia (kW)	29,8	25,5	20,8
Rpm	3500	3500	3500

Unidad de separación

La unidad de separación forma parte del sistema externo de lubricación. Sus componentes son los siguientes:

- Separadora.
- Unidad de alimentación con filtro de succión y válvula de seguridad.
- Precalentador.
- Cabina de control.

Cada motor llevará una separadora de aceite de lubricación que se dimensionará para una separación continua.

El caudal necesario para la separadora se calculará mediante una fórmula que proporciona la guía del motor:

$$Q = \frac{(1{,}35 * P * n)}{t} \; l/h$$

Donde:

P = Potencia del motor kW.

n = Número de flujos a través del volumen del tanque por día.

t = Tiempo de operación (h/día).

A partir de esta fórmula se calculará el caudal necesario para cada tipo de motor instalado.

	W9L32	8L 26	6L 26
Potencia (kW)	5037,3	2625	1969
n	4	4	4
t (h/día)	23	23	23
Q (l/h)	1182,670	616,304	462,287
Qtotal (m3/h)	1,182	0,62	0,462

$$Caudal\ necesario = 2{,}264\ m3/h$$

El modelo comercial elegido es del fabricante Hutchison Hayes Separation Inc.:

Modelo	HH 219 MO
Capacidad (m3/h)	2,5
Potencia (kW)	2

La bomba de alimentación de la separadora se definirá de acuerdo con la capacidad de proceso de la separadora. El caudal de alimentación será igual al caudal de suministro de la separadora y la presión de diseño viene definida por el fabricante:

Caudal (m3/h)	2,5
Presión (bar)	8

Por último se definirá el precalentador de la separadora. Para esto se tendrá en cuenta la capacidad de alimentación de la bomba y la temperatura en el tanque de aceite.

La temperatura después del precalentador será de 95 ºC. Para definir la potencia del precalentador se utilizará la siguiente fórmula proporcionada por el fabricante:

$$P = \frac{Q * \Delta T}{1700}\ kW$$

Donde:

P = Potencia del precalentador (kW).

Q = Capacidad de la bomba de alimentación de la separadora (l/h).

ΔT = Incremento de la temperatura en el precalentador (ºC).

Q (l/h)	2500
T salida (ºC)	40
T entrada (ºC)	20
ΔT (ºC)	20
P (kW)	29,411

5.2.2 Tanques almacén

A partir de los requerimientos del fabricante se obtendrá la capacidad mínima para los tanques almacén y el consumo de aceite para la condición de navegación en aguas libres a la velocidad de servicio:

	W9L32	8L 26	6L 26
Capacidad cárter (m3)	2,3	1,6	1,3
Consumo aceite 100%(g/kWh)	0,35	0,5	0,5
Vol. tanque sist. Segregado (m3)	7	3,7	2,8
Volumen tanques requerido (m3)	13,5		

La capacidad de los tanques de aceite definidos es de 25,14 m^3 por lo que sería suficiente.

5.2.3 Bombas de trasiego

Considerando un tiempo de llenado del cárter de media hora y a partir de los volúmenes de cárter proporcionados por el fabricante se han definido las siguientes bombas de trasiego:

	W9L32	8L 26	6L 26
Capacidad cárter (m3)	2,3	1,6	1,3
Tiempo de llenado (h)	0,5	0,5	0,5
Caudal (m3/h)	21,6	16	11
Presión (bar)	2,5	2,5	2,5

Las bombas comerciales elegidas son de la marca comercial AMPCO y poseen las siguientes características:

	W9L32	8L 26	6L 26
Modelo	AMPCO Z 2x1 1/2	AMPCO Z 2x1 1/2	AMPCO Z 2x1 1/2
Potencia (kW)	3	2,35	1,85
Rpm	3500	3500	3500

5.3 Sistema de refrigeración

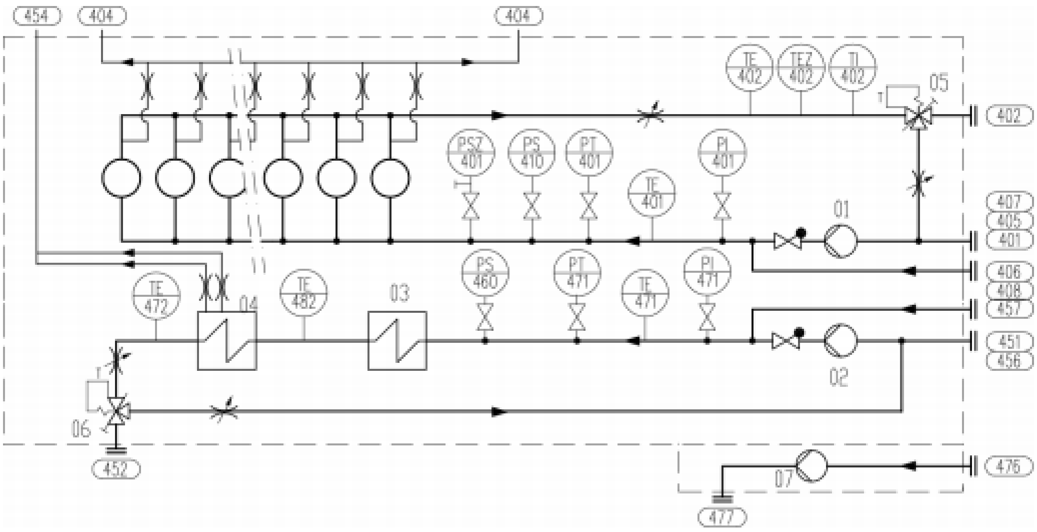
El sistema de refrigeración estará compuesto por un sistema de agua dulce y un sistema de agua salada.

5.3.1. Sistema de agua dulce

Sistema interno del motor

Motores 8L26 y 6L26:

A continuación se muestra el esquema de refrigeración del motor W9L32. Su circuito de refrigeración cuenta con dos circuitos, uno de baja temperatura y otro de alta:

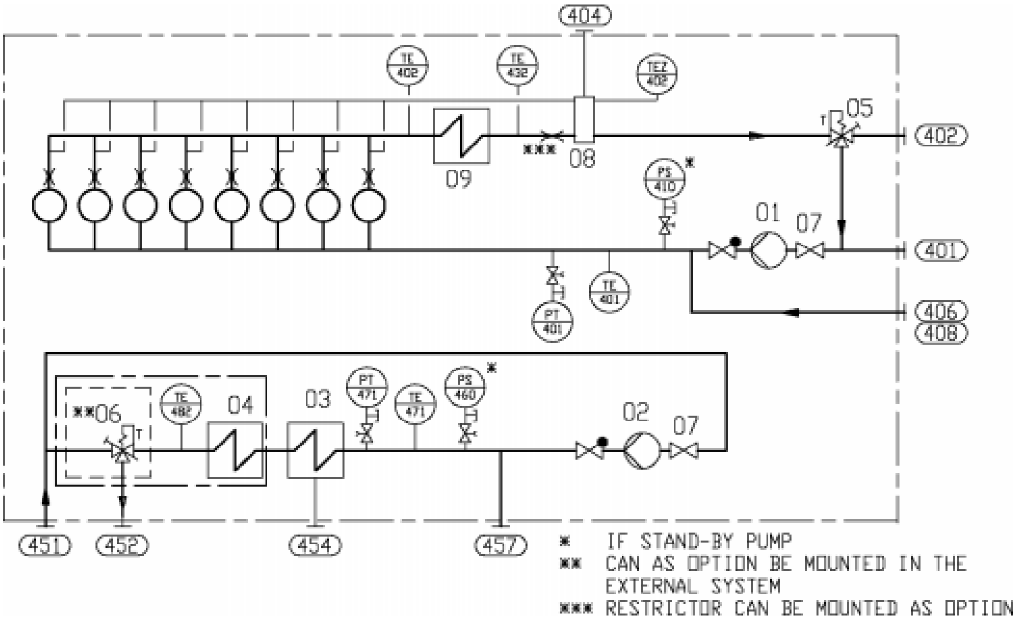


System components					
01	HT cooling water pump	04	Charge air cooler	06	LT thermostatic valve
02	LT cooling water pump	05	HT thermostatic valve	07	Sea water pump
03	Lubricating oil cooler				

Sensors and indicators			
PI401	HT water pressure before cylinder jackets (if GL)	TI402	HT water temp. after cylinder jackets
TE401	HT water temp. before cylinder jackets	PI471	LT water pressure before cylinder jackets (if GL)
PT401	HT water pressure before cylinder jackets	TE471	LT water temp. engine inlet (if GL)
PS410	HT water stand-by pump start (if stand-by pump)	PT471	LT water pressure, engine inlet
PSZ401	HT water pressure before cylinder jackets (if GL)	PS460	LT water stand-by pump start (if stand-by pump)
TE402	HT water temp. after cylinder jackets	TE482	LT water temp. after lube oil cooler (if FAKS)
TEZ402	HT water temp. after cylinder jackets	TE472	LT water temp. after CAC

Pipe connections (in-line engines)		Size	Pressure class	Standard
401	HT water inlet	DN80	PN10	DIN2576
402	HT water outlet	DN80	PN10	DIN2576
404	HT water air vent	OD12	PN250	DIN2353
405	HT water to preheater	DN80	PN10	DIN2576
406	Water from preheater	DN80	PN10	DIN2576
407	HT water to stand-by pump	DN80	PN10	DIN2576
408	HT water from stand-by pump	DN80	PN10	DIN2576
451	LT water inlet	DN80	PN10	DIN2576
452	LT water outlet	DN80	PN10	DIN2576
454	LT water air vent	OD10	PN10	DIN2353
456	LT water to stand-by pump	DN80	PN10	DIN2576
457	LT water from stand-by pump	DN80	PN10	DIN2576
476	Sea water to engine driven pump	DN80	PN10	DIN2576
477	Sea water from engine driven pump	DN80	PN10	DIN2576

Motor W9L32:



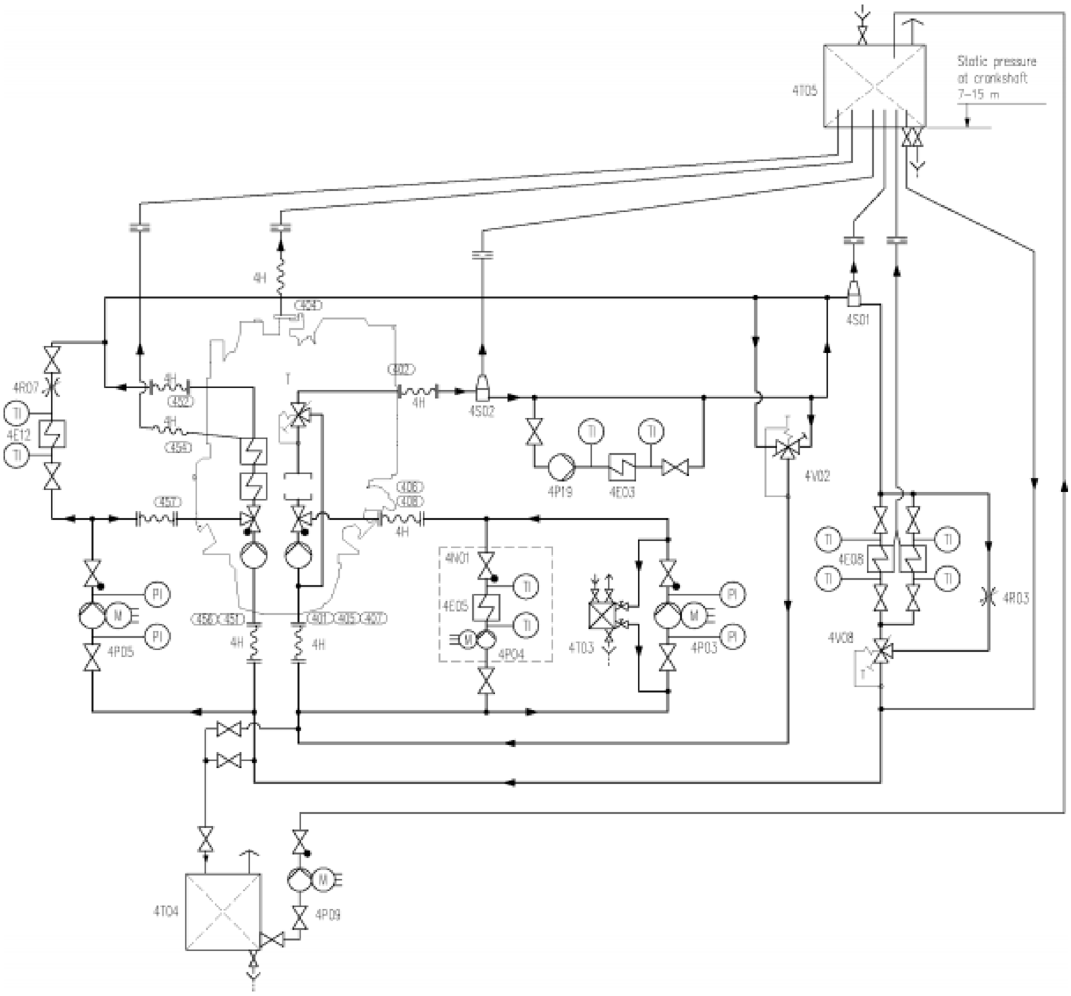
System components:					
01	HT-cooling water pump	04	Lubricating oil cooler	07	Shut-off valve
02	LT-cooling water pump	05	HT-thermostatic valve	08	Connection piece
03	Charge air cooler (LT)	06	LT-thermostatic valve	09	Charge air cooler (HT)

Sensors and indicators:			
PS410	HT-water stand-by pump start	TE402	HT-water temperature, engine outlet
PS460	LT-water stand-by pump start	TE432	HT-water temperature, CAC outlet
PT401	HT-water pressure, engine inlet	TE471	LT-water temperature, LT CAC inlet
PT471	LT-water pressure, LT CAC inlet	TE482	LT-water temperature, LOC inlet
TE401	HT-water temperature, engine inlet	TEZ402	HT-water temp, jacket outlet A-bank

Pipe connections:		Size	Pressure class	Standard
401	HT-water inlet	DN100	PN16	ISO 7005-1
402	HT-water outlet	DN100	PN16	ISO 7005-1
404	HT-water air vent	OD12		DIN 2353
406	Water from preheater to HT-circuit	OD28		DIN 2353
408	HT-water from stand-by pump	DN100	PN16	ISO 7005-1
451	LT-water inlet	DN100	PN16	ISO 7005-1
452	LT-water outlet	DN100	PN16	ISO 7005-1
454	LT-water air vent from air cooler	OD12		DIN 2353
457	LT-water from stand-by pump	DN100	PN16	ISO 7005-1

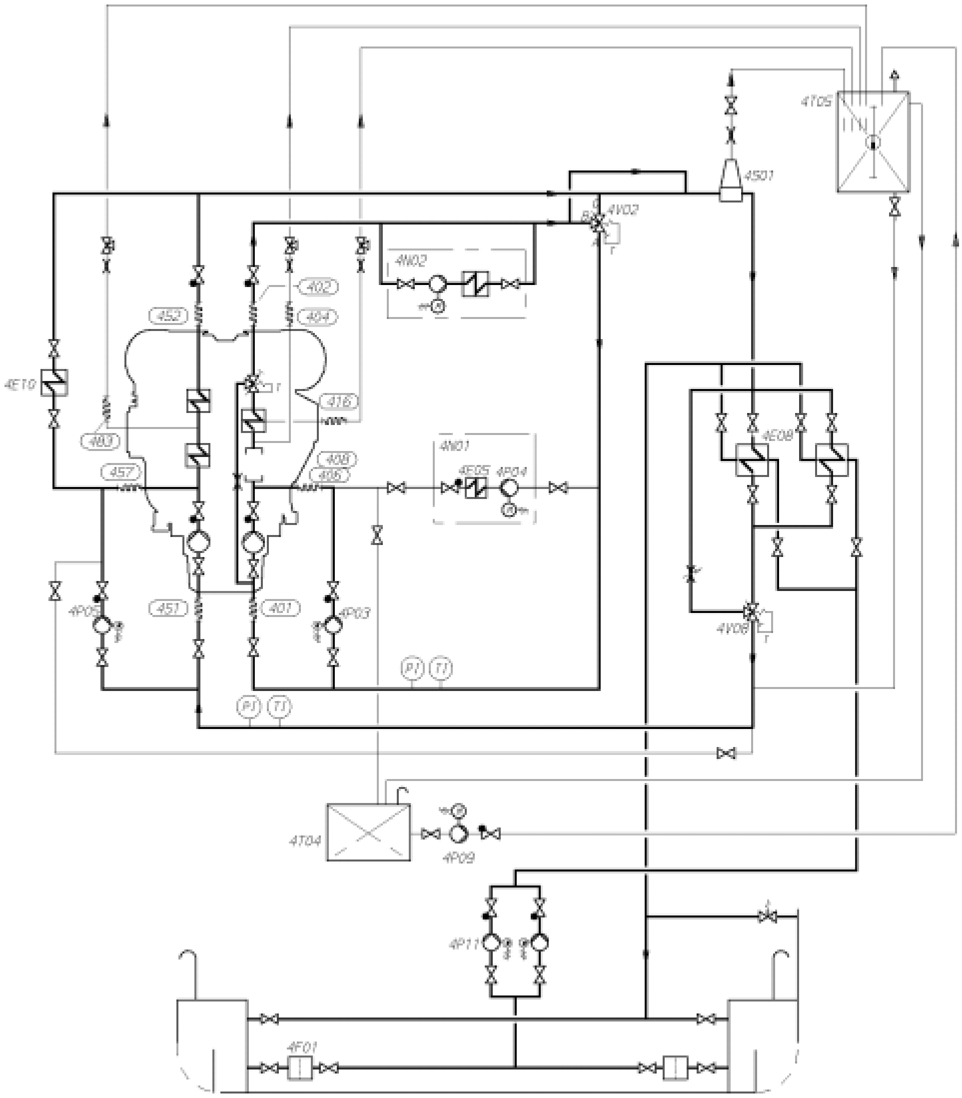
Sistema externo

Motores 8L26 y 6L26:



System components:			
4E03	Heat recovery (evaporator)	4P19	Circulating pump (evaporator)
4E05	Heater (preheater)	4R03	Adjustable throttle valve (LT cooler)
4E08	Central cooler	4R07	Adjustable throttle valve (LT water)
4E12	Cooler (installation parts)	4S02	Air deaerator (HT)
4N01	Preheating unit	4T03	Additive dosing tank
4P03	Stand-by pump (HT)	4T04	Drain tank
4P04	Circulating pump (preheater)	4T05	Expansion tank
4P05	Stand-by pump (LT)	4V02	Temperature control valve (heat recovery)
4P09	Transfer pump	4V08	Temperature control valve (central cooler)
Pipe connections are listed below the internal cooling water system diagrams			

Motor W9L32:



System components:					
4E05	Heater (preheating unit)	4P03	Stand-by pump (HT)	4T04	Drain tank
4E08	Central cooler	4P04	Circulating pump (preheater)	4T05	Expansion tank
4E10	Cooler (reduction gear)	4P05	Stand-by pump (LT)	4V02	Temp. control valve (heat recovery)
4F01	Suction strainer (sea water)	4P09	Transfer pump		
4N01	Preheating unit	4P11	Circulating pump (sea water)	4V08	Temp. control valve (central cooler)
4N02	Evaporator unit	4S01	Air venting		

Pipe connections:			
401	HT-water inlet	416	HT-water airvent from air cooler
402	HT-water	451	LT-water inlet
404	HT-water air vent	452	LT-water outlet
406	Water from preheater to HT-circuit	457	LT-water from stand-by pump
408	HT-water from stand-by pump	483	LT-water air vent

5.3.1.1. Dimensionamiento del sistema de refrigeración de agua dulce

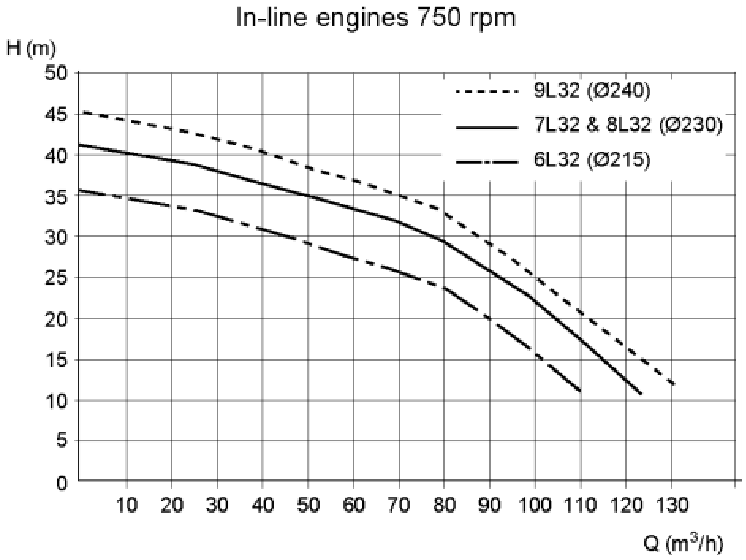
Los elementos internos del sistema de refrigeración del motor no han de definirse ya que forman parte del propio motor. Sólo se definirán los componentes redundantes.

Bombas de refrigeración HT

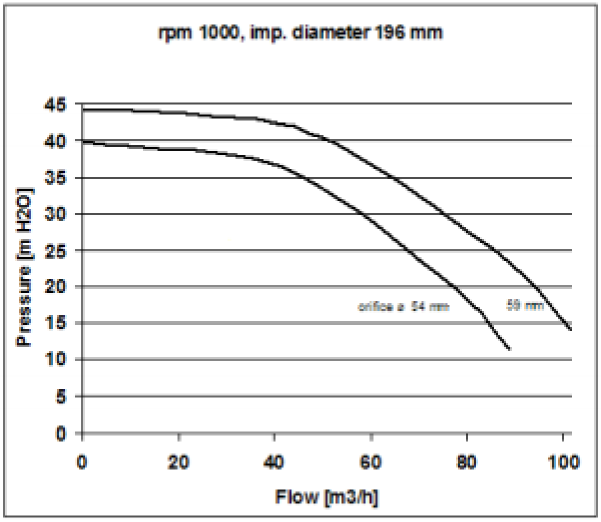
Estas bombas son accionadas por el propio motor. Su caudal y su presión están especificados en los datos técnicos proporcionados por el fabricante y se utilizarán para el dimensionamiento de las bombas de reserva. Las bombas utilizadas serán, de acuerdo con lo requerido por el fabricante, de tipo centrífugo y de accionamiento eléctrico.

	W9L32	8L 26	6L 26
Caudal (m3/h)	85	50	35
Presión (bar)	2,5	3,7	3,5

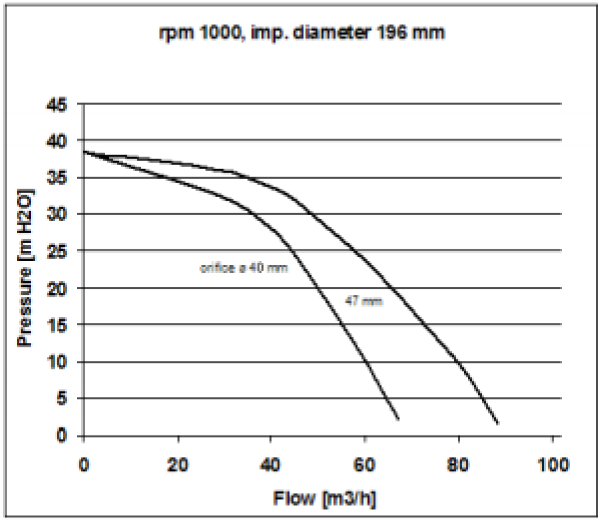
Motor W9L32:



Motor 8L26:



Motor 6L26:



Los modelos comerciales elegidos son los siguientes:

	W9L32	8L 26	6L 26
Modelo	AMPCO Z 4x3	AMPCO Z 3x2 1/2	AMPCO Z 3x2 1/2
Potencia (kW)	8,2	7,45	5,6
Rpm	3500	3500	3500

Bombas de refrigeración LT

Se dimensionarán de la misma forma que las anteriores:

	W9L32	8L 26	6L 26
Modelo	AMPCO Z 4x3	AMPCO Z 3x2 1/2	AMPCO Z 3x2 1/2
Potencia (kW)	8,2	5,96	5,2
Rpm	3500	3500	3500

Intercambiador agua-aire de admisión LT

El intercambiador de calor para el turbocompresor en el circuito de LT será capaz de aportar al fluido la siguiente energía:

	W9L32	8L 26	6L 26
Capacidad (kW)	722	-	-

Intercambiador agua- aire de admisión HT

	W9L32	8L 26	6L 26
Capacidad (kW)	1199	1002	751

Intercambiador agua-aceite LT

	W9L32	8L 26	6L 26
Capacidad (kW)	608	401	301

Precalentador de agua dulce

El precalentador tiene la función de calentar el agua de refrigeración del circuito de alta temperatura hasta una temperatura cercana a la de operación.

El tiempo requerido para calentar el motor desde su condición de motor en frío estará determinada por la potencia de calentamiento:

	W9L32	8L 26	6L 26
Potencia calentamiento(kW/cyl)	5	3	3

Para el cálculo del precalentador necesario se utilizará la siguiente fórmula proporcionada por el fabricante:

$$P = \frac{(T_1 - T_0) * (m_{eng} * 0{,}14 + V_{LO} * 0{,}48 + V_{FW} * 1{,}16)}{t} + k_{eng} * n_{cyl}$$

Donde:

P = Potencia precalentador (kW).

T_1 = Temperatura de precalentamiento = 60…70 ºC.

T_0 = Temperatura ambiente = 20 ºC.

m_{eng} = Peso del motor (ton)

V_{LO} = Volumen de aceite lubricante en el cárter húmedo (m^3).

V_{FW} = Volumen de agua de refrigeración HT (m^3).

t = Tiempo de precalentamiento = 12 horas.

k_{eng} = Coeficiente específico del motor (kW)

n_{cyl} = Número de cilindros.

	W9L32	8L 26	6L 26
T1 (ºC)	70	70	70
To (ºC)	20	20	20
Meng (ton)	84	45	35
Vlo (m3)	2,3	1,6	1,3
Vfw (m3)	0,56	0,4	0,3
T (h)	12	12	12
keng	1	0,75	0,75
ncyl	9	8	6
Potencia (kW)	65,307	37,383	28,967

La potencia total de calentamiento será la suma de las anteriores:

$$Potencia\ total = 131{,}657\ kW$$

Se instalarán tres precalentadores, se utilizarán dos y se dejará uno de reserva. Según la guía del motor el accionamiento del calentador podrá ser eléctrico, por vapor o por aceite térmico. En este caso se utilizará un accionamiento eléctrico.

Precalentador 1:

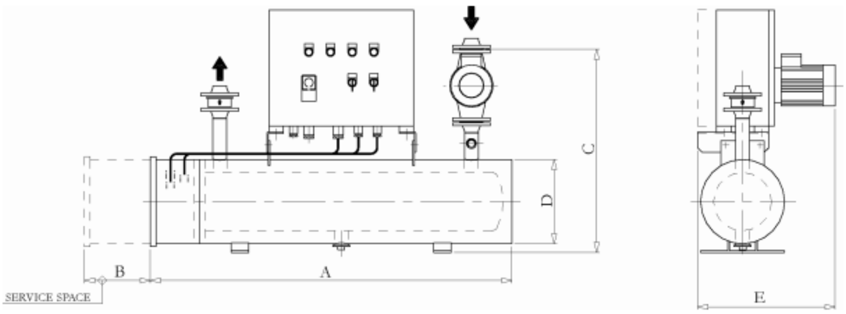


Fig 9.3.13.3.1 Preheating unit, electric (3V60L0562C).

Heater capacity [kW]	Pump capacity [m³/h]		Weight [kg]	Pipe conn.	Dimensions [mm]				
	50 Hz	60 HZ		In/outlet	A	B	C	D	E
18	11	13	95	DN40	1250	900	660	240	460
22.5	11	13	100	DN40	1050	720	700	290	480
27	12	13	103	DN40	1250	900	700	290	480
30	12	13	105	DN40	1050	720	700	290	480
36	12	13	125	DN40	1250	900	700	290	480
45	12	13	145	DN40	1250	720	755	350	510
54	12	13	150	DN40	1250	900	755	350	510
72	12	13	187	DN40	1260	900	805	400	550
81	12	13	190	DN40	1260	900	805	400	550
108	12	13	215	DN40	1260	900	855	450	575

Precalentador 2:

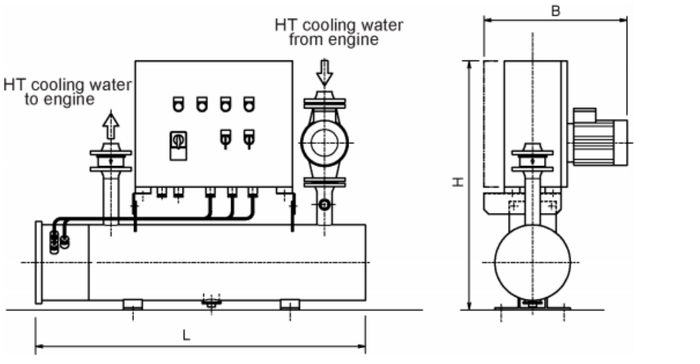


Fig 9.3.12.3.1 Electric pre-heating unit, main dimensions

Heating power [kW]*	L [mm]	H [mm]	B [mm]	Mass [kg] (wet)
12 (16)	1050	800	460	93
16 (21)	1250	800	460	95
18 (24)	1250	800	460	95
24 (32)	1250	840	480	103
32 (42)	1250	840	480	125

Bombas de circulación del precalentador de agua dulce

Los parámetros de las bombas de circulación están definidos en la guía del motor:

	W9L32	8L 26	6L 26
Capacidad (m3/hcyl)	0,4	0,45	0,45
Presión (bar)	0,8-1	0,8-1	0,8-1

Existirá una bomba para cada precalentador y su caudal será el suficiente para abastecer a ambos:

	W9L32	8L 26	6L 26
Capacidad (m3/h)	3,6	3,6	2,7
Capacidad total (m3/h)	9,9		

Por tanto el caudal por bomba será de 4,95 m3/h. Para la presión de la bomba se tomará la presión mayor indicada por el fabricante de 1 bar.

El modelo comercial elegido es de la marca AMPCO y posee las siguientes características:

Modelo	AMPCO Z 1 1/2 X 1 1/4
Potencia (kW)	0,5
Rpm	1750

5.3.2 Sistema de agua salada

Para definir el sistema de agua salada se dimensionará el intercambiador central, que es donde se consigue la refrigeración del agua dulce procedente del motor mediante agua salada. Además se dimensionarán las bombas de agua salada necesarias.

5.3.2.1 Dimensionamiento del sistema de agua salada

Intercambiador central

El intercambiador se utilizará tanto para el caudal de agua dulce de baja como de alta temperatura. La fórmula para el cálculo del caudal que ha sido proporcionada por el fabricante es la siguiente:

$$q = q_{LT} + \frac{3,6 * \phi}{4,15 * (T_{OUT} - T_{IN})}$$

Donde:

q = Caudal total de agua dulce (m^3/h).

q_{LT} = Capacidad total de la bomba de LT (m^3/h).

ϕ = Calor disipado al circuito de HT (kW).

T_{OUT} = Temperatura de salida del agua circuito HT después del motor = 91ºC.

T_{IN} = Temperatura entrada del agua circuito LT después del enfriador = 38 ºC.

	W9L32	8L 26	6L 26
qlt (m3/h)	85	50	35
(kW)	1199	1002	751
Tout (ºC)	91	91	91
Tin (ºC)	38	38	38
q (m3/h)	104,624	66,400	47,292

Según la guía del motor la presión de salida del agua dulce es de 0,6 bares, la del agua de mar de 0,8 a 1,4 bares y el caudal de agua salda es 1,2 o 1,5 veces el caudal de agua dulce. Se tomarán los siguientes valores:

Presión salida agua dulce (bar)	0,6
Presión salida agua de mar (bar)	1,1
Caudal de agua dulce W9l32 (m3/h)	85
Caudal de agua dulce 8L26 (m3/h)	50
Caudal de agua dulce 6L26 (m3/h)	35
Caudal agua salada W9L32 (m3/h)	127,5
Caudal de agua salada 8L26 (m3/h)	75
Caudal de agua salada 6L26 (m3/h)	52,5

Bomba de agua salada

Estas bombas son externas al motor y de accionamiento eléctrico. Se considerarán unas pérdidas de presión de 1,4 bares ya que es lo recomendado por el fabricante.

El caudal será el caudal de agua salada calculado para cada motor que resulta de multiplicar el caudal de agua dulce por 1,5:

Caudal agua salada W9L32 (m3/h)	127,5
Caudal de agua dulce 8L26 (m3/h)	75
Caudal de agua dulce 6L26 (m3/h)	52,5

Con estos datos se calcula el caudal total que tendrá la bomba:

Caudal bomba de agua salada (m3/h)	255
Presión (bar)	2,5

Se ha decidido instalar tres bombas iguales de la mitad del caudal calculado cada una. Se utilizarán dos y se dejará una de reserva. La bomba comercial elegida posee las siguientes características:

Modelo	AMPCO Z 4 x 3L
Potencia (kW)	11,04
Rpm	1750

5.4 Servicio de aire de arranque

El arranque de los motores se realiza mediante una inyección directa de aire en el interior de los cilindros a través de válvulas de aire de arranque en las cabezas de los cilindros. Todos los motores se arrancarán mediante aire comprimido a 30 bares. El sistema puede ser accionado de forma remota o automática.

El servicio de aire de arranque se divide en dos sistemas: sistema interno de aire de arranque y sistema externo.

El tiempo de arranque en condiciones ambientales de 25ºC es de 5 a 7 segundos.

5.4.1 Botellas de aire de arranque

Las botellas se dimensionarán para permitir las arrancadas requeridas en reglamento de la sociedad de clasificación ABS. Están provistas de:

- Válvula de drenaje manual, para eliminar el agua de condensación.
- Válvula de seguridad.
- Válvula de apertura/cierre para la entrada/salida de aire
- Preóstatos, para el arranque automático de los compresores de baja presión.
- Manómetros.

Para cumplir con los requerimientos de la sociedad de clasificación, se instalarán botellas de aire de arranque con capacidad suficiente para realizar 6 arrancadas consecutivas del motor principal sin que sea necesaria la recarga. Se tomará al motor de mayor potencia como el motor principal.

Utilizando la fórmula para el cálculo del volumen de las botellas de la guía del motor:

$$V_r = \frac{p_E * V_E * n}{p_{Rmáx} - p_{Rmín}}\ m3$$

Donde:

$p_E =$ Presión normal barométrica = 0,1 MPa.

$V_E =$ Consumo de aire por arranque (Nm3).

$n =$ Número de arranques = 6.

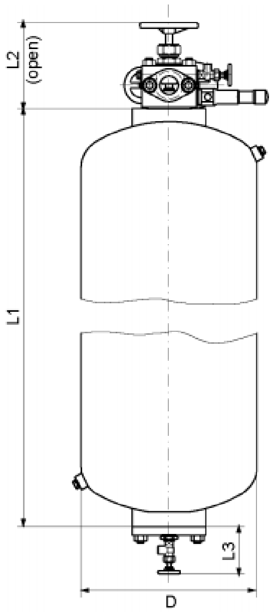
$p_{Rmáx} =$ Presión máxima de arranque = 3 MPa.

$p_{Rmín} =$ Presión mínima de arranque = 1,8 MPa.

	W9L32
pe (MPa)	0,1
Ve (Nm3)	2,7
n	6
prmáx (MPa)	3
prmín (MPa)	1,8

El volumen necesario de cada botella será:

$$V_r = 1{,}35\, m3$$



Size [Litres]	Dimensions [mm]				Weight [kg]
	L1	L2 1)	L3 1)	D	
250	1767	243	110	480	274
500	3204	243	133	480	450
710	2740	255	133	650	625
1000	3560	255	133	650	810
1250	2930	255	133	800	980

1) Dimensions are approximate.

Se instalarán 3 botellas de 500 litros.

5.4.2 Compresores de aire de arranque

Se instalarán 2 compresores de aire capaces de abastecer el aire de arranque necesario a una presión comprendida entre 1,8 MPa y 3 MPa en 30 minutos. Su capacidad debe de ser:

$$V = \sum V_{botella} * 30 = 30\ \frac{m3}{h}.$$

Los compresores instalados tendrán una capacidad de 30 m3/h a 30 bares y serán accionados eléctricamente por un motor eléctrico de 7 kW. Los compresores son de la marca comercial ATLAS COPCO y poseen las siguientes características:

Modelo	ATLAS COPCO LT-53
Presión (bar)	30
Capacidad (m3/h)	30
Potencia (kW)	7

5.5 Ventilación de la cámara de máquinas

La función del sistema de ventilación será la de suministrar el aire de combustión de los motores y evacuar el calor de la cámara de máquinas para obtener unas condiciones de trabajo óptimas y asegurar el correcto funcionamiento de los equipos.

El aire se suministrará por medio de ventiladores centrífugos. Una parte del aire es inyectado directamente a la cámara y el resto es dirigido por conductos a los puntos de consumo.

El sistema de ventilación y extracción se compondrá de:

- Un servicio de impulsión forzada mediante electroventiladores (admisión).
- Un servicio de extracción natural a través del guardacalor.

El cálculo del sistema de ventilación en cámara de máquinas se realizará según la norma UNE-EN ISO 8861:1999, Construcción naval. Ventilación de la sala de máquinas de barcos de motor diésel. Requisitos de diseño y bases de cálculos.

Los requisitos de diseño requeridos por esta norma son los siguientes:

La capacidad de la planta de ventilación debería ser de tales características que proporcionara unas condiciones de trabajo confortables en la sala de máquinas, que suministrara el aire necesario para la combustión de los motores diésel y que evitara el sobrecalentamiento de los aparatos sensibles al calor.

El aire debería distribuirse a todas las partes de la sala de máquinas, de tal manera que se eviten bolsas de aire caliente estancado. Se debería tener especial cuidado con las áreas de gran emisión de calor y con todas las áreas de trabajo habitual, en las que debería suministrarse aire exterior razonablemente fresco y limpio, a través de dispositivos de admisión orientables.

Al establecer la distribución de aire, se debe tener en cuenta todas las condiciones normales de funcionamiento de la maquinaria, tanto en la mar como en puerto.
La temperatura ambiente del aire exterior debe tomarse como 35°C.

El incremento de temperatura del aire desde la aspiración hasta el paso del aire desde la sala de máquinas a la entrada del guardacalor debe ser 12,5 K como máximo.

La emisión de calor de todos los equipos instalados dentro del guardacalor y de la chimenea no debe tenerse en cuenta.

Los cálculos deben basarse en el máximo régimen de los motores diésel generadores y el resto de maquinaria trabajando simultáneamente en condiciones normales de mar, y con un aumento de temperatura de 12,5 K.

Los espacios separados de la sala de máquinas del motor principal, tales como las salas para motores auxiliares, salas de calderas y salas del separador, deben calcularse también separadamente.

5.5.1 Dimensionamiento del sistema de ventilación

En este apartado se calculará el caudal necesario para la ventilación. Este se compone de dos partes:

- Flujo de aire para la combustión.
- Flujo de aire para disipar el calor irradiado.

El flujo de aire mínimo en la cámara de máquinas será el valor máximo de los obtenidos mediante las siguientes fórmulas:

$$Q = q_c + q_h$$
$$Q = 1{,}5 * q_c$$

Donde:

q_c = Flujo de aire para la combustión.
q_h = Flujo de aire para la disipación del calor irradiado.

- Flujo de aire para la combustión

El flujo de aire para la combustión se compone a su vez de tres sumandos:

$$q_c = q_{dp} + q_{dg} + q_b$$

Donde:

q_{dp} = Flujo de aire para la combustión de motores diésel (m3/s).

q_{dg} = Flujo de aire de combustión de motores diésel generadores (m3/s).

q_b = Flujo de aire para la combustión de la caldera (m3/s).

En este caso los motores son diésel generadores y no existen calderas para la propulsión. Por esto, sólo se considerará en la fórmula lo siguiente:

$$q_c = q_{dg}$$

Para calcular q_{dg} se utilizará la siguiente fórmula:

$$q_{dg} = \frac{P_{dg} * m_{ad}}{\rho} \ m3/s$$

Donde:

P_{dg} = Potencia normalizada de servicio de los motores diésel de los generadores a la máxima potencia de salida (kW).

m_{ad} = Aire para la combustión del motor diésel (kg/kWs).

ρ = Densidad del aire a 35 ºC y 101,3 kPa.

	W9L32	8L 26	6L 26
Pdg (kW	5037,3	2625	1969
mad (kg/kWs)	0,0019	0,0021	0,0021
Densidad (kg/m3)	1,13	1,13	1,13
qdg(m3/s)	8,336	4,779	3,628

Por lo tanto el flujo de aire para la combustión será:

$$\boldsymbol{q_c = 16,743\ m3/s}$$

- Flujo de aire para disipar el calor irradiado.

El flujo de aire para disipar el calor irradiado por el motor y auxiliares se calculará con la siguiente fórmula:

$$q_h = \frac{\phi_{dp} + \phi_{dg} + \phi_b + \phi_p + \phi_g + \phi_{el} + \phi_{ep} + \phi_t + \phi_0}{\rho * c * \Delta T} - 0{,}4 * \left(q_{dp} + q_{dg}\right) - q_b$$

Donde:

ϕ_{dp} = Emisión de calor de los motores diésel de propulsión principal (kW) = 0.

ϕ_{dg} = Emisión de calor de motores diésel generadores (kW).

ϕ_b = Emisión de calor de calderas y calentadores de fluido térmico (kW).

ϕ_p = Emisión de calor de tuberías de vapor y condensación (kW) = 0.

ϕ_g = Emisión de calor del generador eléctrico refrigerado por aire (kW).

ϕ_{el} = Emisión de calor de las instalaciones eléctricas (kW).

ϕ_{ep} = Emisión de calor de las tuberías de escape (kW).

ϕ_t = Emisión de calor de los tanques de calefacción (kW) = 0.

ϕ_0 = Emisión de calor de los otros componentes (kW).

ρ = Densidad del aire a 35 ºC y 101,3 kPa.

c = Calor específico del aire.

ΔT = Aumento de la temperatura del aire de la sala de máquinas (K).

La emisión de calor de los motores diésel generadores ϕ_{dg} se calculará mediante la siguiente fórmula indicada por la norma:

$$\phi_{dg} = P_{dg} * \left(\frac{\Delta h_d}{100}\right) kW$$

Donde:

Δh_d = Pérdidas de calor de los motores diésel.

En este caso el fabricante ya proporciona el dato de emisión de calor por lo que este será, en cada caso:

	W9L32	8L 26	6L 26
φdp (KW)	165	128	96

La emisión de calentadores de fluido térmico se calculará para el calentador de aceite térmico instalado para los tanques de carga.

$$\phi_b = Q * B_1 * \frac{\Delta h_b}{100} kW$$

Donde:

Q = Máximo rendimiento continuo del calentador del fluído térmico (kW).

B_1 = Constante aplicada a la ubicación del intercambiador.

Δh_b = Pérdida de calor, en porcentaje, al máximo rendimiento continuo del calentador de fluido térmico

Q (kW)	600
B1	0,1
Δ hb (kW)	75

El valor de la constante B_1 es un dato obtenido en la norma y tanto el porcentaje de pérdida de calor cono el rendimiento máximo contínuo del calentador se han obtenido del fabricante del calentador que has sido definido en el cuaderno 12.

$$\phi_b = 45\ kW$$

La emisión de calor de los generadores eléctricos se calculará con la siguiente fórmula:

$$\phi_g = P_g * (1 - \frac{\eta}{100})$$

Donde:

P_g = Potencia de los generadores instalados refrigerados con aire (kW).

η = Rendimiento del generador.

	W9L32	8L 26	6L 26
Pdg (kW	5037,3	2625	1969
η	96.5	96.5	96.5

La emisión total de los tres generadores será:

$$\phi_g total = 337,1\ kW$$

La emisión de calor de las instalaciones eléctricas se aproximará según nos dice la norma al 20% de la potencia de régimen del equipo eléctrico y de la iluminación que se utiliza en el mar.

Para realizar la aproximación en el buque proyecto, se ha utilizado la condición más desfavorable que es la condición de remolque. La potencia consumida en la condición de remolque es:

$$Potencia\ cons.cond.Remolque\ CCMM = 625\ kW$$

Aplicando un 20 % a esta potencia se obtiene:

$$\phi_{el} = 125\ kW$$

La emisión de calor de tuberías se estimará en base a los datos obtenidos en buques de referencia:

$$\phi_{ep} = 20\ kW$$

La emisión de otros componentes tales como compresores, mecanismos reductores, intercambiadores de calor, sistemas de tuberías e hidráulicos, etc, se realizará de forma aproximada estimando un valor equivalente al 20% de la emisión de los generadores eléctricos:

$$\phi_{dg} = 389\ kW$$

$$\phi_0 = 77,8\ kW$$

Una vez definidas las distintas emisiones de calor en la cámara de máquinas, utilizamos la fórmula ya definida anteriormente para el caudal total necesario para la disipación del calor en la cámara de máquinas:

$$q_h = \frac{\phi_{dp} + \phi_{dg} + \phi_b + \phi_p + \phi_g + \phi_{el} + \phi_{ep} + \phi_t + \phi_0}{\rho * c * \Delta T} - 0{,}4 * (q_{dp} + q_{dg}) - q_b$$

$$q_h = \frac{389 + 45 + 337{,}1 + 125 + 20 + 77{,}8}{1{,}13 * 1{,}01 * 12{,}5} - 0{,}4 * 16{,}743$$

$$q_h = 62{,}97\ kW$$

El flujo de aire total para la ventilación de la cámara de máquinas será el máximo de los siguientes valores:

$$Q1 = q_c + q_h$$

$$Q2 = 1{,}5 * q_c$$

$$Q1 = 16{,}743 + 62{,}97 = 79{,}713\ kW$$

$$Q2 = 1{,}5 * 16{,}743 = 25{,}114\ kW$$

El caudal total de la ventilación será por tanto:

$$Qtot = 79{,}713\ m3/s$$

$$\boldsymbol{Qtot = 286966{,}8\ m3/h}$$

5.5.2 Elección de los ventiladores

Se ha decidido instalar tres ventiladores de la marca comercial SODECA con las siguientes características:

Modelo	HGT-125-4T/9-100
Velocidad (r/min)	1480
Potencia (kW)	75
Caudal máximo (m3/h)	155000
Nivel pres. sonora (dB)	99
Peso (kg)	557

Se utilizarán dos ventiladores y se dejará uno de reserva. El caudal conseguido con dos ventiladores sería de 310000 m3/h por lo que sería suficiente para cubrir las necesidades calculadas de ventilación en la cámara de máquinas.

ANEXO I

DATOS TÉCNICOS DE LOS DIÉSEL - GENERADORES

3.8 Wärtsilä 9L32, 750 rpm

Wärtsilä 9L32		AE/DE IMO Tier 2	ME IMO Tier 2	DE IMO Tier 2	AE IMO Tier 2	ME IMO Tier 2	DE SCR mode	AE SCR mode	ME SCR mode
Engine speed Cylinder output	**RPM kW/cyl**	**750 500**	**750 500**	**750 580**	**750 580**	**750 580**	**750 580**	**750 580**	**750 580**
Engine output	kW	4500	4500	5220	5220	5220	5220	5220	5220
Mean effective pressure	MPa	2.49	2.49	2.88	2.88	2.88	2.88	2.88	2.88
Combustion air system (Note 1)									
Flow at 100% load	kg/s	7.86	7.86	9.42	9.42	9.12	9.42	9.42	9.12
Temperature at turbocharger intake, max.	°C	45	45	45	45	45	45	45	45
Air temperature after air cooler (TE 601)	°C	55	55	55	55	55	55	55	55
Exhaust gas system (Note 2)									
Flow at 100% load	kg/s	8.1	8.1	9.7	9.7	9.4	9.7	9.7	9.4
Flow at 85% load	kg/s	7.71	7.44	8.8	8.8	8.4	8.1	8.1	8.1
Flow at 75% load	kg/s	6.98	6.64	8.0	8.0	7.3	7.4	7.4	7.3
Flow at 50% load	kg/s	4.89	5.57	5.4	5.4	5.0	5.4	5.4	5.0
Temperature after turbocharger, 100% load (TE 517)	°C	380	380	350	350	370	350	350	370
Temperature after turbocharger, 85% load (TE 517)	°C	325	336	320	320	330	340	340	340
Temperature after turbocharger, 75% load (TE 517)	°C	325	345	320	320	340	340	340	340
Temperature after turbocharger, 50% load (TE 517)	°C	345	315	360	360	350	360	360	350
Backpressure, max.	kPa	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0
Calculated pipe diameter for 35m/s	mm	736	736	787	787	787	787	787	787
Heat balance (Note 3)									
Jacket water, HT-circuit	kW	765	765	674	674	660	674	674	660
Charge air, HT-circuit	kW	731	731	1199	1199	1217	1199	1199	1217
Charge air, LT-circuit	kW	596	596	722	722	734	722	722	734
Lubricating oil, LT-circuit	kW	585	585	608	608	594	608	608	594
Radiation	kW	160	160	165	165	165	165	165	165
Fuel system (Note 4)									
Pressure before injection pumps (PT 101)	kPa	700±50	700±50	700±50	700±50	700±50	700±50	700±50	700±50
Engine driven pump capacity (MDF only)	m^3/h	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Fuel flow to engine (without engine driven pump), approx.	m^3/h	4.6	4.6	5.3	5.3	5.3	5.3	5.3	5.3
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45	45	45	45	45
Fuel consumption at 100% load, HFO	g/kWh	185	185	184	185	184	184	185	184
Fuel consumption at 85% load, HFO	g/kWh	182	181	181	182	180	183	184	180
Fuel consumption at 75% load, HFO	g/kWh	183	182	181	182	180	183	184	180

Wärtsilä 9L32		AE/DE IMO Tier 2	ME IMO Tier 2	DE IMO Tier 2	AE IMO Tier 2	ME IMO Tier 2	DE SCR mode	AE SCR mode	ME SCR mode
Engine speed Cylinder output	RPM kW/cyl	750 500	750 500	750 580	750 580	750 580	750 580	750 580	750 580
Fuel consumption at 50% load, HFO	g/kWh	193	191	188	189	180	190	191	180
Fuel consumption at 100% load, MDF	g/kWh	185	185	183	183	183	183	183	183
Fuel consumption at 85% load, MDF	g/kWh	182	181	180	181	179	181	182	180
Fuel consumption at 75% load, MDF	g/kWh	183	182	180	181	179	181	182	180
Fuel consumption at 50% load, MDF	g/kWh	193	191	187	189	179	188	190	180
Clean leak fuel quantity, MDF at 100% load	kg/h	17.5	17.5	20.0	20.1	20.1	20.0	20.1	20.1
Clean leak fuel quantity, HFO at 100% load	kg/h	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.0
Lubricating oil system									
Pressure before bearings, nom. (PT 201)	kPa	500	500	500	500	500	500	500	500
Suction ability main pump, including pipe loss, max.	kPa	30	30	30	30	30	30	30	30
Priming pressure, nom. (PT 201)	kPa	50	50	50	50	50	50	50	50
Suction ability priming pump, including pipe loss, max.	kPa	30	30	30	30	30	30	30	30
Temperature before bearings, nom. (TE 201)	°C	63	63	63	63	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79	79	79	79	79
Pump capacity (main), engine driven	m^3/h	112	112	112	112	112	112	112	112
Pump capacity (main), stand-by	m^3/h	100	100	100	100	100	100	100	100
Priming pump capacity, 50Hz/60Hz	m^3/h	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9	21.6 / 25.9
Oil volume, wet sump, nom.	m^3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Oil volume in separate system oil tank, nom.	m^3	6.1	6.1	7.0	7.0	7.0	7.0	7.0	7.0
Oil consumption (100% load), approx.	g/kWh	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Crankcase ventilation flow rate at full load	l/min	1485	1485	2060	2060	2060	2060	2060	2060
Crankcase ventilation backpressure, max.	kPa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oil volume in turning device	liters	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5	8.5...9.5
Oil volume in speed governor	liters	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Cooling water system									
High temperature cooling water system									
Pressure at engine, after pump, nom. (PT 401)	kPa	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static
Pressure at engine, after pump, max. (PT 401)	kPa	530	530	530	530	530	530	530	530
Temperature before cylinders, approx. (TE 401)	°C	85	85	77	77	77	77	77	77
HT-water out from engine, nom (TE402) (single stage CAC)	°C	96	96	96	96	96	96	96	96
HT-water out from engine, nom (TE432) (two stage CAC)	°C	96	96	96	96	96	96	96	96
Capacity of engine driven pump, nom.	m^3/h	85	85	85	85	85	85	85	85
Pressure drop over engine, total (single stage CAC)	kPa	100	100	100	100	100	100	100	100
Pressure drop over engine, total (two stage CAC)	kPa	150	150	150	150	150	150	150	150

Wärtsilä 9L32		AE/DE IMO Tier 2	ME IMO Tier 2	DE IMO Tier 2	AE IMO Tier 2	ME IMO Tier 2	DE SCR mode	AE SCR mode	ME SCR mode
Engine speed **Cylinder output**	**RPM** **kW/cyl**	**750** **500**	**750** **500**	**750** **580**	**750** **580**	**750** **580**	**750** **580**	**750** **580**	**750** **580**
Pressure drop in external system, max.	kPa	100	100	100	100	100	100	100	100
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Low temperature cooling water system									
Pressure at engine, after pump, nom. (PT 451)	kPa	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static	250 + static
Pressure at engine, after pump, max. (PT 451)	kPa	530	530	530	530	530	530	530	530
Temperature before engine (TE 451)	°C	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38	25 ... 38
Capacity of engine driven pump, nom.	m³/h	85	85	85	85	85	85	85	85
Pressure drop over charge air cooler	kPa	35	35	35	35	35	35	35	35
Pressure drop over oil cooler	kPa	30	30	30	30	30	30	30	30
Pressure drop in external system, max.	kPa	100	100	100	100	100	100	100	100
Pressure from expansion tank	kPa	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150	70 ... 150
Starting air system (Note 5)									
Pressure, nom.	kPa	3000	3000	3000	3000	3000	3000	3000	3000
Pressure at engine during start, min. (20°C)	kPa	1600	1600	1600	1600	1600	1600	1600	1600
Pressure, max.	kPa	3000	3000	3000	3000	3000	3000	3000	3000
Low pressure limit in air vessels	kPa	1600	1600	1600	1600	1600	1600	1600	1600
Air consumption per start	Nm³	2.7	-	2.7	2.7	-	2.7	2.7	-
Air consumption per start without propeller shaft engaged	Nm³	-	2.7	-	-	2.7	-	-	2.7
Air consumption with automatic start and slowturning	Nm³	-	-	-	-	-	-	-	-
Air consumption per start with propeller shaft engaged	Nm³	-	4.3	-	-	4.3	-	-	4.3
Air consumption with automatic start and high inertia slowturning	Nm³	-	-	-	-	-	-	-	-
Air assist consumption (for engines with 580 kW/cyl)	Nm³	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 10°C.

Note 3 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance for cooling water heat 10%, tolerance for radiation heat 30%. Fouling factors and a margin to be taken into account when dimensioning heat exchangers.

Note 4 At ambient conditions according to ISO 15550. Lower calorific value 42 700 kJ/kg. With engine driven pumps (two cooling water + one lubricating oil pump). Tolerance 5%.

Note 5 Automatic (remote or local) starting air consumption (average) per start, at 20°C for a specific long start impulse (DE/AUX: 2...3 sec, CPP/FPP: 4...6 sec) which is the shortest time required for a safe start.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Lubricating oil, foreign substances or chemical waste, hazardous to the safety of the installation or detrimental to the performance of the engines, should not be contained in the fuel.

6.2 Internal fuel oil system

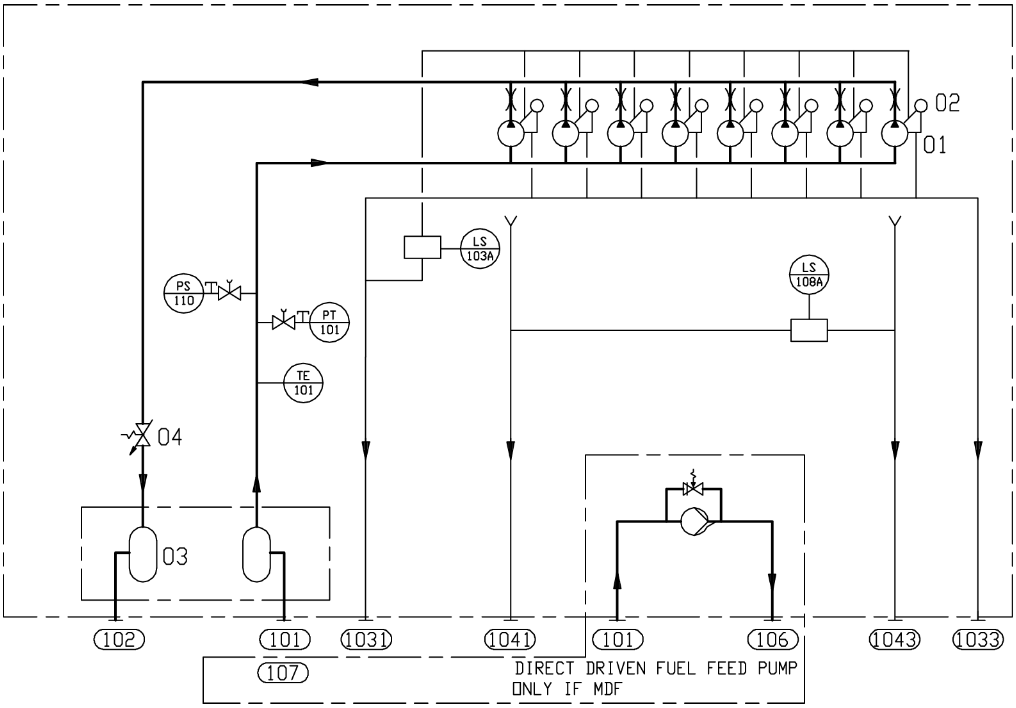


Fig 6.2.1 Internal fuel oil system, in-line engines (DAAE005307C)

System components:					
01	Injection pump	03	Pulse damper (for 500 kW/cyl)	Option A: Option B:	Pressure relief valve Without pressure relief valve
02	Injection valve	04	Pressure relief valve		

Sensors and indicators:			
LS103A	Fuel oil leakage, injection pipe A-bank	PT101	Fuel oil pressure, engine inlet
LS108A	Fuel oil leakage, dirty fuel A-bank	TE101	Fuel oil temperature, engine inlet
PS110	Fuel oil stand-by pump start (if stand-by)		

Pipe connections:		Size	Pressure class	Standard
101	Fuel inlet	DN32 (DN40)*	PN40	ISO 7005-1
102	Fuel outlet	DN32	PN40	ISO 7005-1
1031	Clean fuel leakage, outlet	OD28		DIN 2353
1033	Clean fuel leakage, outlet	OD28		DIN 2353
1041	Dirty fuel leakage, outlet	OD18		DIN 2353
1043	Dirty fuel leakage, outlet	OD28		DIN 2353
106	Fuel to external filter	DN32	PN40	ISO 7005-1
107	Fuel from external filter	DN32	PN40	ISO 7005-1
*) DN40 if engine driven fuel feed pump				

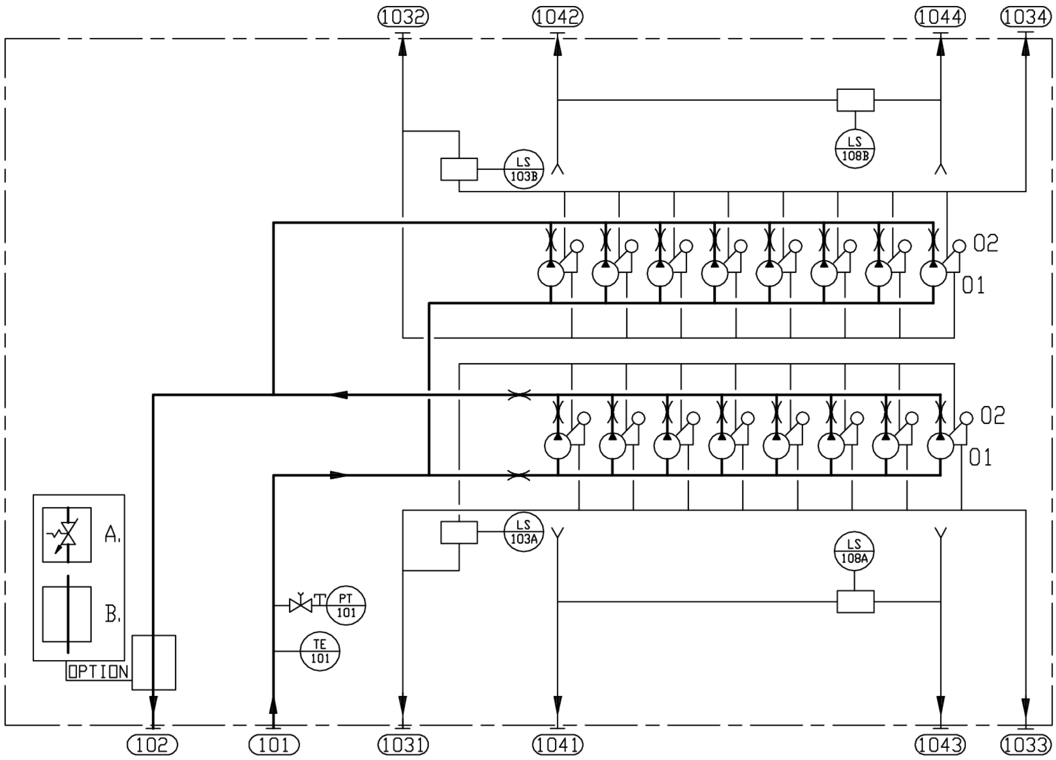


Fig 6.2.2 Internal fuel oil system, V-engines (DAAE005308E)

System components:			
01	Injection pump	Option A:	Pressure relief valve
02	Injection valve	Option B:	Without pressure relief valve

Sensors and indicators:			
LS103A,B	Fuel oil leakage, injection pipe A-, B-bank	PT101	Fuel oil pressure, engine inlet
LS108A,B	Fuel oil leakage, dirty fuel A-, B-bank	TE101	Fuel oil temperature, engine inlet

Pipe connections:		Size	Pressure class	Standard
101	Fuel inlet	DN32	PN40	ISO 7005-1
102	Fuel outlet	DN32	PN40	ISO 7005-1
1031,32	Clean fuel leakage, outlet	OD28		DIN 2353
1033,34	Clean fuel leakage, outlet	DN20		DIN 2353
1041,42	Dirty fuel leakage, outlet	OD18		DIN 2353
1043,44	Dirty fuel leakage, outlet	DN32		DIN 2353

The engine can be specified to either operate on heavy fuel oil (HFO) or on marine diesel fuel (MDF). The engine is designed for continuous operation on HFO. It is however possible to operate HFO engines on MDF intermittently without alternations. If the operation of the engine is changed from HFO to continuous operation on MDF, then a change of exhaust valves from Nimonic to Stellite is recommended.

A pressure control valve in the fuel return line on the engine maintains desired pressure before the injection pumps.

6.2.1 Leak fuel system

Clean leak fuel from the injection valves and the injection pumps is collected on the engine and drained by gravity through a clean leak fuel connection. The clean leak fuel can be re-used without separation. The quantity of clean leak fuel is given in chapter *Technical data*.

Other possible leak fuel and spilled water and oil is separately drained from the hot-box through dirty fuel oil connections and it shall be led to a sludge tank.

6.3 External fuel oil system

The design of the external fuel system may vary from ship to ship, but every system should provide well cleaned fuel of correct viscosity and pressure to each engine. Temperature control is required to maintain stable and correct viscosity of the fuel before the injection pumps (see *Technical data*). Sufficient circulation through every engine connected to the same circuit must be ensured in all operating conditions.

The fuel treatment system should comprise at least one settling tank and two separators. Correct dimensioning of HFO separators is of greatest importance, and therefore the recommendations of the separator manufacturer must be closely followed. Poorly centrifuged fuel is harmful to the engine and a high content of water may also damage the fuel feed system.

Injection pumps generate pressure pulses into the fuel feed and return piping. The fuel pipes between the feed unit and the engine must be properly clamped to rigid structures. The distance between the fixing points should be at close distance next to the engine. See chapter *Piping design, treatment and installation*.

A connection for compressed air should be provided before the engine, together with a drain from the fuel return line to the clean leakage fuel or overflow tank. With this arrangement it is possible to blow out fuel from the engine prior to maintenance work, to avoid spilling.

NOTE

In multiple engine installations, where several engines are connected to the same fuel feed circuit, it must be possible to close the fuel supply and return lines connected to the engine individually. This is a SOLAS requirement. It is further stipulated that the means of isolation shall not affect the operation of the other engines, and it shall be possible to close the fuel lines from a position that is not rendered inaccessible due to fire on any of the engines.

6.3.1 Fuel heating requirements HFO

Heating is required for:

- Bunker tanks, settling tanks, day tanks
- Pipes (trace heating)
- Separators
- Fuel feeder/booster units

To enable pumping the temperature of bunker tanks must always be maintained 5...10°C above the pour point, typically at 40...50°C. The heating coils can be designed for a temperature of 60°C.

The tank heating capacity is determined by the heat loss from the bunker tank and the desired temperature increase rate.

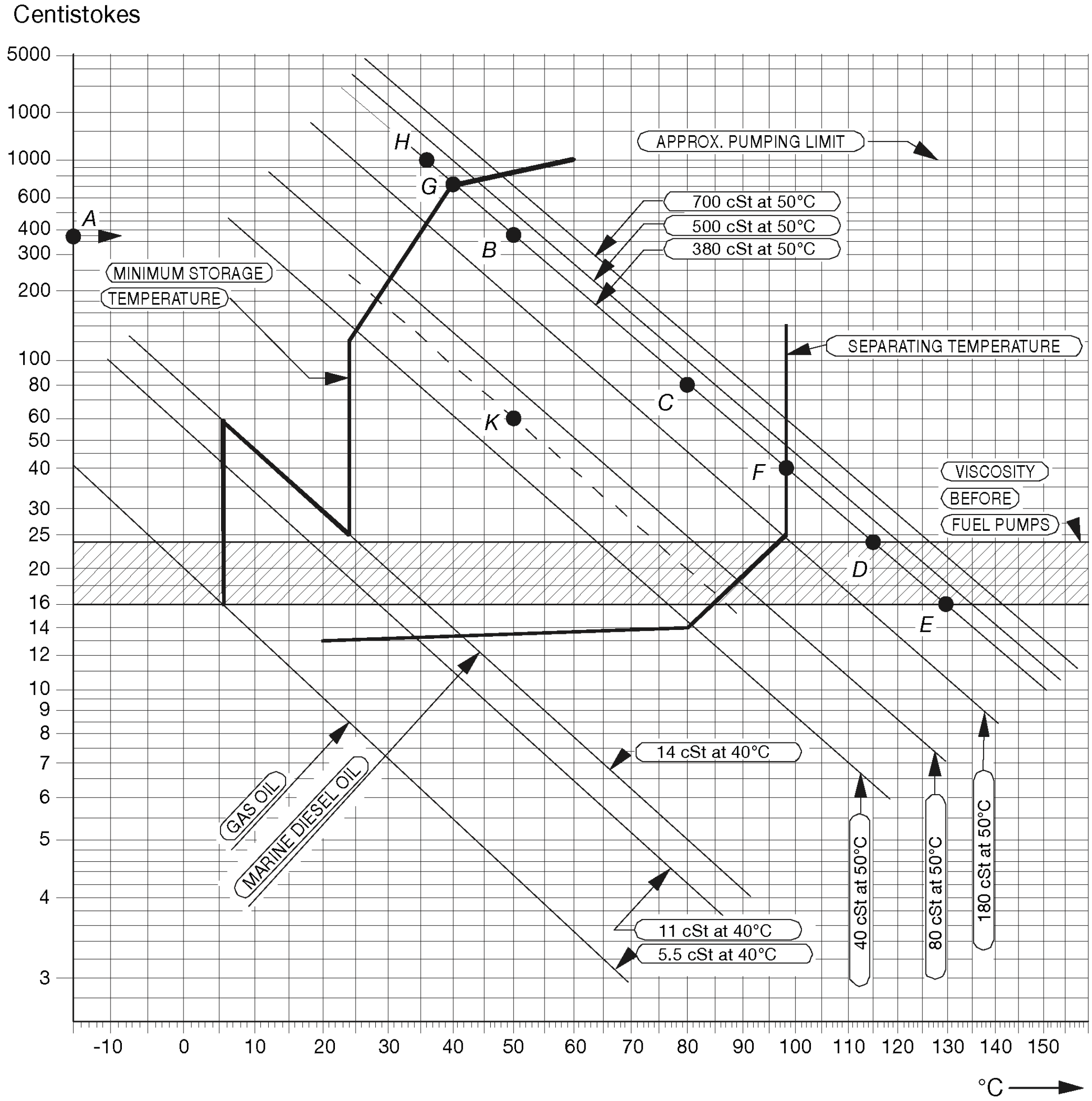


Fig 6.3.1.1 Fuel oil viscosity-temperature diagram for determining the pre-heating temperatures of fuel oils (4V92G0071b)

Example 1: A fuel oil with a viscosity of 380 cSt (A) at 50°C (B) or 80 cSt at 80°C (C) must be pre-heated to 115 - 130°C (D-E) before the fuel injection pumps, to 98°C (F) at the separator and to minimum 40°C (G) in the bunker tanks. The fuel oil may not be pumpable below 36°C (H).

To obtain temperatures for intermediate viscosities, draw a line from the known viscosity/temperature point in parallel to the nearest viscosity/temperature line in the diagram.

Example 2: Known viscosity 60 cSt at 50°C (K). The following can be read along the dotted line: viscosity at 80°C = 20 cSt, temperature at fuel injection pumps 74 - 87°C, separating temperature 86°C, minimum bunker tank temperature 28°C.

6.3.2 Fuel tanks

The fuel oil is first transferred from the bunker tanks to settling tanks for initial separation of sludge and water. After centrifuging the fuel oil is transferred to day tanks, from which fuel is supplied to the engines.

6.3.2.1 Settling tank, HFO (1T02) and MDF (1T10)

Separate settling tanks for HFO and MDF are recommended.

To ensure sufficient time for settling (water and sediment separation), the capacity of each tank should be sufficient for min. 24 hours operation at maximum fuel consumption.

The tanks should be provided with internal baffles to achieve efficient settling and have a sloped bottom for proper draining.

The temperature in HFO settling tanks should be maintained between 50°C and 70°C, which requires heating coils and insulation of the tank. Usuallly MDF settling tanks do not need heating or insulation, but the tank temperature should be in the range 20...40°C.

6.3.2.2 Day tank, HFO (1T03) and MDF (1T06)

Two day tanks for HFO are to be provided, each with a capacity sufficient for at least 8 hours operation at maximum fuel consumption.

A separate tank is to be provided for MDF. The capacity of the MDF tank should ensure fuel supply for 8 hours.

Settling tanks may not be used instead of day tanks.

The day tank must be designed so that accumulation of sludge near the suction pipe is prevented and the bottom of the tank should be sloped to ensure efficient draining.

HFO day tanks shall be provided with heating coils and insulation. It is recommended that the viscosity is kept below 140 cSt in the day tanks. Due to risk of wax formation, fuels with a viscosity lower than 50 cSt at 50°C must be kept at a temperature higher than the viscosity would require. Continuous separation is nowadays common practice, which means that the HFO day tank temperature normally remains above 90°C.

The temperature in the MDF day tank should be in the range 20...40°C.

The level of the tank must ensure a positive static pressure on the suction side of the fuel feed pumps. If black-out starting with MDF from a gravity tank is foreseen, then the tank must be located at least 15 m above the engine crankshaft.

6.3.2.3 Leak fuel tank, clean fuel (1T04)

Clean leak fuel is drained by gravity from the engine. The fuel should be collected in a separate clean leak fuel tank, from where it can be pumped to the day tank and reused without separation. The pipes from the engine to the clean leak fuel tank should be arranged continuosly sloping. The tank and the pipes must be heated and insulated, unless the installation is designed for operation on MDF only.

The leak fuel piping should be fully closed to prevent dirt from entering the system.

6.3.2.4 Leak fuel tank, dirty fuel (1T07)

In normal operation no fuel should leak out from the components of the fuel system. In connection with maintenance, or due to unforeseen leaks, fuel or water may spill in the hot box of the engine. The spilled liquids are collected and drained by gravity from the engine through the dirty fuel connection.

Dirty leak fuel shall be led to a sludge tank. The tank and the pipes must be heated and insulated, unless the installation is designed for operation exclusively on MDF.

6.3.3 Fuel treatment

6.3.3.1 Separation

Heavy fuel (residual, and mixtures of residuals and distillates) must be cleaned in an efficient centrifugal separator before it is transferred to the day tank.

Classification rules require the separator arrangement to be redundant so that required capacity is maintained with any one unit out of operation.

All recommendations from the separator manufacturer must be closely followed.

Centrifugal disc stack separators are recommended also for installations operating on MDF only, to remove water and possible contaminants. The capacity of MDF separators should be sufficient to ensure the fuel supply at maximum fuel consumption. Would a centrifugal separator be considered too expensive for a MDF installation, then it can be accepted to use coalescing type filters instead. A coalescing filter is usually installed on the suction side of the circulation pump in the fuel feed system. The filter must have a low pressure drop to avoid pump cavitation.

6.3.3.1.1 Separator mode of operation

The best separation efficiency is achieved when also the stand-by separator is in operation all the time, and the throughput is reduced according to actual consumption.

Separators with monitoring of cleaned fuel (without gravity disc) operating on a continuous basis can handle fuels with densities exceeding 991 kg/m3 at 15°C. In this case the main and stand-by separators should be run in parallel.

When separators with gravity disc are used, then each stand-by separator should be operated in series with another separator, so that the first separator acts as a purifier and the second as clarifier. This arrangement can be used for fuels with a density of max. 991 kg/m3 at 15°C. The separators must be of the same size.

6.3.3.1.2 Separation efficiency

The term Certified Flow Rate (CFR) has been introduced to express the performance of separators according to a common standard. CFR is defined as the flow rate in l/h, 30 minutes after sludge discharge, at which the separation efficiency of the separator is 85%, when using defined test oils and test particles. CFR is defined for equivalent fuel oil viscosities of 380 cSt and 700 cSt at 50°C. More information can be found in the CEN (European Committee for Standardisation) document CWA 15375:2005 (E).

The separation efficiency is measure of the separator's capability to remove specified test particles. The separation efficiency is defined as follows:

$$n = 100 \times \left(1 - \frac{C_{out}}{C_{in}}\right)$$

where:

n = separation efficiency [%]

C_{out} = number of test particles in cleaned test oil

C_{in} = number of test particles in test oil before separator

6.3.3.2 Separator unit (1N02/1N05)

Separators are usually supplied as pre-assembled units designed by the separator manufacturer.

Typically separator modules are equipped with:

- Suction strainer (1F02)
- Feed pump (1P02)
- Pre-heater (1E01)
- Sludge tank (1T05)
- Separator (1S01/1S02)

- Sludge pump
- Control cabinets including motor starters and monitoring

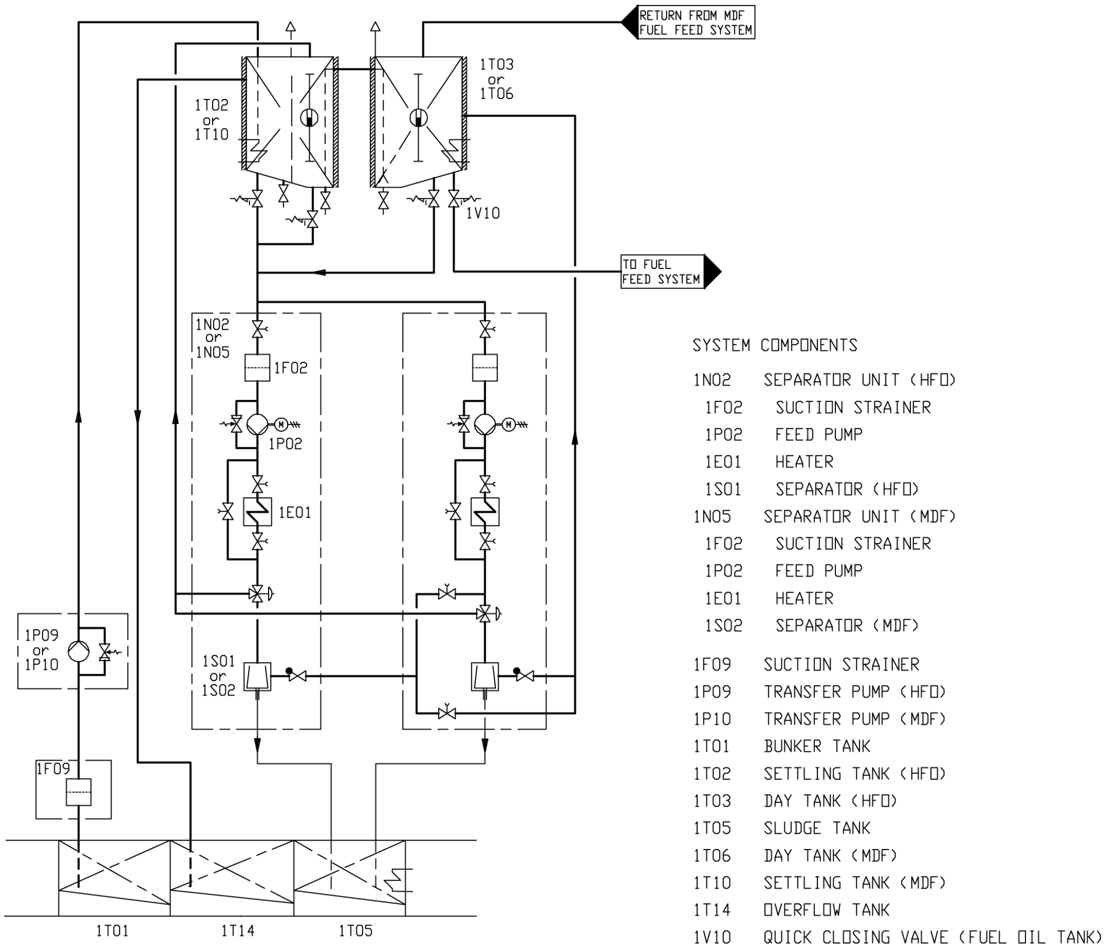


Fig 6.3.3.2.1 Fuel transfer and separating system (3V76F6626E)

6.3.3.3 Separator feed pumps (1P02)

Feed pumps should be dimensioned for the actual fuel quality and recommended throughput of the separator. The pump should be protected by a suction strainer (mesh size about 0.5 mm)

An approved system for control of the fuel feed rate to the separator is required.

Design data:	HFO	MDF
Design pressure	0.5 MPa (5 bar)	0.5 MPa (5 bar)
Design temperature	100°C	50°C
Viscosity for dimensioning electric motor	1000 cSt	100 cSt

6.3.3.4 Separator pre-heater (1E01)

The pre-heater is dimensioned according to the feed pump capacity and a given settling tank temperature.

The surface temperature in the heater must not be too high in order to avoid cracking of the fuel. The temperature control must be able to maintain the fuel temperature within ± 2°C.

Recommended fuel temperature after the heater depends on the viscosity, but it is typically 98°C for HFO and 20...40°C for MDF. The optimum operating temperature is defined by the sperarator manufacturer.

The required minimum capacity of the heater is:

$$P = \frac{Q \times \Delta T}{1700}$$

where:

P = heater capacity [kW]

Q = capacity of the separator feed pump [l/h]

ΔT = temperature rise in heater [°C]

For heavy fuels ΔT = 48°C can be used, i.e. a settling tank temperature of 50°C. Fuels having a viscosity higher than 5 cSt at 50°C require pre-heating before the separator.

The heaters to be provided with safety valves and drain pipes to a leakage tank (so that the possible leakage can be detected).

6.3.3.5 Separator (1S01/1S02)

Based on a separation time of 23 or 23.5 h/day, the service throughput Q [l/h] of the separator can be estimated with the formula:

$$Q = \frac{P \times b \times 24[h]}{\rho \times t}$$

where:

P = max. continuous rating of the diesel engine(s) [kW]

b = specific fuel consumption + 15% safety margin [g/kWh]

ρ = density of the fuel [kg/m^3]

t = daily separating time for self cleaning separator [h] (usually = 23 h or 23.5 h)

The flow rates recommended for the separator and the grade of fuel must not be exceeded. The lower the flow rate the better the separation efficiency.

Sample valves must be placed before and after the separator.

6.3.3.6 MDF separator in HFO installations (1S02)

A separator for MDF is recommended also for installations operating primarily on HFO. The MDF separator can be a smaller size dedicated MDF separator, or a stand-by HFO separator used for MDF.

6.3.3.7 Sludge tank (1T05)

The sludge tank should be located directly beneath the separators, or as close as possible below the separators, unless it is integrated in the separator unit. The sludge pipe must be continuously falling.

6.3.4 Fuel feed system - MDF installations

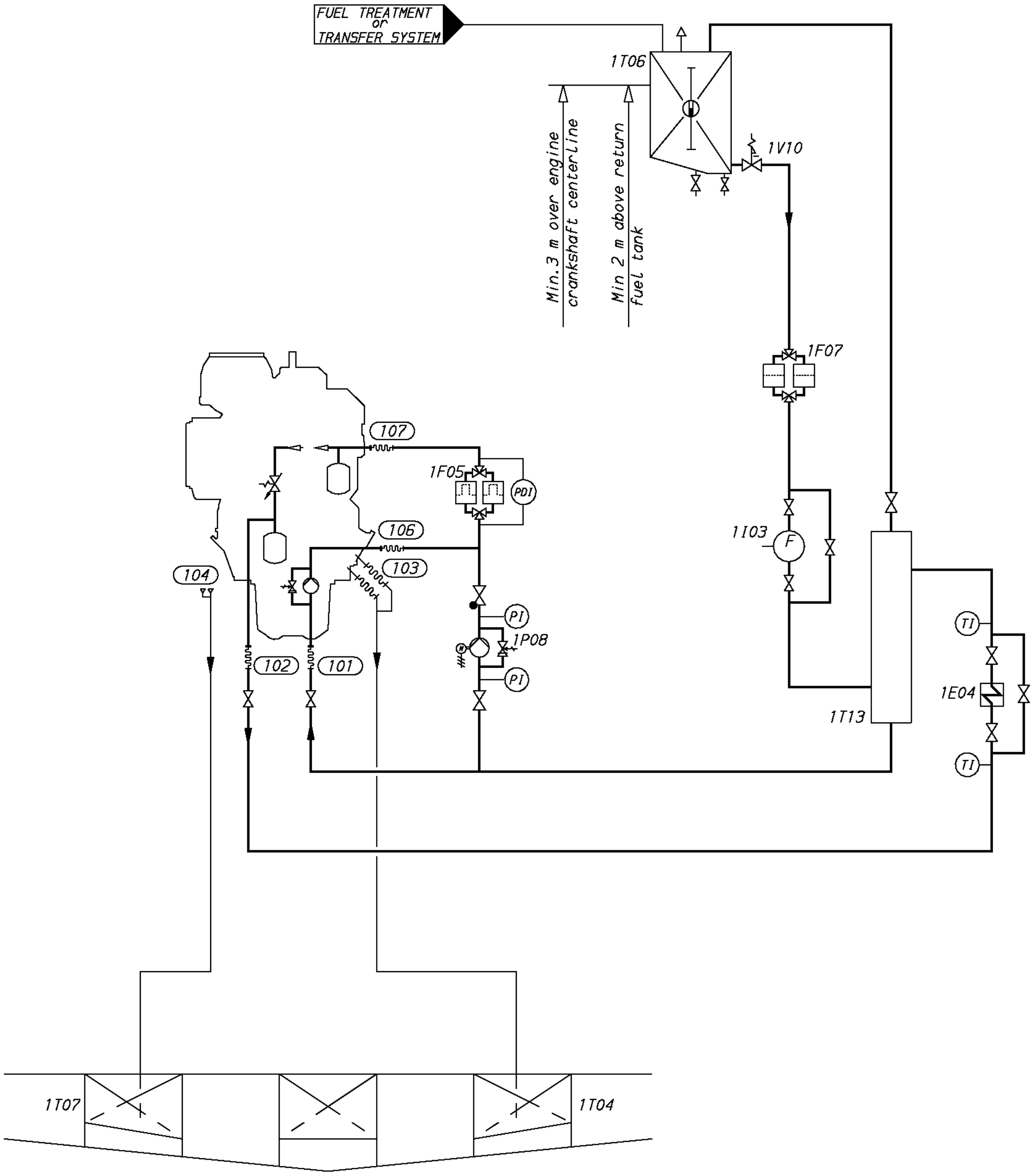


Fig 6.3.4.1 Typical example of fuel oil system (MDF) with engine driven pump (3V76F6629d)

System components		Pipe connections	
1E04	Cooler (MDF)	101	Fuel inlet
1F05	Fine filter (MDF)	102	Fuel outlet
1F07	Suction strainer (MDF)	103	Leak fuel drain, clean fuel
1I03	Flow meter (MDF)	104	Leak fuel drain, dirty fuel
1P08	Stand-by pump (MDF)	106	Fuel to external filter
1T04	Leak fuel tank (clean fuel)	107	Fuel from external filter
1T06	Day tank (MDF)		
1T07	Leak fuel tank (dirty fuel)		
1T13	Return fuel tank		
1V10	Quick closing valve (fuel oil tank)		

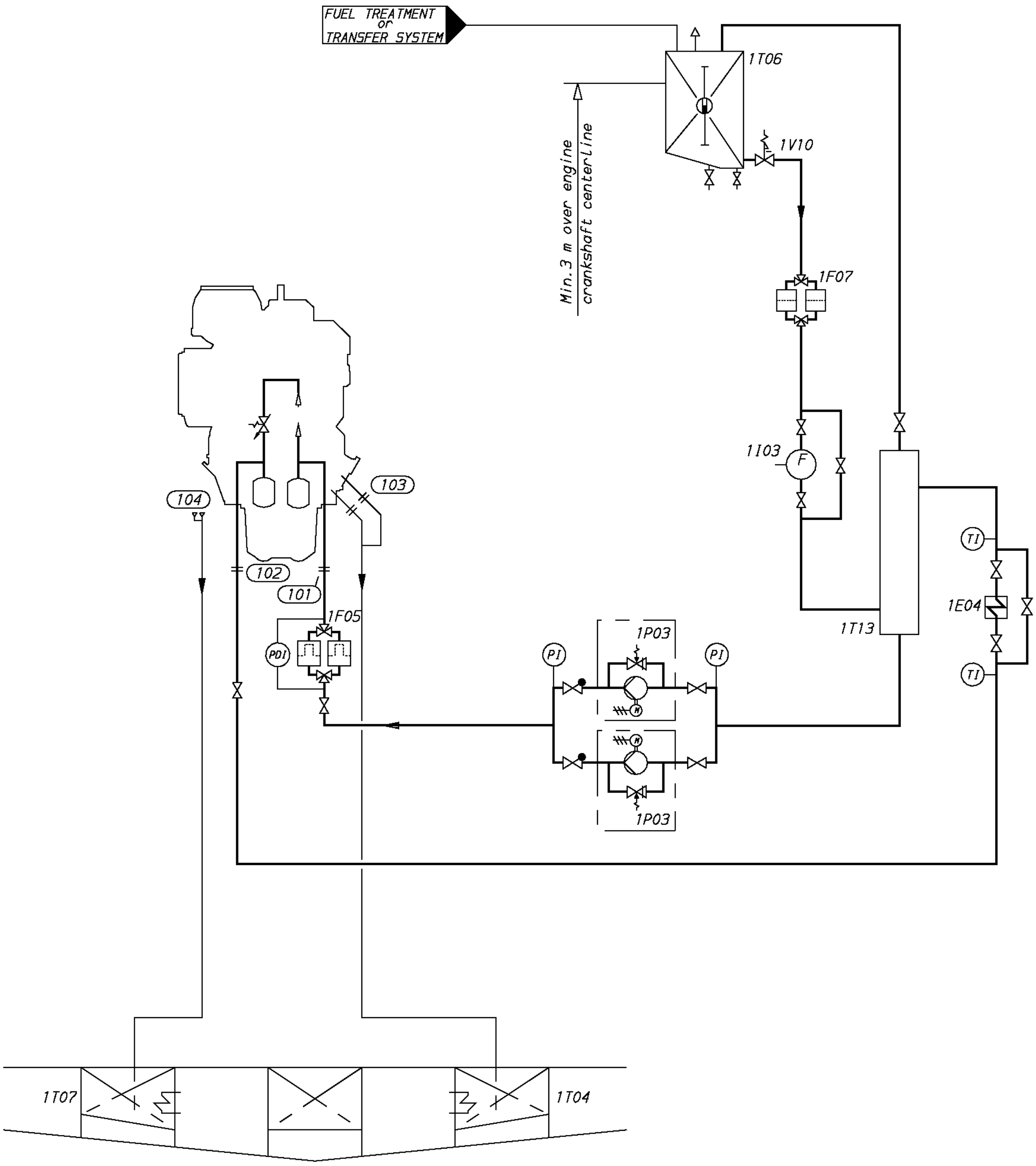


Fig 6.3.4.2 Typical example of fuel oil system (MDF) without engine driven pump (3V76F6116c)

System components		Pipe connections	
1E04	Cooler (MDF)	101	Fuel inlet
1F05	Fine filter (MDF)	102	Fuel outlet
1F07	Suction strainer (MDF)		
1I03	Flowmeter (MDF)	103	Leak fuel drain, clean fuel
1P03	Circulation pump (MDF)	104	Leak fuel drain, dirty fuel
1T04	Leak fuel tank (clean fuel)		
1T06	Day tank (MDF)		
1T07	Leak fuel tank (dirty fuel)		
1T13	Return fuel tank		
1V10	Quick closing valve (fuel oil tank)		

If the engines are to be operated on MDF only, heating of the fuel is normally not necessary. In such case it is sufficient to install the equipment listed below. Some of the equipment listed below is also to be installed in the MDF part of a HFO fuel oil system.

6.3.4.1 Circulation pump, MDF (1P03)

The circulation pump maintains the pressure at the injection pumps and circulates the fuel in the system. It is recommended to use a screw pump as circulation pump. A suction strainer with a fineness of 0.5 mm should be installed before each pump. There must be a positive static pressure of about 30 kPa on the suction side of the pump.

Design data:	
Capacity	5 x the total consumption of the connected engines
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Nominal pressure	see chapter "*Technical Data*"
Design temperature	50°C
Viscosity for dimensioning of electric motor	90 cSt

6.3.4.2 Stand-by pump, MDF (1P08)

The stand-by pump is required in case of a single main engine equipped with an engine driven pump. It is recommended to use a screw pump as stand-by pump. The pump should be placed so that a positive static pressure of about 30 kPa is obtained on the suction side of the pump.

Design data:	
Capacity	5 x the total consumption of the connected engine
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.2 MPa (12 bar)
Design temperature	50°C
Viscosity for dimensioning of electric motor	90 cSt

6.3.4.3 Flow meter, MDF (1I03)

If the return fuel from the engine is conducted to a return fuel tank instead of the day tank, one consumption meter is sufficient for monitoring of the fuel consumption, provided that the meter is installed in the feed line from the day tank (before the return fuel tank). A fuel oil cooler is usually required with a return fuel tank.

The total resistance of the flow meter and the suction strainer must be small enough to ensure a positive static pressure of about 30 kPa on the suction side of the circulation pump.

There should be a by-pass line around the consumption meter, which opens automatically in case of excessive pressure drop.

6.3.4.4 Fine filter, MDF (1F05)

The fuel oil fine filter is a full flow duplex type filter with steel net. This filter must be installed as near the engine as possible.

The diameter of the pipe between the fine filter and the engine should be the same as the diameter before the filters.

Design data:	
Fuel viscosity	according to fuel specifications
Design temperature	50°C
Design flow	Larger than feed/circulation pump capacity
Design pressure	1.6 MPa (16 bar)
Fineness	37 μm (absolute mesh size)
Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

6.3.4.5 Pressure control valve, MDF (1V02)

The pressure control valve is installed when the installation includes a feeder/booster unit for HFO and there is a return line from the engine to the MDF day tank. The purpose of the valve is to increase the pressure in the return line so that the required pressure at the engine is achieved.

Design data:	
Capacity	Equal to circulation pump
Design temperature	50°C
Design pressure	1.6 MPa (16 bar)
Set point	0.4...0.7 MPa (4...7 bar)

6.3.4.6 MDF cooler (1E04)

The fuel viscosity may not drop below the minimum value stated in *Technical data*. When operating on MDF, the practical consequence is that the fuel oil inlet temperature must be kept below 45°C. Very light fuel grades may require even lower temperature.

Sustained operation on MDF usually requires a fuel oil cooler. The cooler is to be installed in the return line after the engine(s). LT-water is normally used as cooling medium.

If MDF viscosity in day tank drops below stated minimum viscosity limit then it is recommended to install an MDF cooler into the engine fuel supply line in order to have reliable viscosity control.

Design data:	
Heat to be dissipated	2.5 kW/cyl
Max. pressure drop, fuel oil	80 kPa (0.8 bar)
Max. pressure drop, water	60 kPa (0.6 bar)
Margin (heat rate, fouling)	min. 15%
Design temperature MDF/HFO installation	50/150°C

6.3.4.7 Return fuel tank (1T13)

The return fuel tank shall be equipped with a vent valve needed for the vent pipe to the MDF day tank. The volume of the return fuel tank should be at least 100 l.

6.3.4.8 Black out start

Diesel generators serving as the main source of electrical power must be able to resume their operation in a black out situation by means of stored energy. Depending on system design and classification regulations, it may in some cases be permissible to use the emergency generator. HFO engines without engine driven fuel feed pump can reach sufficient fuel pressure to enable black out start by means of:

- A gravity tank located min. 15 m above the crankshaft
- A pneumatically driven fuel feed pump (1P11)
- An electrically driven fuel feed pump (1P11) powered by an emergency power source

6.3.5 Fuel feed system - HFO installations

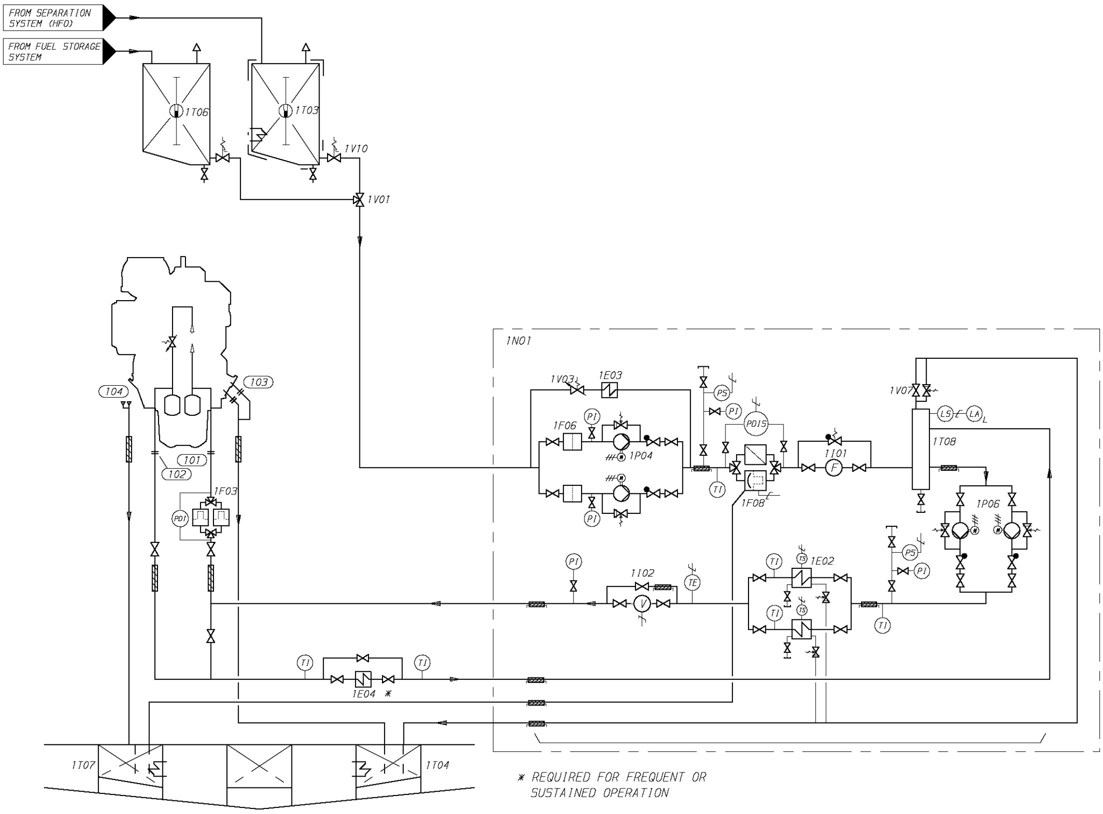
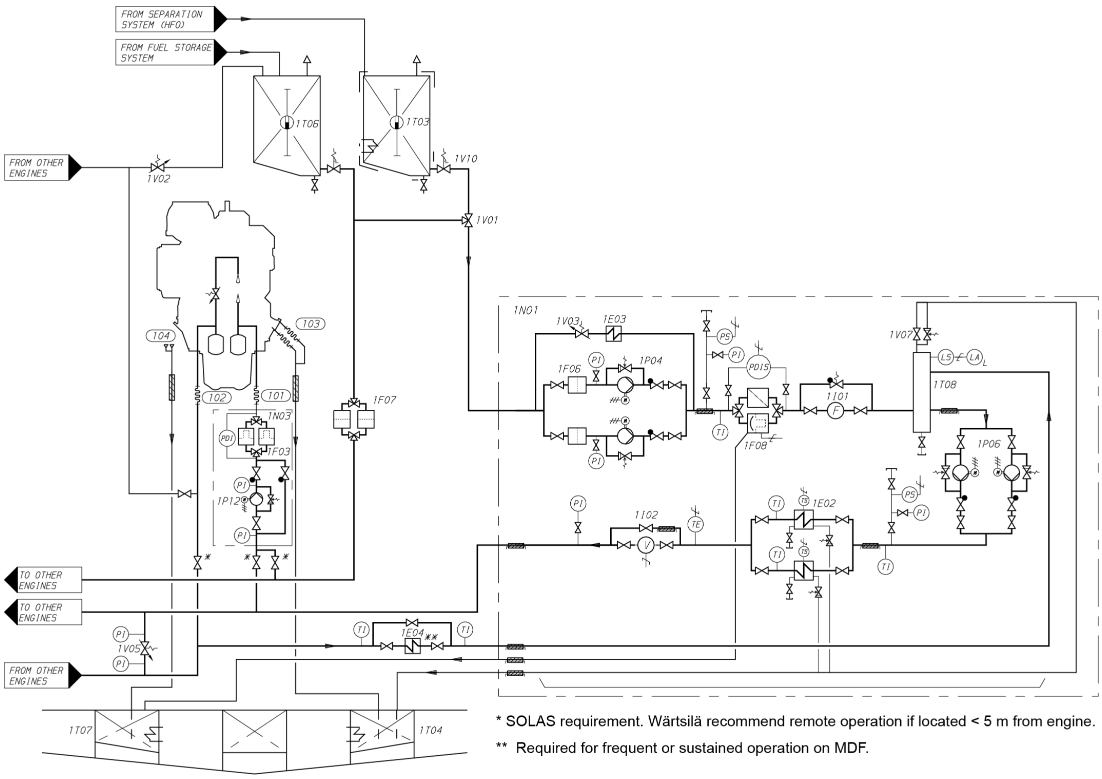


Fig 6.3.5.1 Example of fuel oil system (HFO) single engine installation (3V76F6627b)

System components:			
1E02	Heater (booster unit)	1P06	Circulation pump (booster unit)
1E03	Cooler (booster unit)	1T03	Day tank (HFO)
1E04	Cooler (MDF)	1T04	Leak fuel tank (clean fuel)
1F03	Safety filter (HFO)	1T06	Day tank (MDF)
1F06	Suction filter (booster unit)	1T07	Leak fuel tank (dirty fuel)
1F08	Automatic filter (booster unit)	1T08	De-aeration tank (booster unit)
1I01	Flow meter (booster unit)	1V01	Changeover valve
1I02	Viscosity meter (booster unit)	1V03	Pressure control valve (booster unit)
1N01	Feeder/booster unit	1V07	Venting valve (booster unit)
1P04	Fuel feed pump (booster unit)	1V10	Quick closing valve (fuel oil tank)

Pipe connections:			
101	Fuel inlet	1031...34	Leak fuel drain, clean fuel
102	Fuel outlet	1041...44	Leak fuel drain, dirty fuel



* SOLAS requirement. Wärtsilä recommend remote operation if located < 5 m from engine.

** Required for frequent or sustained operation on MDF.

Fig 6.3.5.2 Example of fuel oil system (HFO) multiple engine installation (3V76F6628d)

System components:			
1E02	Heater (booster unit)	1P12	Circulation pump (HFO/MDF)
1E03	Cooler (booster unit)	1T03	Day tank (HFO)
1E04	Cooler (MDF)	1T04	Leak fuel tank (clean fuel)
1F03	Safety filter (HFO)	1T06	Day tank (MDF)
1F06	Suction filter (booster unit)	1T07	Leak fuel tank (dirty fuel)
1F07	Suction strainer (MDF)	1T08	De-aeration tank (booster unit)
1F08	Automatic filter (booster unit)	1V01	Changeover valve
1I01	Flow meter (booster unit)	1V02	Pressure control valve (MDF)
1I02	Viscosity meter (booster unit)	1V03	Pressure control valve (booster unit)
1N01	Feeder/booster unit	1V05	Overflow valve (HFO/MDF)
1N03	Pump and filter unit (HFO/MDF)	1V07	Venting valve (booster unit)
1P04	Fuel feed pump (booster unit)	1V10	Quick closing valve (fuel oil tank)
1P06	Circulation pump (booster unit)		

Pipe connections:			
101	Fuel inlet	1031...34	Leak fuel drain, clean fuel
102	Fuel outlet	1041...44	Leak fuel drain, dirty fuel

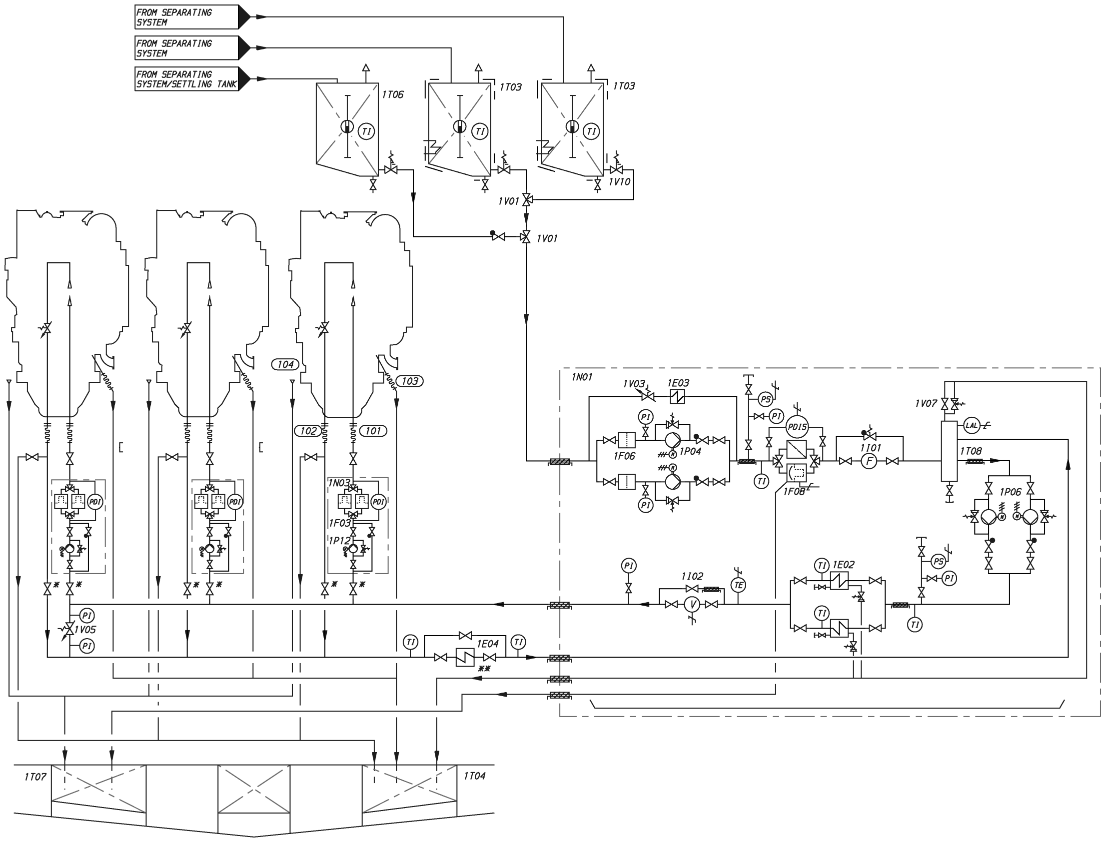


Fig 6.3.5.3 Example of fuel oil system (HFO) multiple engine installation (DAAE057999C)

*	SOLAS requirement. Wärtsilä recommend remote operation of located < 5m from engine.	**	Required for frequent or sustained operation on MDF.

System components:			
1E02	Heater (booster unit)	1P06	Circulation pump (booster unit)
1E03	Cooler (booster unit)	1P12	Circulation pump (HFO/MDF)
1E04	Cooler (MDF)	1T03	Day tank (HFO)
1F03	Safety filter (HFO)	1T04	Leak fuel tank (clean fuel)
1F06	Suction filter (booster unit)	1T06	Day tank (MDF)
1F07	Suction strainer (MDF)	1T07	Leak fuel tank (dirty fuel)
1F08	Automatic filter (booster unit)	1T08	De-aeration tank (booster unit)
1I01	Flow meter (booster unit)	1V01	Changeover valve
1I02	Viscosity meter (booster unit)	1V03	Pressure control valve (booster unit)
1N01	Feeder/booster unit	1V05	Overflow valve (HFO/MDF)
1N03	Pump and filter unit (HFO/MDF)	1V07	Venting valve (booster unit)
1P04	Fuel feed pump (booster unit)	1V10	Quick closing valve (fuel oil tank)

Pipe connections:			
101	Fuel inlet	1031...34	Leak fuel drain, clean fuel
102	Fuel outlet	1041...44	Leak fuel drain, dirty fuel

HFO pipes shall be properly insulated. If the viscosity of the fuel is 180 cSt/50°C or higher, the pipes must be equipped with trace heating. It sha ll be possible to shut off the heating of the pipes when operating on MDF (trace heating to be grouped logically).

6.3.5.1 Starting and stopping

The engine can be started and stopped on HFO provided that the engine and the fuel system are pre-heated to operating temperature. The fuel must be continuously circulated also through a stopped engine in order to maintain the operating temperature. Changeover to MDF for start and stop is not required.

Prior to overhaul or shutdown of the external system the engine fuel system shall be flushed and filled with MDF.

6.3.5.2 Changeover from HFO to MDF

The control sequence and the equipment for changing fuel during operation must ensure a smooth change in fuel temperature and viscosity. When MDF is fed through the HFO feeder/booster unit, the volume in the system is sufficient to ensure a reasonably smooth transfer.

When there are separate circulating pumps for MDF, then the fuel change should be performed with the HFO feeder/booster unit before switching over to the MDF circulating pumps. As mentioned earlier, sustained operation on MDF usually requires a fuel oil cooler. The viscosity at the engine shall not drop below the minimum limit stated in chapter *Technical data*.

6.3.5.3 Number of engines in the same system

When the fuel feed unit serves Wärtsilä 32 engines only, maximum one engine should be connected to the same fuel feed circuit, unless individual circulating pumps before each engine are installed.

Main engines and auxiliary engines should preferably have separate fuel feed units. Individual circulating pumps or other special arrangements are often required to have main engines and auxiliary engines in the same fuel feed circuit. Regardless of special arrangements it is not recommended to supply more than maximum two main engines and two auxiliary engines, or one main engine and three auxiliary engines from the same fuel feed unit.

In addition the following guidelines apply:

- Twin screw vessels with two engines should have a separate fuel feed circuit for each propeller shaft.
- Twin screw vessels with four engines should have the engines on the same shaft connected to different fuel feed circuits. One engine from each shaft can be connected to the same circuit.

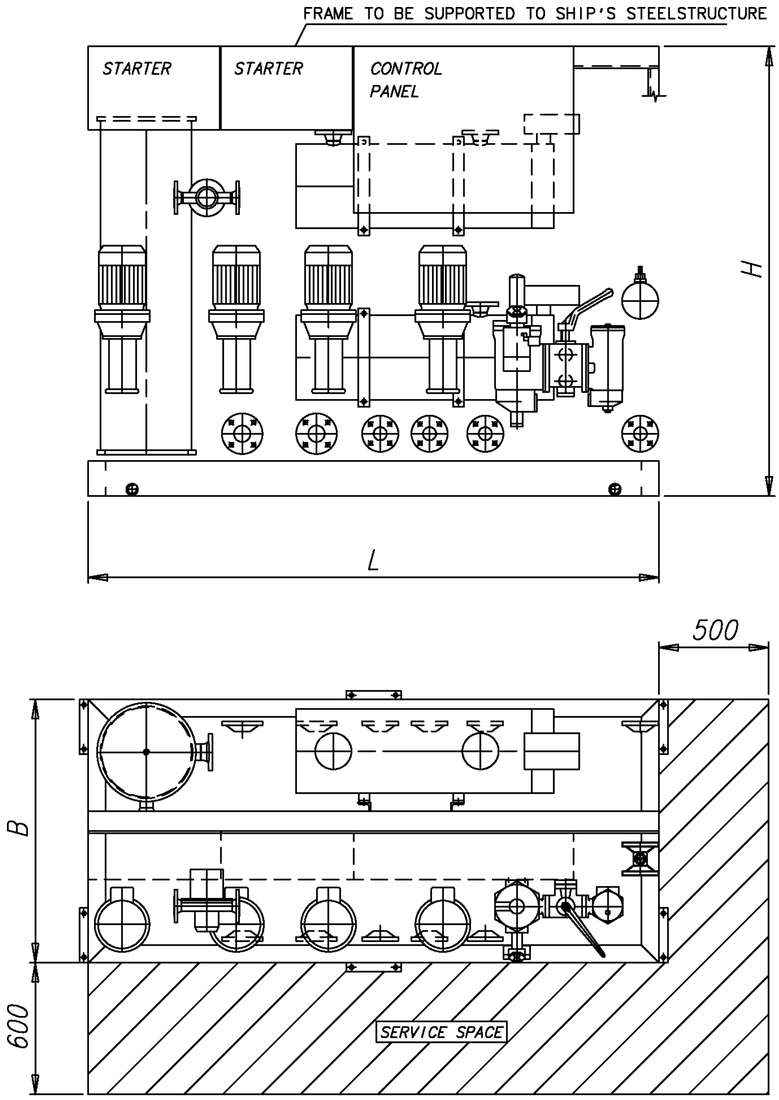
6.3.5.4 Feeder/booster unit (1N01)

A completely assembled feeder/booster unit can be supplied. This unit comprises the following equipment:

- Two suction strainers
- Two fuel feed pumps of screw type, equipped with built-on safety valves and electric motors
- One pressure control/overflow valve
- One pressurized de-aeration tank, equipped with a level switch operated vent valve
- Two circulating pumps, same type as the fuel feed pumps
- Two heaters, steam, electric or thermal oil (one heater in operation, the other as spare)
- One automatic back-flushing filter with by-pass filter
- One viscosimeter for control of the heaters

- One control valve for steam or thermal oil heaters, a control cabinet for electric heaters
- One thermostatic valve for emergency control of the heaters
- One control cabinet including starters for pumps
- One alarm panel

The above equipment is built on a steel frame, which can be welded or bolted to its foundation in the ship. The unit has all internal wiring and piping fully assembled. All HFO pipes are insulated and provided with trace heating.



	H	L	B
STEAM	1800	2500	1100
ELECTRICAL	2050	2600	1200

All dimensions in mm.

Fig 6.3.5.4.1 Feeder/booster unit, example (DAAE006659)

6.3.5.4.1 Fuel feed pump, booster unit (1P04)

The feed pump maintains the pressure in the fuel feed system. It is recommended to use a screw pump as feed pump. The capacity of the feed pump must be sufficient to prevent pressure drop during flushing of the automatic filter.

A suction strainer with a fineness of 0.5 mm should be installed before each pump. There must be a positive static pressure of about 30 kPa on the suction side of the pump.

Design data:

Capacity	Total consumption of the connected engines added with the flush quantity of the automatic filter (1F08)
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	0.7 MPa (7 bar)
Design temperature	100°C
Viscosity for dimensioning of electric motor	1000 cSt

6.3.5.4.2 Pressure control valve, booster unit (1V03)

The pressure control valve in the feeder/booster unit maintains the pressure in the de-aeration tank by directing the surplus flow to the suction side of the feed pump.

Design data:	
Capacity	Equal to feed pump
Design pressure	1.6 MPa (16 bar)
Design temperature	100°C
Set-point	0.3...0.5 MPa (3...5 bar)

6.3.5.4.3 Automatic filter, booster unit (1F08)

It is recommended to select an automatic filter with a manually cleaned filter in the bypass line. The automatic filter must be installed before the heater, between the feed pump and the de-aeration tank, and it should be equipped with a heating jacket. Overheating (temperature exceeding 100°C) is however to be prevented, and it must be possible to switch off the heating for operation on MDF.

Design data:	
Fuel viscosity	According to fuel specification
Design temperature	100°C
Preheating	If fuel viscosity is higher than 25 cSt/100°C
Design flow	Equal to feed pump capacity
Design pressure	1.6 MPa (16 bar)
Fineness:	
- automatic filter	35 µm (absolute mesh size)
- by-pass filter	35 µm (absolute mesh size)
Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

6.3.5.4.4 Flow meter, booster unit (1I01)

If a fuel consumption meter is required, it should be fitted between the feed pumps and the de-aeration tank. When it is desired to monitor the fuel consumption of individual engines in a multiple engine installation, two flow meters per engine are to be installed: one in the feed line and one in the return line of each engine.

There should be a by-pass line around the consumption meter, which opens automatically in case of excessive pressure drop.

If the consumption meter is provided with a prefilter, an alarm for high pressure difference across the filter is recommended.

6.3.5.4.5 De-aeration tank, booster unit (1T08)

It shall be equipped with a low level alarm switch and a vent valve. The vent pipe should, if possible, be led downwards, e.g. to the overflow tank. The tank must be insulated and equipped with a heating coil. The volume of the tank should be at least 100 l.

6.3.5.4.6 Circulation pump, booster unit (1P06)

The purpose of this pump is to circulate the fuel in the system and to maintain the required pressure at the injection pumps, which is stated in the chapter *Technical data*. By circulating the fuel in the system it also maintains correct viscosity, and keeps the piping and the injection pumps at operating temperature.

When more than one engine is connected to the same feeder/booster unit, individual circulation pumps (1P12) must be installed before each engine.

Design data:	
Capacity:	
- without circulation pumps (1P12)	5 x the total consumption of the connected engines
- with circulation pumps (1P12)	15% more than total capacity of all circulation pumps
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Design temperature	150°C
Viscosity for dimensioning of electric motor	500 cSt

6.3.5.4.7 Heater, booster unit (1E02)

The heater must be able to maintain a fuel viscosity of 14 cSt at maximum fuel consumption, with fuel of the specified grade and a given day tank temperature (required viscosity at injection pumps stated in *Technical data*). When operating on high viscosity fuels, the fuel temperature at the engine inlet may not exceed 135°C however.

The power of the heater is to be controlled by a viscosimeter. The set-point of the viscosimeter shall be somewhat lower than the required viscosity at the injection pumps to compensate for heat losses in the pipes. A thermostat should be fitted as a backup to the viscosity control.

To avoid cracking of the fuel the surface temperature in the heater must not be too high. The heat transfer rate in relation to the surface area must not exceed 1.5 W/cm^2.

The required heater capacity can be estimated with the following formula:

$$P = \frac{Q \times \Delta T}{1700}$$

where:

P = heater capacity (kW)

Q = total fuel consumption at full output + 15% margin [l/h]

ΔT = temperature rise in heater [°C]

6.3.5.4.8 Viscosimeter, booster unit (1I02)

The heater is to be controlled by a viscosimeter. The viscosimeter should be of a design that can withstand the pressure peaks caused by the injection pumps of the diesel engine.

Design data:	
Operating range	0...50 cSt
Design temperature	180°C
Design pressure	4 MPa (40 bar)

6.3.5.5 Pump and filter unit (1N03)

When more than one engine is connected to the same feeder/booster unit, a circulation pump (1P12) must be installed before each engine. The circulation pump (1P12) and the safety filter (1F03) can be combined in a pump and filter unit (1N03). A safety filter is always required.

There must be a by-pass line over the pump to permit circulation of fuel through the engine also in case the pump is stopped. The diameter of the pipe between the filter and the engine should be the same size as between the feeder/booster unit and the pump and filter unit.

6.3.5.5.1 Circulation pump (1P12)

The purpose of the circulation pump is to ensure equal circulation through all engines. With a common circulation pump for several engines, the fuel flow will be divided according to the pressure distribution in the system (which also tends to change over time) and the control valve on the engine has a very flat pressure versus flow curve.

In installations where MDF is fed directly from the MDF tank (1T06) to the circulation pump, a suction strainer (1F07) with a fineness of 0.5 mm shall be installed to protect the circulation pump. The suction strainer can be common for all circulation pumps.

Design data:	
Capacity	5 x the fuel consumption of the engine
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Design temperature	150°C
Pressure for dimensioning of electric motor (ΔP):	
- if MDF is fed directly from day tank	0.7 MPa (7 bar)
- if all fuel is fed through feeder/booster unit	0.3 MPa (3 bar)
Viscosity for dimensioning of electric motor	500 cSt

6.3.5.5.2 Safety filter (1F03)

The safety filter is a full flow duplex type filter with steel net. The filter should be equipped with a heating jacket. The safety filter or pump and filter unit shall be installed as close as possible to the engine.

Design data:	
Fuel viscosity	according to fuel specification
Design temperature	150°C

Design flow	Equal to circulation pump capacity
Design pressure	1.6 MPa (16 bar)

Filter fineness	37 μm (absolute mesh size)
Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

6.3.5.6 Overflow valve, HFO (1V05)

When several engines are connected to the same feeder/booster unit an overflow valve is needed between the feed line and the return line. The overflow valve limits the maximum pressure in the feed line, when the fuel lines to a parallel engine are closed for maintenance purposes.

The overflow valve should be dimensioned to secure a stable pressure over the whole operating range.

Design data:	
Capacity	Equal to circulation pump (1P06)
Design pressure	1.6 MPa (16 bar)
Design temperature	150°C
Set-point (Δp)	0.2...0.7 MPa (2...7 bar)

6.3.6 Flushing

The external piping system must be thoroughly flushed before the engines are connected and fuel is circulated through the engines. The piping system must have provisions for installation of a temporary flushing filter.

The fuel pipes at the engine (connections 101 and 102) are disconnected and the supply and return lines are connected with a temporary pipe or hose on the installation side. All filter inserts are removed, except in the flushing filter of course. The automatic filter and the viscosimeter should be bypassed to prevent damage. The fineness of the flushing filter should be 35 μm or finer.

7.2 Internal lubricating oil system

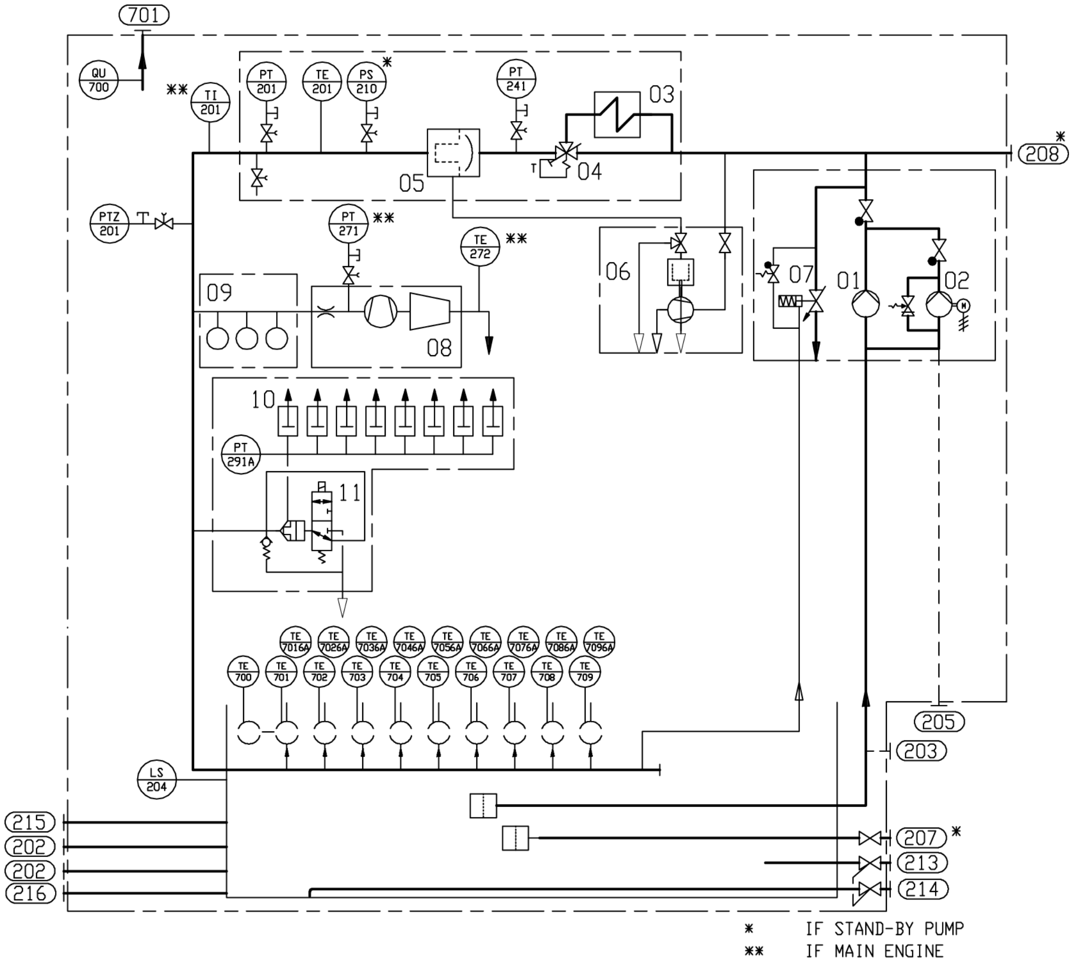


Fig 7.2.1 Internal lubricating oil system 500 kW/cyl, in-line engines (DAAE005309H)

System components:			
01	Lubricating oil main pump	07	Pressure control valve
02	Prelubricating oil pump	08	Turbocharger
03	Lubricating oil cooler	09	Camshaft bearings and cylinder head lubrication
04	Thermostatic valve	10	Guide block
05	Automatic filter	11	Control valve
06	Centrifugal filter		

Sensors and indicators:			
LS204	Lubricating oil low level, wet sump	TE272	Lubricating oil temperature, TC A outlet
PS210	Lubricating oil stand-by pump start (if stand-by)	PT291A	Control air pressure after VIC valve, A-bank
PT201	Lubricating oil pressure, engine inlet	TE7#	Main bearing temperature
PT271	Lubricating oil pressure, TC A inlet (not if TPS61 turboc.)	TE70#6A	Big end bearing temp, cyl 0#A (optional)
PT241	Lubricating oil pressure, filter inlet	QU700	Oil mist detector
PTZ201	Lubricating oil pressure, engine inlet	TI201	Lubricating oil temperature, engine inlet (if ME)
TE201	Lubricating oil temperature, engine inlet		

Pipe connections:		Size	Pressure class	Standard
202	Lubricating oil outlet (dry sump)	DN150	PN16	ISO 7005-1
203	Lubricating oil to engine driven pump (dry sump)	DN200	PN16	ISO 7005-1
205	Lubricating oil to priming pump (dry sump)	DN80	PN16	ISO 7005-1
207	Lubricating oil to el. driven pump (stand-by pump)	DN150	PN16	ISO 7005-1
208	Lubricating oil from el. driven pump (stand-by pump)	DN100	PN16	ISO 7005-1
213	Lubricating oil from separator and filling (wet sump)	DN40	PN40	ISO 7005-1
214	Lubricating oil to separator and drain (wet sump)	DN40	PN40	ISO 7005-1
215	Lubricating oil filling (wet sump)	DN40		ISO 7005-1
216	Lubricating oil drain (wet sump)	M22 x 1.5		
701	Crankcase ventilation	DN100	PN16	ISO 7005-1

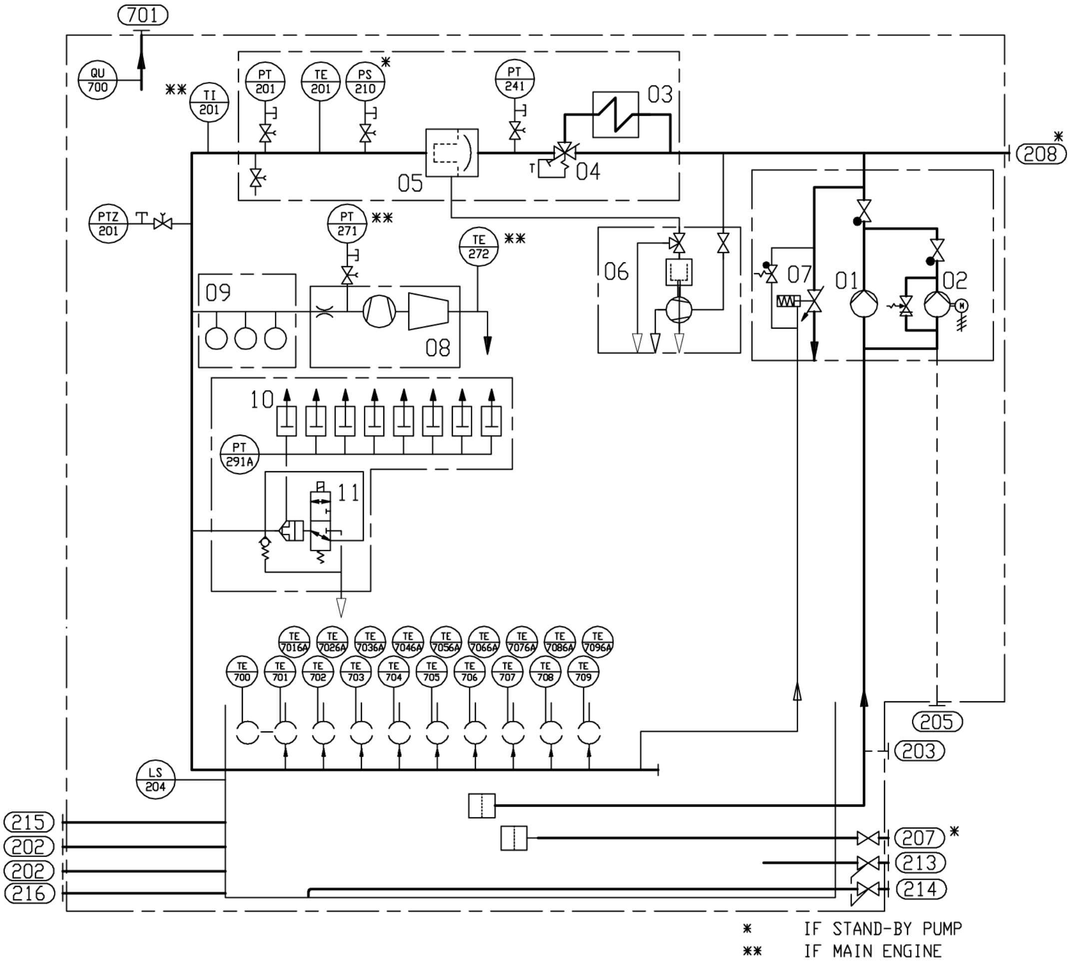


Fig 7.2.2 Internal lubricating oil system 580 kW/cyl, in-line engines (DAAF057025C)

System components:			
01	Lubricating oil main pump	07	Pressure control valve
02	Prelubricating oil pump	08	Turbocharger
03	Lubricating oil cooler	09	Camshaft bearings and cylinder head lubrication
04	Thermostatic valve	10	Guide block
05	Automatic filter	11	Control valve
06	Centrifugal filter		

Sensors and indicators:			
LS204	Lubricating oil low level, wet sump	TE272	Lubricating oil temperature, TC A outlet
PS210	Lubricating oil stand-by pump start (if stand-by)	TE7##	Main bearing temperature
PT201	Lubricating oil pressure, engine inlet	TE70#6A	Big end bearing temp, cyl 0#A
PT271	Lubricating oil pressure, TC A inlet	PT700	Crankcase pressure
PTZ201	Lubricating oil pressure, engine inlet	QU700	Oil mist detector
TE201	Lubricating oil temperature, engine inlet	TI201	Lubricating oil temperature, engine inlet

Pipe connections:		Size	Pressure class	Standard
202	Lubricating oil outlet (dry sump)	DN150	PN16	ISO 7005-1
203	Lubricating oil to engine driven pump (dry sump)	DN200	PN16	ISO 7005-1
205	Lubricating oil to priming pump (dry sump)	DN80	PN16	ISO 7005-1
207	Lubricating oil to el. driven pump (stand-by pump)	DN150	PN16	ISO 7005-1

Pipe connections:		Size	Pressure class	Standard
208	Lubricating oil from el. driven pump (stand-by pump)	DN100	PN16	ISO 7005-1
213	Lubricating oil from separator and filling (wet sump)	DN40	PN40	ISO 7005-1
214	Lubricating oil to separator and drain (wet sump)	DN40	PN40	ISO 7005-1
215	Lubricating oil filling (wet sump)	DN40		ISO 7005-1
216	Lubricating oil drain (wet sump)	M22 x 1.5		
701	Crankcase ventilation	DN100	PN16	ISO 7005-1

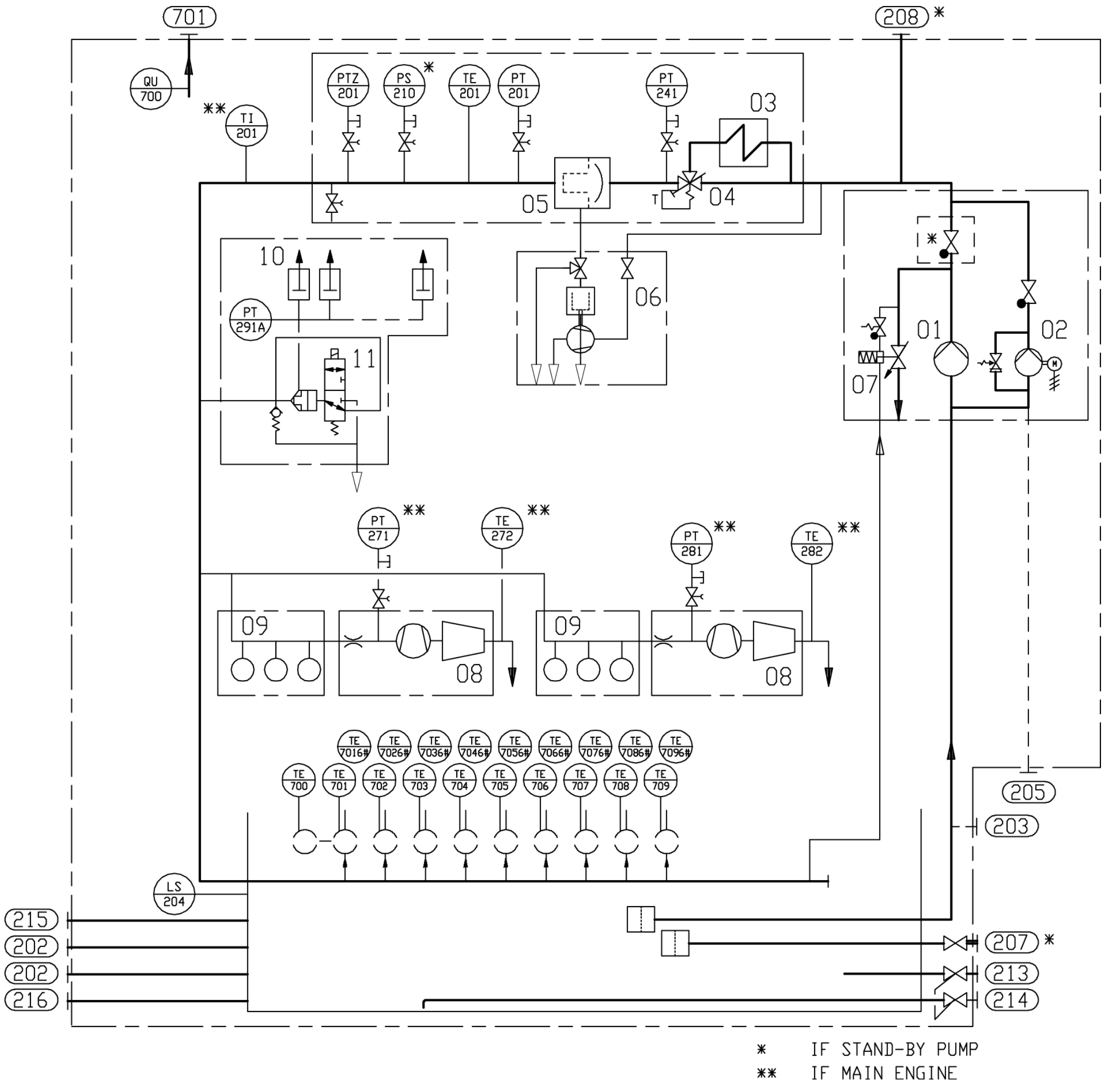


Fig 7.2.3 Internal lubricating oil system 500 kW/cyl, V-engines (DAAE005310G)

System components:			
01	Lubricating oil main pump	07	Pressure control valve
02	Prelubricating oil pump	08	Turbocharger
03	Lubricating oil cooler	09	Camshaft bearings and cylinder head lubrication
04	Thermostatic valve	10	Guide block
05	Automatic filter	11	Control valve
06	Centrifugal filter		

Sensors and indicators:			
LS204	Lubricating oil level, wet sump, low	TE201	Lubricating oil temperature, engine inlet
PS210	Lubricating oil stand-by pump start (if stand-by)	TE272	Lubricating oil temperature, TC A outlet
PT201	Lubricating oil pressure, engine inlet	TE282	Lubricating oil temperature, TC B outlet
PT241	Lubricating oil pressure, filter inlet	TE291A	Control oil pressure after VIC valve, A-bank
PT271	Lubricating oil pressure, TC A inlet (not if TPS61 turboc.)	TE70#	Main bearing temperature
PT281	Lubricating oil pressure, TC B inlet (not if TPS61 turboc.)	TE70#6#	Big end bearing temp, cyl0#A/B
PTZ201	Lubricating oil pressure, engine inlet	QU700	Oil mist detector
		TI201	Lubricating oil temperature, engine inlet (if ME)

Pipe connections:		Size	Pressure class	Standard
202	Lubricating oil outlet (dry sump)	DN150	PN16	ISO 7005-1
203	Lubricating oil to engine driven pump (dry sump)	DN250	PN16	ISO 7005-1
205	Lubricating oil to priming pump (dry sump)	DN125	PN16	ISO 7005-1
207	Lubricating oil to el. driven pump (stand-by pump)	DN200	PN16	ISO 7005-1
208	Lubricating oil from el. driven pump (stand-by pump)	DN125	PN16	ISO 7005-1
213	Lubricating oil from separator and filling (wet sump)	DN40	PN40	ISO 7005-1
214	Lubricating oil to separator and drain (wet sump)	DN40	PN40	ISO 7005-1
215	Lubricating oil filling (wet sump)	DN40		ISO 7005-1
216	Lubricating oil drain (wet sump)	M22 x 1.5		
701	Crankcase ventilation	DN125	PN16	ISO 7005-1

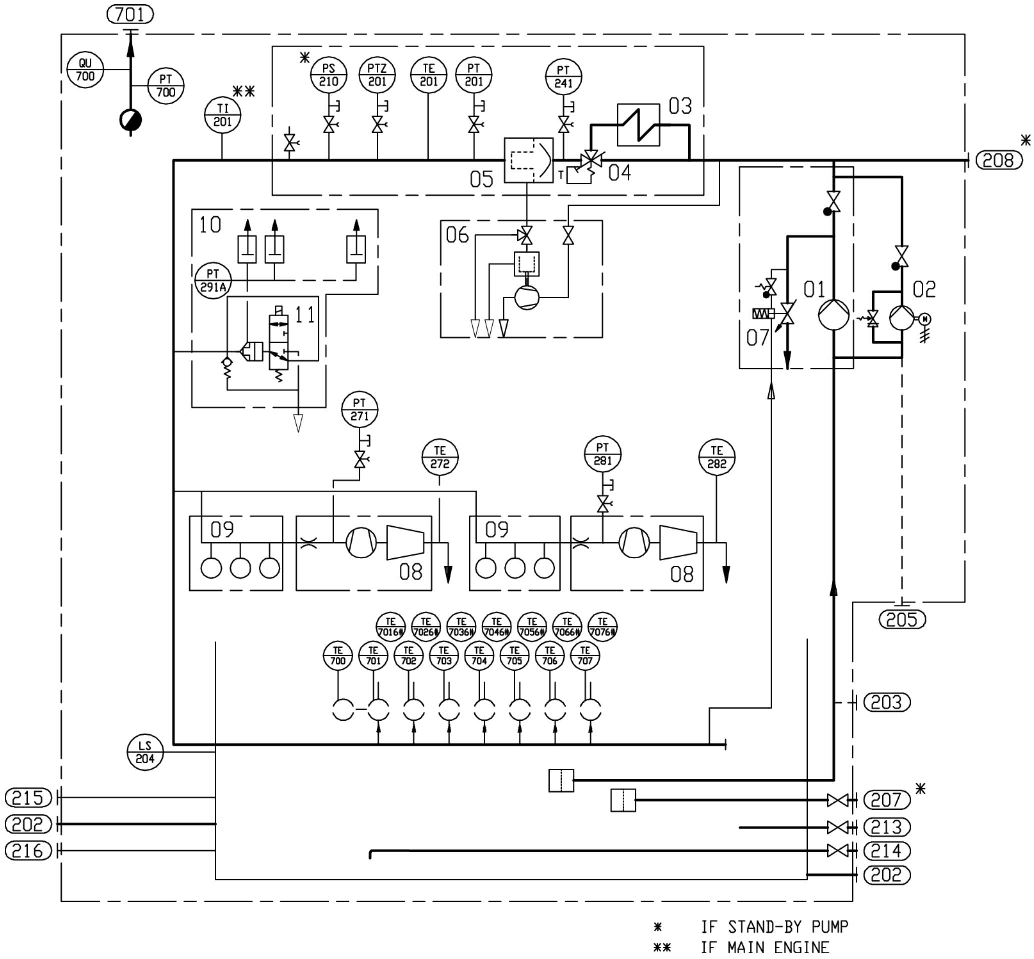


Fig 7.2.4 Internal lubricating oil system 580 kW/cyl, V-engines (DAAF057026B)

System components:			
01	Lubricating oil main pump	07	Pressure control valve
02	Prelubricating oil pump	08	Turbocharger
03	Lubricating oil cooler	09	Camshaft bearings and cylinder head lubrication
04	Thermostatic valve	10	Guide block
05	Automatic filter	11	Control valve
06	Centrifugal filter	12	Oil mist detector

Sensors and indicators:			
LS204	Lubricating oil level, wet sump, low	TE201	Lubricating oil temperature, engine inlet
PS210	Lubricating oil stand-by pump start (if stand-by)	TE272	Lubricating oil temperature, TC A outlet
PT201	Lubricating oil pressure, engine inlet	TE282	Lubricating oil temperature, TC B outlet
PT241	Lubricating oil pressure, filter inlet	TE7##	Main bearing temperature
PT271	Lubricating oil pressure, TC A inlet	TE70#6#	Big end bearing temp, cyl #A/B
PT281	Lubricating oil pressure, TC B inlet	PT700	Crankcase pressure
PTZ201	Lubricating oil pressure, engine inlet	QU700	Oil mist detector
PT291A		TI201	Lubricating oil temperature, engine inlet

Pipe connections:		Size	Pressure class	Standard
202	Lubricating oil outlet (dry sump)	DN150	PN16	ISO 7005-1
203	Lubricating oil to engine driven pump (dry sump)	DN250	PN16	ISO 7005-1

Pipe connections:		Size	Pressure class	Standard
205	Lubricating oil to priming pump (dry sump)	DN125	PN16	ISO 7005-1
207	Lubricating oil to el. driven pump (stand-by pump)	DN200	PN16	ISO 7005-1
208	Lubricating oil from el. driven pump (stand-by pump)	DN125	PN16	ISO 7005-1
213	Lubricating oil from separator and filling (wet sump)	DN40	PN40	ISO 7005-1
214	Lubricating oil to separator and drain (wet sump)	DN40	PN40	ISO 7005-1
215	Lubricating oil filling (wet sump)	DN40		ISO 7005-1
216	Lubricating oil drain (wet sump)	M22 x 1.5		
701	Crankcase ventilation	DN125	PN16	ISO 7005-1

The lubricating oil sump is of wet sump type for auxiliary and diesel-electric engines. Dry sump is recommended for main engines operating on HFO. The dry sump type has two oil outlets at each end of the engine. Two of the outlets shall be connected to the system oil tank.

The direct driven lubricating oil pump is of gear type and equipped with a pressure control valve. The pump is dimensioned to provide sufficient flow even at low speeds. A stand-by pump connection is available as option. Concerning flow rate and pressure of the engine driven pump, *see Technical data.*

The pre-lubricating oil pump is an electric motor driven gear pump equipped with a safety valve. The pump should always be running, when the engine is stopped. Concerning flow rate and pressure of the pre-lubricating oil pump, *see Technical data.*

The lubricating oil module built on the engine consists of the lubricating oil cooler, thermostatic valve and automatic filter.

The centrifugal filter is installed to clean the back-flushing oil from the automatic filter.

All dry sump engines are delivered with a running-in filter before each main bearing. These filters are to be removed after commissioning.

7.3 External lubricating oil system

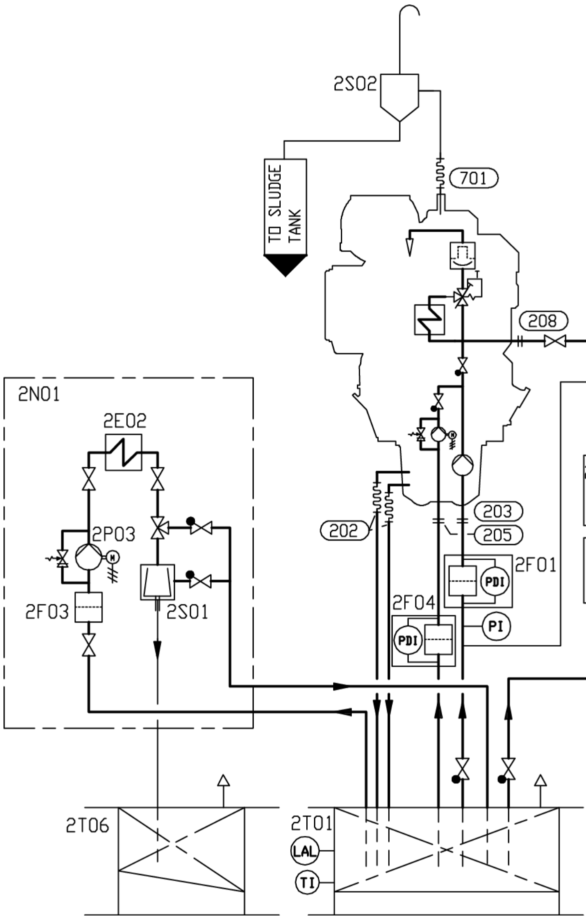


Fig 7.3.1 Lubricating oil system, main engines (V76E4562D)

System components:			
2E02	Heater (separator unit)	2P03	Separator pump (separator unit)
2F01	Suction strainer (main lubricating oil pump)	2P04	Stand-by pump
2F03	Suction filter (separator unit)	2S01	Separator
2F04	Suction strainer (Prelubricating oil pump)	2S02	Condensate trap
2F06	Suction strainer (stand-by pump)	2T01	System oil tank
2N01	Separator unit	2T06	Sludge tank

Pipe connections:		Size L32	Size V32
202	Lubricating oil outlet	DN150	DN150
203	Lubricating oil to engine driven pump	DN200	DN250
205	Lubricating oil to priming pump	DN80	DN125
208	Lubricating oil from electric driven pump	DN100	DN125
701	Crankcase air vent	DN100	DN125

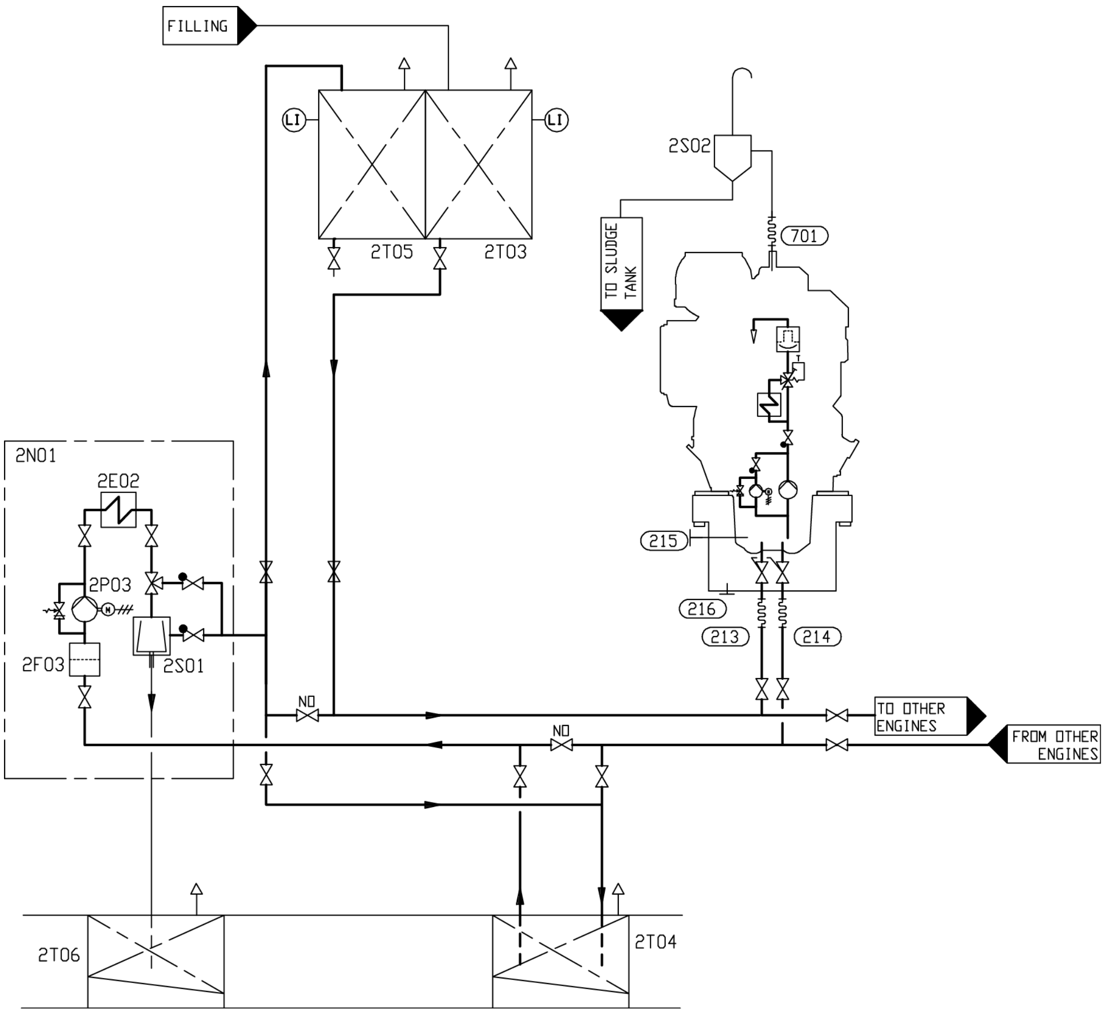


Fig 7.3.2 Lubricating oil system, auxiliary engines (3V76E4563C)

System components:			
2E02	Heater (separator unit)	2S02	Condensate trap
2F03	Suction filter (separator unit)	2T03	New oil tank
2N01	Separator unit	2T04	Renovating oil tank
2P03	Separator pump (separator unit)	2T05	Renovated oil tank
2S01	Separator	2T06	Sludge tank

Pipe connections:		Size L32	Size V32
213	Lubricating oil from separator and filling	DN40	DN40
214	Lubricating oil to separator and drain	DN40	DN40
215	Lubricating oil filling	DN40	DN40
216	Lubricating oil drain	M22*1.5	M22*1.5
701	Crankcase air vent	DN100	DN125

7.3.1 Separation system

7.3.1.1 Separator unit (2N01)

Each engine must have a dedicated lubricating oil separator and the separators shall be dimensioned for continuous separating.

Auxiliary engines operating on a fuel having a viscosity of max. 380 cSt / 50°C may have a common lubricating oil separator unit. Two engines may have a common lubricating oil separator unit. In installations with four or more engines two lubricating oil separator units should be installed.

Separators are usually supplied as pre-assembled units.

Typically lubricating oil separator units are equipped with:

- Feed pump with suction strainer and safety valve
- Preheater
- Separator
- Control cabinet

The lubricating oil separator unit may also be equipped with an intermediate sludge tank and a sludge pump, which offers flexibility in placement of the separator since it is not necessary to have a sludge tank directly beneath the separator.

7.3.1.1.1 Separator feed pump (2P03)

The feed pump must be selected to match the recommended throughput of the separator. Normally the pump is supplied and matched to the separator by the separator manufacturer.

The lowest foreseen temperature in the system oil tank (after a long stop) must be taken into account when dimensioning the electric motor.

7.3.1.1.2 Separator preheater (2E02)

The preheater is to be dimensioned according to the feed pump capacity and the temperature in the system oil tank. When the engine is running, the temperature in the system oil tank located in the ship's bottom is normally 65...75°C. To enable separation with a stopped engine the heater capacity must be sufficient to maintain the required temperature without heat supply from the engine.

Recommended oil temperature after the heater is 95°C.

The surface temperature of the heater must not exceed 150°C in order to avoid cooking of the oil.

The heaters should be provided with safety valves and drain pipes to a leakage tank (so that possible leakage can be detected).

7.3.1.1.3 Separator (2S01)

The separators should preferably be of a type with controlled discharge of the bowl to minimize the lubricating oil losses.

The service throughput *Q* [*l/h*] of the separator can be estimated with the formula:

$$Q = \frac{1.35 \times P \times n}{t}$$

where:

Q = volume flow [l/h]

P = engine output [kW]

n = number of through-flows of tank volume per day: 5 for HFO, 4 for MDF

t = operating time [h/day]: 24 for continuous separator operation, 23 for normal dimensioning

7.3.1.1.4 Sludge tank (2T06)

The sludge tank should be located directly beneath the separators, or as close as possible below the separators, unless it is integrated in the separator unit. The sludge pipe must be continuously falling.

7.3.1.2 Renovating oil tank (2T04)

In case of wet sump engines the oil sump content can be drained to this tank prior to separation.

7.3.1.3 Renovated oil tank (2T05)

This tank contains renovated oil ready to be used as a replacement of the oil drained for separation.

7.3.2 System oil tank (2T01)

Recommended oil tank volume is stated in chapter *Technical data.*

The system oil tank is usually located beneath the engine foundation. The tank may not protrude under the reduction gear or generator, and it must also be symmetrical in transverse direction under the engine. The location must further be such that the lubricating oil is not cooled down below normal operating temperature. Suction height is especially important with engine driven lubricating oil pump. Losses in strainers etc. add to the geometric suction height. Maximum suction ability of the pump is stated in chapter *Technical data.*

The pipe connection between the engine oil sump and the system oil tank must be flexible to prevent damages due to thermal expansion. The return pipes from the engine oil sump must end beneath the minimum oil level in the tank. Further on the return pipes must not be located in the same corner of the tank as the suction pipe of the pump.

The suction pipe of the pump should have a trumpet shaped or conical inlet to minimise the pressure loss. For the same reason the suction pipe shall be as short and straight as possible and have a sufficient diameter. A pressure gauge shall be installed close to the inlet of the lubricating oil pump. The suction pipe shall further be equipped with a non-return valve of flap type without spring. The non-return valve is particularly important with engine driven pump and it must be installed in such a position that self-closing is ensured.

Suction and return pipes of the separator must not be located close to each other in the tank.

The ventilation pipe from the system oil tank may not be combined with crankcase ventilation pipes.

It must be possible to raise the oil temperature in the tank after a long stop. In cold conditions it can be necessary to have heating coils in the oil tank in order to ensure pumpability. The separator heater can normally be used to raise the oil temperature once the oil is pumpable. Further heat can be transferred to the oil from the preheated engine, provided that the oil viscosity and thus the power consumption of the pre-lubricating oil pump does not exceed the capacity of the electric motor.

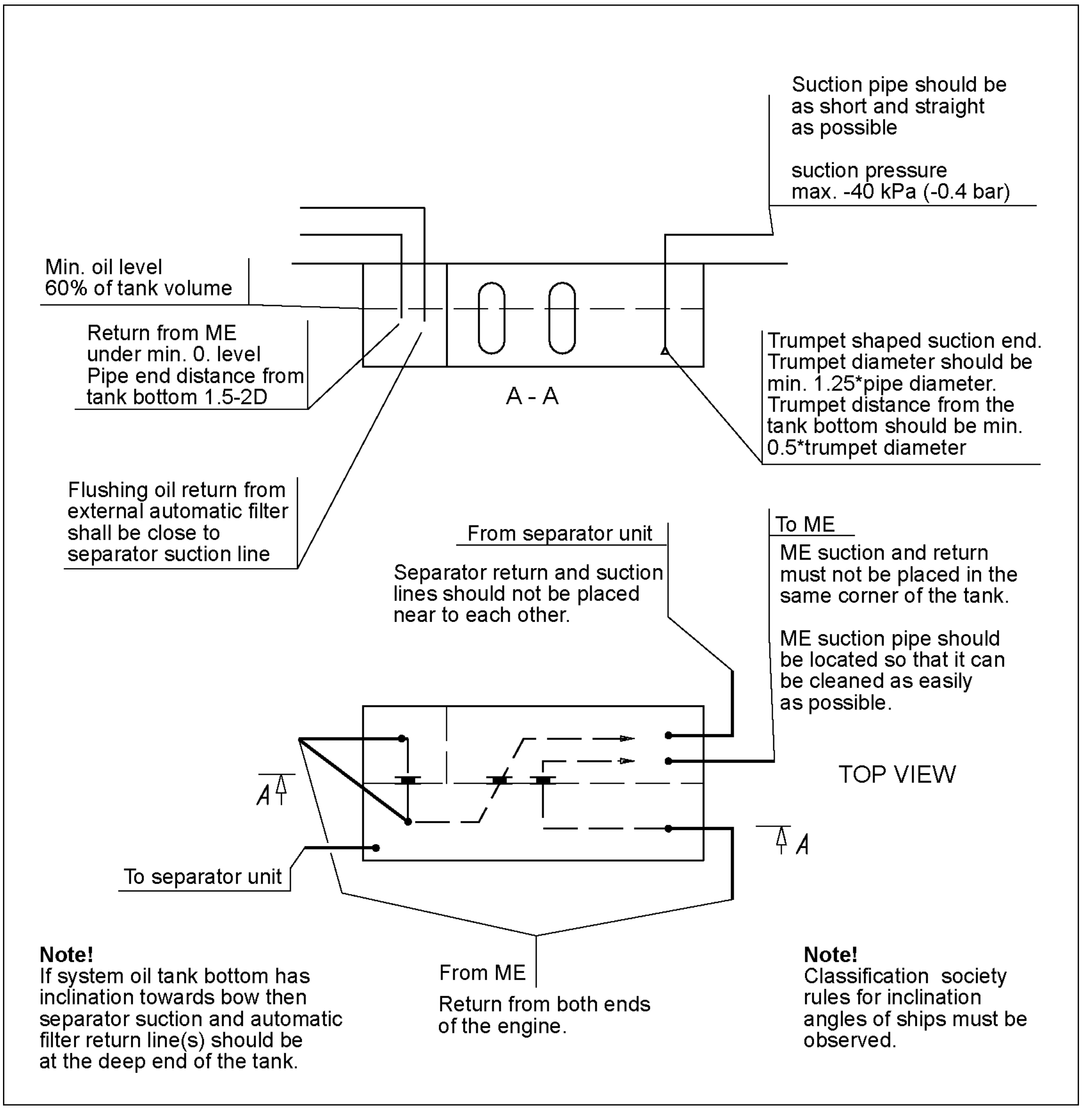


Fig 7.3.2.1 Example of system oil tank arrangement (DAAE007020e)

Design data:

Oil tank volume	1.2...1.5 l/kW, see also *Technical data*
Oil level at service	75...80% of tank volume
Oil level alarm	60% of tank volume

7.3.3 New oil tank (2T03)

In engines with wet sump, the lubricating oil may be filled into the engine, using a hose or an oil can, through the crankcase cover or through the separator pipe. The system should be arranged so that it is possible to measure the filled oil volume.

7.3.4 Suction strainers (2F01, 2F04, 2F06)

It is recommended to install a suction strainer before each pump to protect the pump from damage. The suction strainer and the suction pipe must be amply dimensioned to minimize pressure losses. The suction strainer should always be provided with alarm for high differential pressure.

Design data:

Fineness	0.5...1.0 mm

7.3.5 Lubricating oil pump, stand-by (2P04)

The stand-by lubricating oil pump is normally of screw type and should be provided with an overflow valve.

Design data:

Capacity	see *Technical data*
Design pressure, max	0.8 MPa (8 bar)
Design temperature, max.	100°C
Lubricating oil viscosity	SAE 40
Viscosity for dimensioning the electric motor	500 mm^2/s (cSt)

7.4 Crankcase ventilation system

The purpose of the crankcase ventilation is to evacuate gases from the crankcase in order to keep the pressure in the crankcase within acceptable limits.

Each engine must have its own vent pipe into open air. The crankcase ventilation pipes may not be combined with other ventilation pipes, e.g. vent pipes from the system oil tank.

The diameter of the pipe shall be large enough to avoid excessive back pressure. Other possible equipment in the piping must also be designed and dimensioned to avoid excessive flow resistance.

A condensate trap must be fitted on the vent pipe near the engine.

The connection between engine and pipe is to be flexible.

Design data:

Flow	see *Technical data*
Backpressure, max.	see *Technical data*
Temperature	80°C

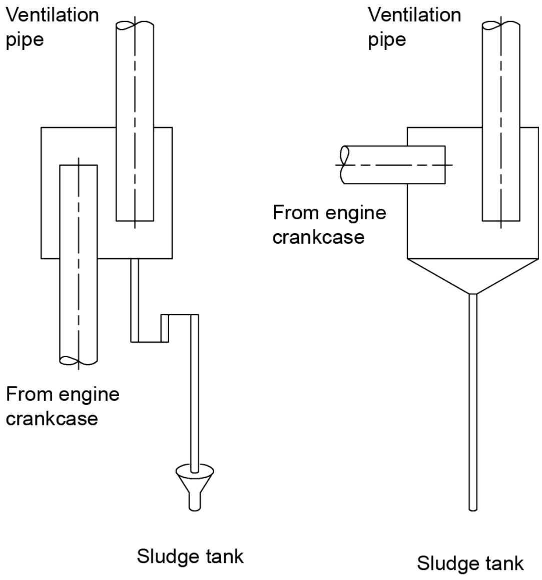


Fig 7.4.1 Condensate trap (DAAE032780A)

Minimum size of the ventilation pipe after the condensate trap is:

W L32: DN100
W V32: DN125

The max. backpressure must also be considered when selecting the ventilation pipe size.

7.5 Flushing instructions

Flushing instructions in this Product Guide are for guidance only. For contracted projects, read the specific instructions included in the installation planning instructions (IPI).

7.5.1 Piping and equipment built on the engine

Flushing of the piping and equipment built on the engine is not required and flushing oil shall not be pumped through the engine oil system (which is flushed and clean from the factory). It is however acceptable to circulate the flushing oil via the engine sump if this is advantageous. Cleanliness of the oil sump shall be verified after completed flushing.

7.5.2 External oil system

Refer to the system diagram(s) in section *External lubricating oil system* for location/description of the components mentioned below.

If the engine is equipped with a wet oil sump the external oil tanks, new oil tank (2T03), renovating oil tank (2T04) and renovated oil tank (2T05) shall be verified to be clean before bunkering oil. Especially pipes leading from the separator unit (2N01) directly to the engine shall be ensured to be clean for instance by disconnecting from engine and blowing with compressed air.

If the engine is equipped with a dry oil sump the external oil tanks, new oil tank and the system oil tank (2T01) shall be verified to be clean before bunkering oil.

Operate the separator unit continuously during the flushing (not less than 24 hours). Leave the separator running also after the flushing procedure, this to ensure that any remaining contaminants are removed.

If an electric motor driven stand-by pump (2P04) is installed then piping shall be flushed running the pump circulating engine oil through a temporary external oil filter (recommended mesh 34 microns) into the engine oil sump through a hose and a crankcase door. The pump shall be protected by a suction strainer (2F06).

Whenever possible the separator unit shall be in operation during the flushing to remove dirt. The separator unit is to be left running also after the flushing procedure, this to ensure that any remaining contaminants are removed.

7.5.3 Type of flushing oil

7.5.3.1 Viscosity

In order for the flushing oil to be able to remove dirt and transport it with the flow, ideal viscosity is 10...50 cSt. The correct viscosity can be achieved by heating engine oil to about 65°C or by using a separate flushing oil which has an ideal viscosity in ambient temperature.

7.5.3.2 Flushing with engine oil

The ideal is to use engine oil for flushing. This requires however that the separator unit is in operation to heat the oil. Engine oil used for flushing can be reused as engine oil provided that no debris or other contamination is present in the oil at the end of flushing.

7.5.3.3 Flushing with low viscosity flushing oil

If no separator heating is available during the flushing procedure it is possible to use a low viscosity flushing oil instead of engine oil. In such a case the low viscosity flushing oil must be disposed of after completed flushing. Great care must be taken to drain all flushing oil from pockets and bottom of tanks so that flushing oil remaining in the system will not compromise the viscosity of the actual engine oil.

7.5.3.4 Lubricating oil sample

To verify the cleanliness a LO sample shall be taken by the shipyard after the flushing is completed. The properties to be analyzed are Viscosity, BN, AN, Insolubles, Fe and Particle Count.

Commissioning procedures shall in the meantime be continued without interruption unless the commissioning engineer believes the oil is contaminated.

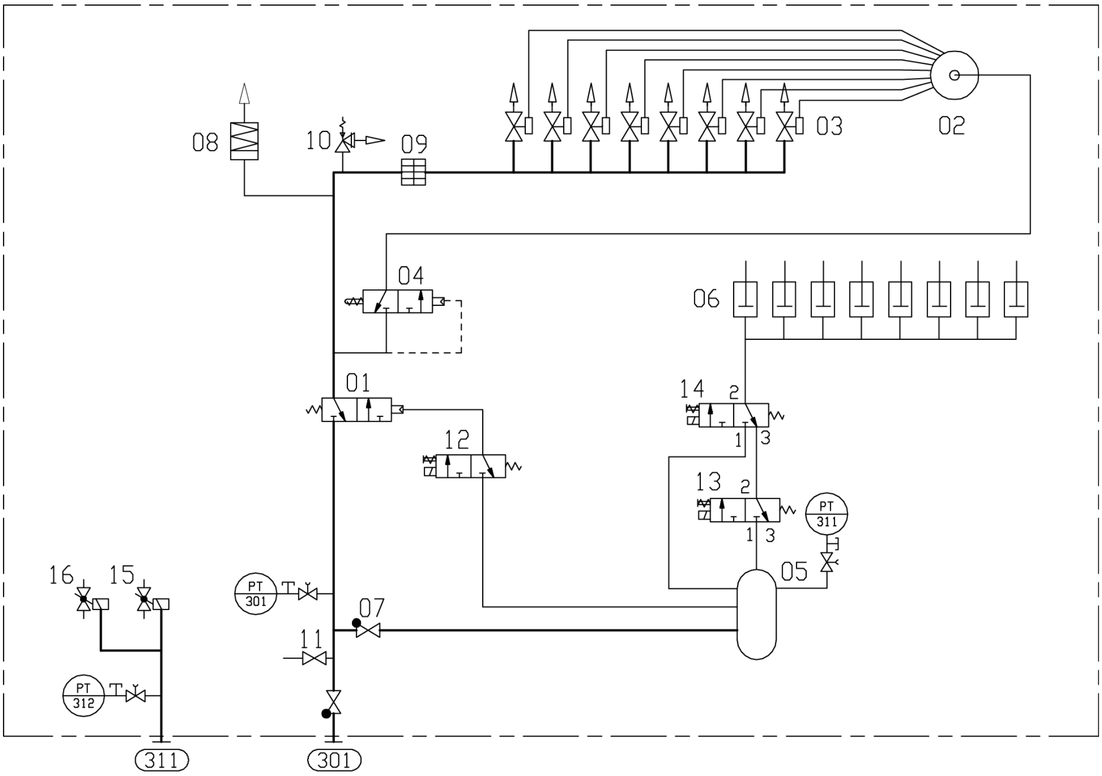


Fig 8.2.1 Internal starting air system 500 kW/cyl, in-line engines (DAAE005311F)

System components:					
01	Main starting air valve	07	Non return valve	13	Stop solenoid valve
02	Starting air distributor	08	Starting booster for speed governor	14	Stop solenoid valve
03	Starting air valve in cyl. head	09	Flame arrester	15	Wastegate valve
04	Blocking valve of turning gear	10	Safety valve	16	By-pass valve *
05	Air container	11	Drain valve	17	Air wastegate *
06	Pneumatic stop cylinder at each injection pump	12	Start solenoid valve		*) If equipped on engine

Sensors and indicators:			
PT301	Starting air pressure engine inlet	PT312	Instrument air pressure
PT311	Control air pressure		

Pipe connections:		Size
301	Starting air inlet	DN32
311	Control air to waste gate valve	OD8

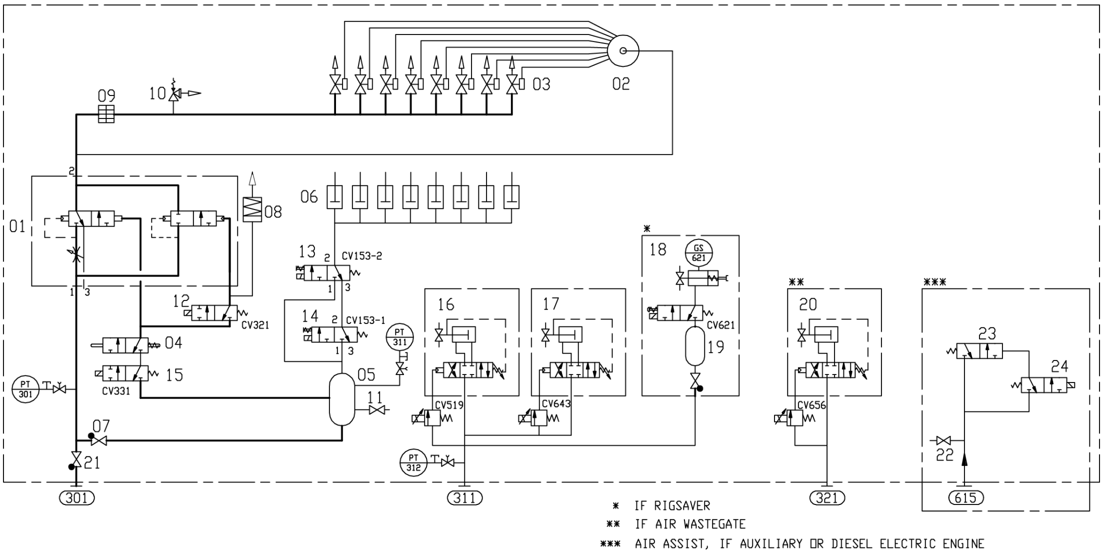


Fig 8.2.2 Internal starting air system 580 kW/cyl, in-line engines (DAAF057029C)

System components:					
01	Main starting air valve	09	Flame arrester	17	Charge air by-pass valve *
02	Starting air distributor	10	Safety valve	18	Charge air shut-off valve *
03	Starting air valve in cyl. head	11	Drain valve	19	Pressure tank
04	Blocking valve of turning gear	12	Start solenoid valve	20	Air wastegate *
05	Air container	13	Stop solenoid valve	21	Non return valve
06	Pneumatic stop cylinder at each injection pump	14	Stop solenoid valve	22	Drain valve
07	Non return valve	15	Slow turning solenoid valve	23	Air assist valve
08	Starting booster for speed gov- ernor	16	Exhaust wastegate valve	24	3/2 solenoid valve
					*) If equipped on engine

Sensors and indicators:			
CV153-1	Stop/shutdown solenoid valve	PT312	Instrument air pressure
CV153-2	Stop/shutdown solenoid valve 2	CV519	Exhaust wastegate control
CV321	Start solenoid valve	CV621	Charge air shut-off valve control
CV331	Slowturning solenoid	CV643	Charge air by-pass valve control
PT301	Starting air pressure, engine inlet	CV656	Air wastegate control
PT311	Control air pressure	GS621	Charge air shut-off valve position, A-bank

Pipe connections:		Size	Pressure class	Standard
301	Starting air inlet	DN32	PN40	ISO 7005-1
311	Control air to waste gate valve	OD08		DIN 2353
321	Control air for pressure reducing device	OD08		
615	Air inlet to air assist system	OD28		

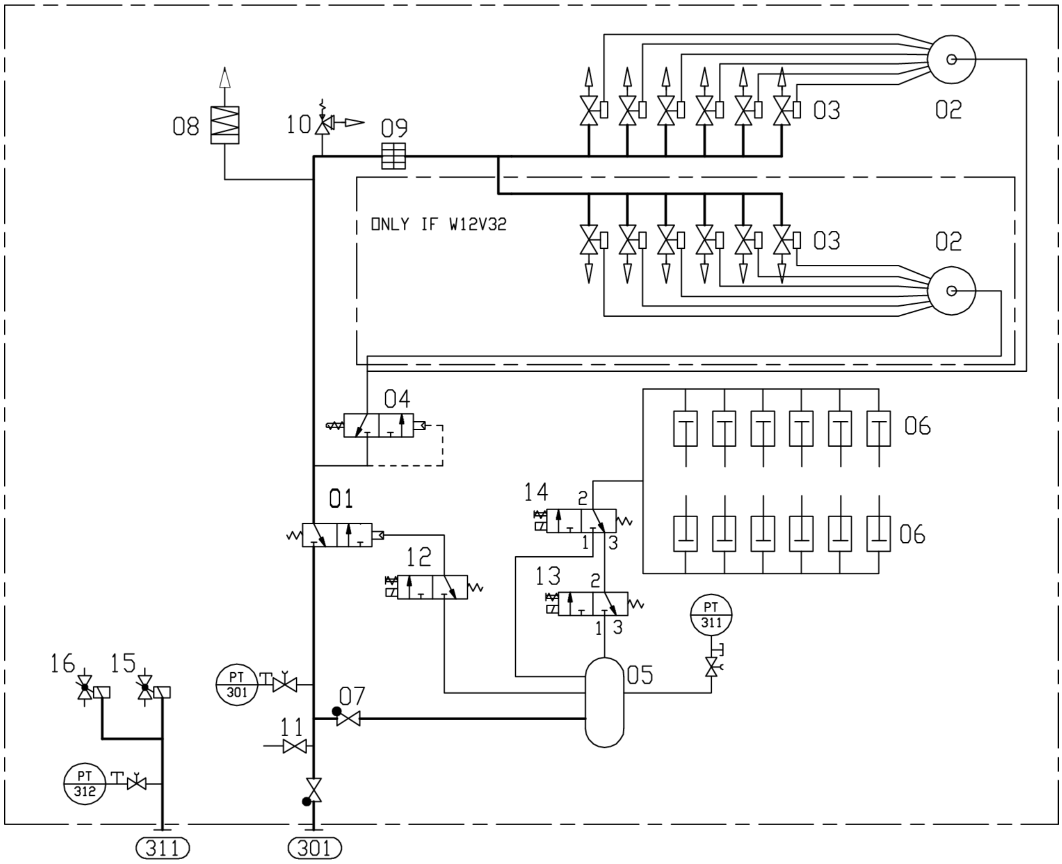


Fig 8.2.3 Internal starting air system 500 kW/cyl, V-engines (DAAE082194D)

System components:					
01	Main starting air valve	07	Non return valve	13	Stop solenoid valve CV153-1
02	Starting air distributor	08	Start booster for speed governor	14	Stop solenoid valve CV153-2
03	Starting air valve in cyl. head	09	Flame arrestor	15	Waste gate
04	Blocking valve, when turning gear engaged	10	Safety valve	16	By-pass valve
05	Air container	11	Drain valve		
06	Pneum. stop cyl. at each inj. pump	12	Start solenoid valve CV321		

Sensors and indicators:	
PT301	Starting air pressure, engine inlet
PT311	Control air pressure
PT312	Instrument air pressure

Pipe connections:		Size	Pressure class	Standard
301	Starting air inlet	DN32	PN40	ISO 7005-1
311	Control air to waste gate valve	OD10		DIN 2353

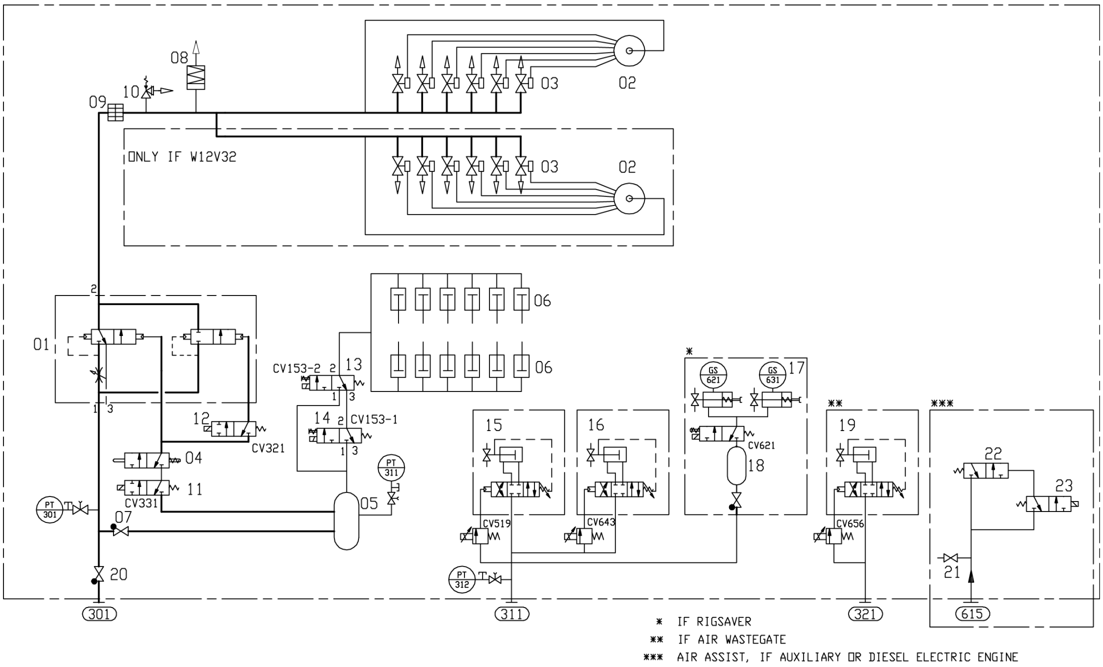


Fig 8.2.4 Internal starting air system 580kW/cyl, V-engines (DAAF057030C)

System components:					
01	Main starting air valve	09	Flame arrestor	17	Charge air shut-off valve
02	Starting air distributor	10	Safety valve	18	Pressure tank
03	Starting air valve in cyl. head	11	Slow turning solenoid valve	19	Air wastegate valve
04	Blocking valve, when turning gear engaged	12	Start solenoid valve CV321	20	Non return valve
05	Air container	13	Stop solenoid valve	21	Drain valve
06	Pneum. stop cyl. at each inj. pump	14	Stop solenoid valve	22	air assist valve
07	Non return valve	15	Exhaust wastegate valve	23	3/2 solenoid valve
08	Start booster for speed governor	16	Charge air by-pass valve		

Sensors and indicators:			
CV153-1	Stop/shutdown solenoid valve	PT312	Instrument air pressure
CV153-2	Stop/shutdown solenoid valve 2	CV519	Exhaust wastegate control
CV321	Start solenoid valve	CV621	Charge air shut-off valve control
CV331	Slowturning solenoid	CV643	Charge air by-pass valve control
PT301	Starting air pressure, engine inlet	CV656	Air wastegate control
PT311	Control air pressure	GS621	Charge air shut-off valve position, A-bank
		GS631	Charge air shut-off valve position, B-bank

Pipe connections:		Size	Pressure class	Standard
301	Starting air inlet	DN32	PN40	ISO 7005-1
311	Control air to waste gate valve	OD10		DIN 2353
321	Control air for pressure reducing device	OD10		
615	Air inlet to air assist system	OD28		

8.3 External compressed air system

The design of the starting air system is partly determined by classification regulations. Most classification societies require that the total capacity is divided into two equally sized starting air receivers and starting air compressors. The requirements concerning multiple engine installations can be subject to special consideration by the classification society.

The starting air pipes should always be slightly inclined and equipped with manual or automatic draining at the lowest points.

Instrument air to safety and control devices must be treated in an air dryer.

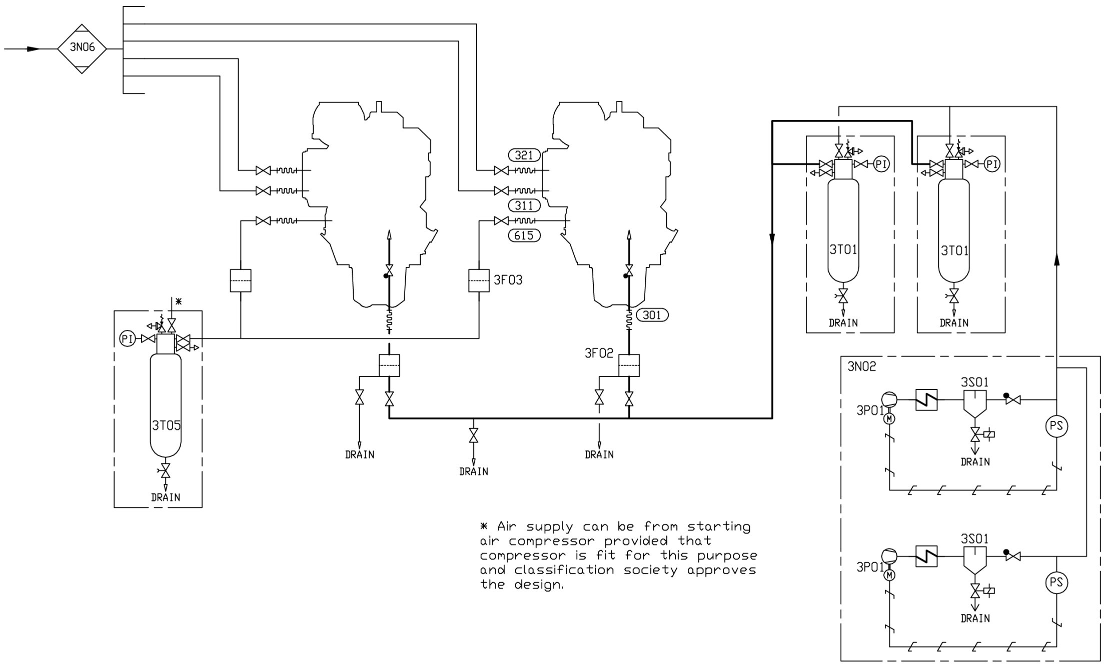


Fig 8.3.1 External starting air system (3V76H4142F)

System components:		Pipe connections:		Size L32	Size V32
3F02	Air filter (starting air inlet)	301	Starting air inlet	DN32	
3F03	Air filter (air assist inlet)	311	Control air to wastegate valve	OD08	OD10
3N02	Starting air compressor unit	321	Control air for pressure reducing device	OD08	OD10
3N06	Air dryer unit	615	Air inlet to air assist system	OD28	
3P01	Compressor (starting air compressor unit)				
3S01	Separator (starting air compressor unit)				
3T01	Starting air vessel				
3T05	Air bottle				

8.3.1 Starting air compressor unit (3N02)

At least two starting air compressors must be installed. It is recommended that the compressors are capable of filling the starting air vessel from minimum (1.8 MPa) to maximum pressure in 15...30 minutes. For exact determination of the minimum capacity, the rules of the classification societies must be followed. If the system is designed so that air assist will be used, bigger compressors are needed.

8.3.2 Oil and water separator (3S01)

An oil and water separator should always be installed in the pipe between the compressor and the air vessel. Depending on the operation conditions of the installation, an oil and water separator may be needed in the pipe between the air vessel and the engine.

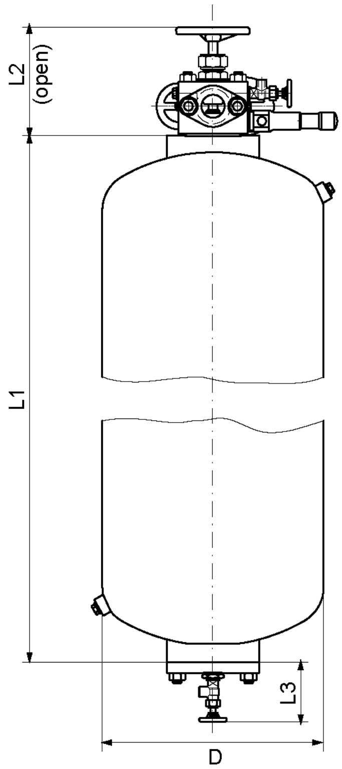
8.3.3 Air vessels (3T01 & 3T05)

The air vessels should be dimensioned for a nominal pressure of 3 MPa.

The number and the capacity of the air vessels for propulsion engines depend on the requirements of the classification societies and the type of installation.

It is recommended to use a minimum air pressure of 1.8 MPa, when calculating the required volume of the vessels.

The air vessels are to be equipped with at least a manual valve for condensate drain. If the air vessels are mounted horizontally, there must be an inclination of 3...5° towards the drain valve to ensure efficient draining.



Size [Litres]	Dimensions [mm]				Weight [kg]
	L1	L2 [1)]	L3 [1)]	D	
250	1767	243	110	480	274
500	3204	243	133	480	450
710	2740	255	133	650	625
1000	3560	255	133	650	810
1250	2930	255	133	800	980

[1)] Dimensions are approximate.

Fig 8.3.3.1 Air vessel

8.3.3.1 Starting air vessel (3T01)

The starting air consumption stated in technical data is for a successful start. During start the main starting valve is kept open until the engine starts, or until the max. time for the starting attempt has elapsed. A failed start can consume two times the air volume stated in technical data. If the ship has a class notation for unattended machinery spaces, then the starts are to be demonstrated.

The required total air vessel volume can be calculated using the formula:

$$V_R = \frac{p_E \times V_E \times n}{p_{Rmax} - p_{Rmin}}$$

where:

V_R = total starting air vessel volume [m³]

p_E = normal barometric pressure (NTP condition) = 0.1 MPa

V_E = air consumption per start [Nm³] See *Technical data*

n = required number of starts according to the classification society

p_{Rmax} = maximum starting air pressure = 3 MPa

p_{Rmin} = minimum starting air pressure = 1.8 MPa

8.3.3.2 Air assist vessel (3T05)

The required total air assist air vessel volume can be calculated using the formula:

Table 8.3.3.2.1

$$V_R = \frac{V_A \times n_1}{p_{Rmax} - p_{Rmin}} \quad (*$$

* if air assist supply is taken from starting air vessels it is a subject to class approval.

where:

V_R = total air vessel volume [m³]

V_A = Air consumption per activation, see *Technical data*

n_1 = Number of activations

p_{Rmax} = maximum air pressure = 3 MPa

p_{Rmin} = minimum air pressure = 1.8 MPa

> **NOTE**
>
> The total vessel volume shall be divided into at least two equally sized starting air vessels.

8.3.4 Air filter, starting air inlet (3F02)

Condense formation after the water separator (between starting air compressor and starting air vessels) create and loosen abrasive rust from the piping, fittings and receivers. Therefore it is recommended to install a filter before the starting air inlet on the engine to prevent particles to enter the starting air equipment.

An Y-type strainer can be used with a stainless steel screen and mesh size 400 µm. The pressure drop should not exceed 20 kPa (0.2 bar) for the engine specific starting air consumption under a time span of 4 seconds.

8.3.5 Air filter, air assist inlet (3F03)

Condense formation after the water separator (between starting air compressor and air vessels) create and loosen abrasive rust from the piping, fittings and receivers. Therefore it is recommended to install a filter before the starting air inlet on the engine to prevent particles to enter the starting air equipment.

An Y-type strainer can be used with a stainless steel screen and mesh size 400 µm. The pressure drop should not exceed 20 kPa (0.2 bar) for the engine specific air assist consumption.

8.3.6 Air assist (for 560 & 580 kW/cyl)

A receiver air injections system (air assist) is installed on all auxilliary and diesel electric applications. If the first load step of 0-33% is required then air assist is to be connected and used. If the system is designed for 0-28-60-100% load steps, the air assist do not have to be connected or used.

The air assist is controlled by UNIC. The consumption for one air assist activation can be found in the *Technical data* (*3-1*) section.

The air supply to the air assist is to be arranged from a separate air vessel or alternatively from the starting air vessels. Air supply from the starting air vessels must be approved by classification society, this must be checked on a project specific basis.

Air assist consumption is depending on the operation profile of the vessel, it is only activated when initial load is below ~15%.

9.2 Internal cooling water system

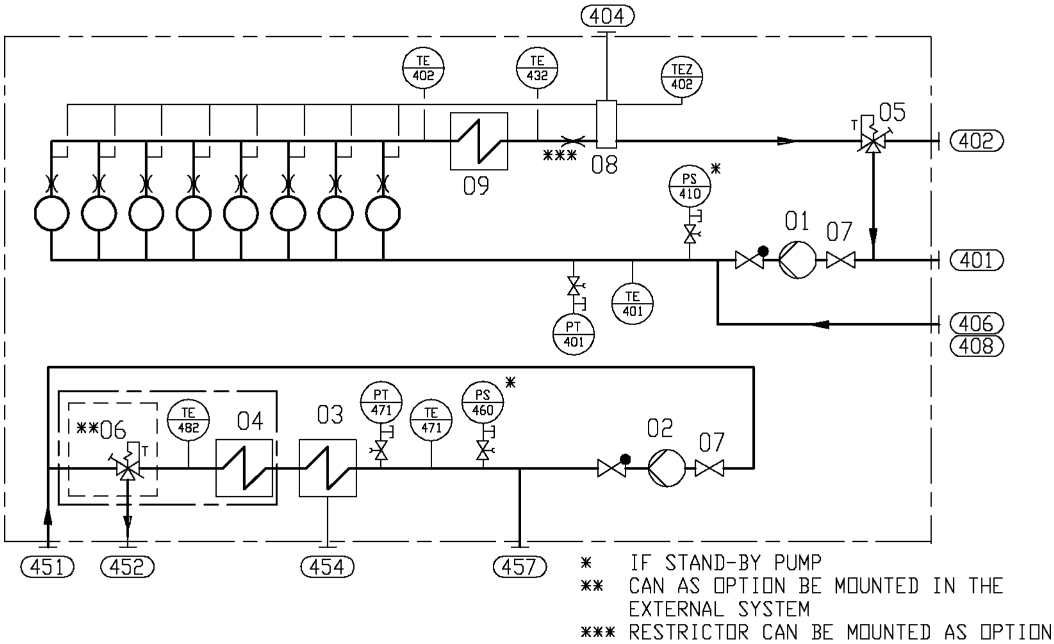


Fig 9.2.1 Internal cooling water system, two stage air cooler, in-line engines (DAAE005313C)

System components:					
01	HT-cooling water pump	04	Lubricating oil cooler	07	Shut-off valve
02	LT-cooling water pump	05	HT-thermostatic valve	08	Connection piece
03	Charge air cooler (LT)	06	LT-thermostatic valve	09	Charge air cooler (HT)

Sensors and indicators:			
PS410	HT-water stand-by pump start	TE402	HT-water temperature, engine outlet
PS460	LT-water stand-by pump start	TE432	HT-water temperature, CAC outlet
PT401	HT-water pressure, engine inlet	TE471	LT-water temperature, LT CAC inlet
PT471	LT-water pressure, LT CAC inlet	TE482	LT-water temperature, LOC inlet
TE401	HT-water temperature, engine inlet	TEZ402	HT-water temp, jacket outlet A-bank

Pipe connections:		**Size**	**Pressure class**	**Standard**
401	HT-water inlet	DN100	PN16	ISO 7005-1
402	HT-water outlet	DN100	PN16	ISO 7005-1
404	HT-water air vent	OD12		DIN 2353
406	Water from preheater to HT-circuit	OD28		DIN 2353
408	HT-water from stand-by pump	DN100	PN16	ISO 7005-1
451	LT-water inlet	DN100	PN16	ISO 7005-1
452	LT-water outlet	DN100	PN16	ISO 7005-1
454	LT-water air vent from air cooler	OD12		DIN 2353
457	LT-water from stand-by pump	DN100	PN16	ISO 7005-1

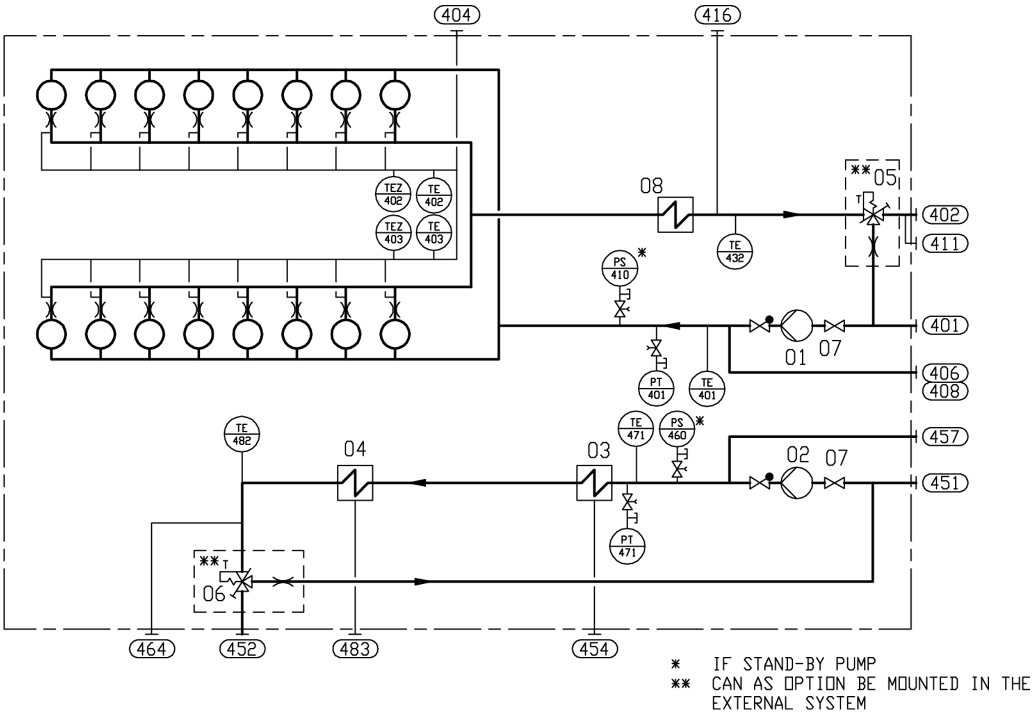


Fig 9.2.2 Internal cooling water system, V-engines (DAAE005314D)

System components:					
01	HT-cooling water pump	04	Lubricating oil cooler	07	Shut-off valve
02	LT-cooling water pump	05	HT-thermostatic valve (*	08	Charge air cooler (HT)
03	Charge air cooler (LT)	06	LT-thermostatic valve (*		*) Optionally in the external system

Sensors and indicators:			
PS410	HT-water stand-by pump start	TE403	HT-water temperature, engine outlet B-bank
PS460	LT-water stand-by pump start	TE432	HT-water temperature, CAC outlet
PT401	HT-water pressure, engine inlet	TE471	LT-water temperature, LT CAC inlet
PT471	LT-water pressure, LT CAC inlet	TE482	LT-water temperature, LOC inlet
TE401	HT-water temperature, engine inlet	TEZ402	HT-water temp, engine outlet A-bank
TE402	HT-water temperature, engine outlet A-bank	TEZ403	HT-water temp, engine outlet B-bank

Pipe connections:		**Size**	**Pressure class**	**Standard**
401	HT-water inlet	DN125	PN16	ISO 7005-1
402	HT-water outlet	DN125	PN16	ISO 7005-1
404	HT-water air vent	OD12		DIN 2353
406	Water from preheater to HT-circuit	DN32	PN40	ISO 7005-1
408	HT-water from stand-by pump	DN125	PN16	ISO 7005-1
411	HT-water drain	M18 * 1.5		
416	HT-water airvent from aircooler	OD12		DIN 2353
451	LT-water inlet	DN125	PN16	ISO 7005-1
452	LT-water outlet	DN125	PN16	ISO 7005-1
454	LT-water airvent from air cooler	OD12		
457	LT-water from stand-by pump	DN125	PN16	ISO 7005-1
464	LT-water drain	M22 * 1.5		
483	LT water air vent from air cooler	OD12		DIN 2353

The fresh water cooling system is divided into a high temperature (HT) and a low temperature (LT) circuit. The HT water circulates through cylinder jackets, cylinder heads and the 1st stage of the charge air cooler, while the LT water circulates through the 2nd stage of the charge air cooler and through the lubricating oil cooler.

A two-stage charge air cooler enables more efficient heat recovery and heating of cold combustion air.

The LT water circulates through the charge air cooler and the lubricating oil cooler, which is built on the engine.

Temperature control valves regulate the temperature of the water out from the engine, by circulating some water back to the cooling water pump inlet. The HT temperature control valve is always mounted on the engine, while the LT temperature control valve can be either on the engine or separate. In installations where the engines operate on MDF only it is possible to install the LT temperature control valve in the external system and thus control the LT water temperature before the engine.

9.2.1 Engine driven circulating pumps

The LT and HT cooling water pumps are engine driven. The engine driven pumps are located at the free end of the engine.

Pump curves for engine driven pumps are shown in the diagrams. The nominal pressure and capacity can be found in the chapter *Technical data*.

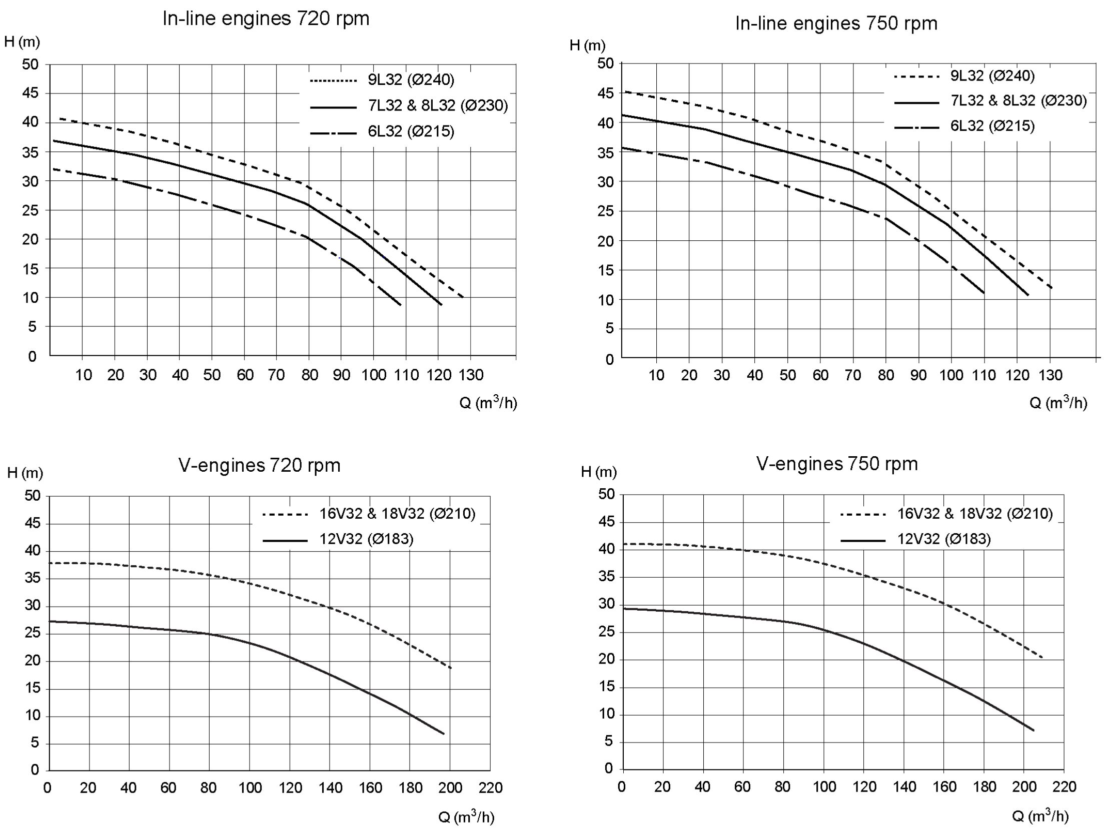


Fig 9.2.1.1 Pump curves for engine driven HT- and LT- water pumps (4V19L0240C, DAAF022986, DAAF022987, DAAF022998, DAAF022999)

9.3 External cooling water system

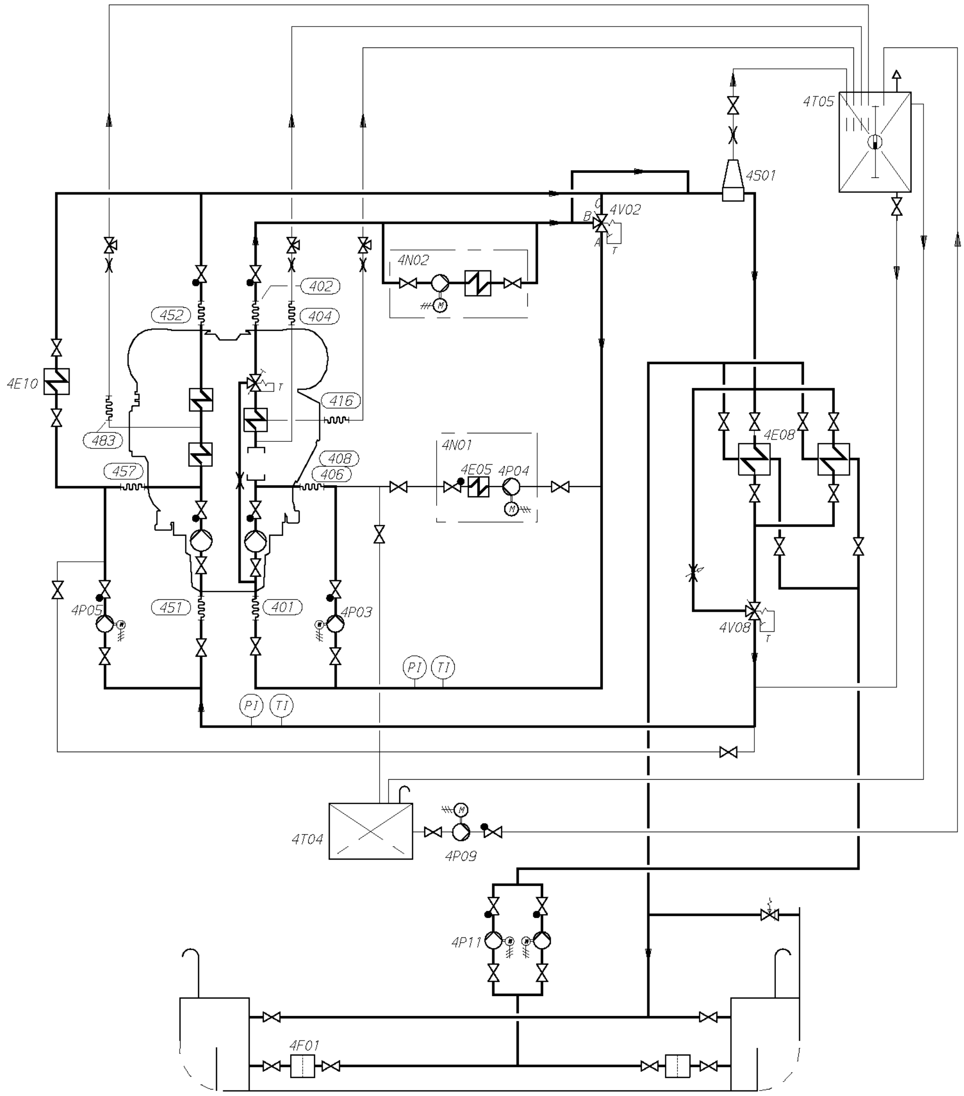


Fig 9.3.1 Example diagram for single main engine (MDF) (3V76C5775b)

System components:					
4E05	Heater (preheating unit)	4P03	Stand-by pump (HT)	4T04	Drain tank
4E08	Central cooler	4P04	Circulating pump (preheater)	4T05	Expansion tank
4E10	Cooler (reduction gear)	4P05	Stand-by pump (LT)	4V02	Temp. control valve (heat recovery)
4F01	Suction strainer (sea water)	4P09	Transfer pump		
4N01	Preheating unit	4P11	Circulating pump (sea water)	4V08	Temp. control valve (central cooler)
4N02	Evaporator unit	4S01	Air venting		

Pipe connections:			
401	HT-water inlet	416	HT-water airvent from air cooler
402	HT-water	451	LT-water inlet
404	HT-water air vent	452	LT-water outlet
406	Water from preheater to HT-circuit	457	LT-water from stand-by pump
408	HT-water from stand-by pump	483	LT-water air vent

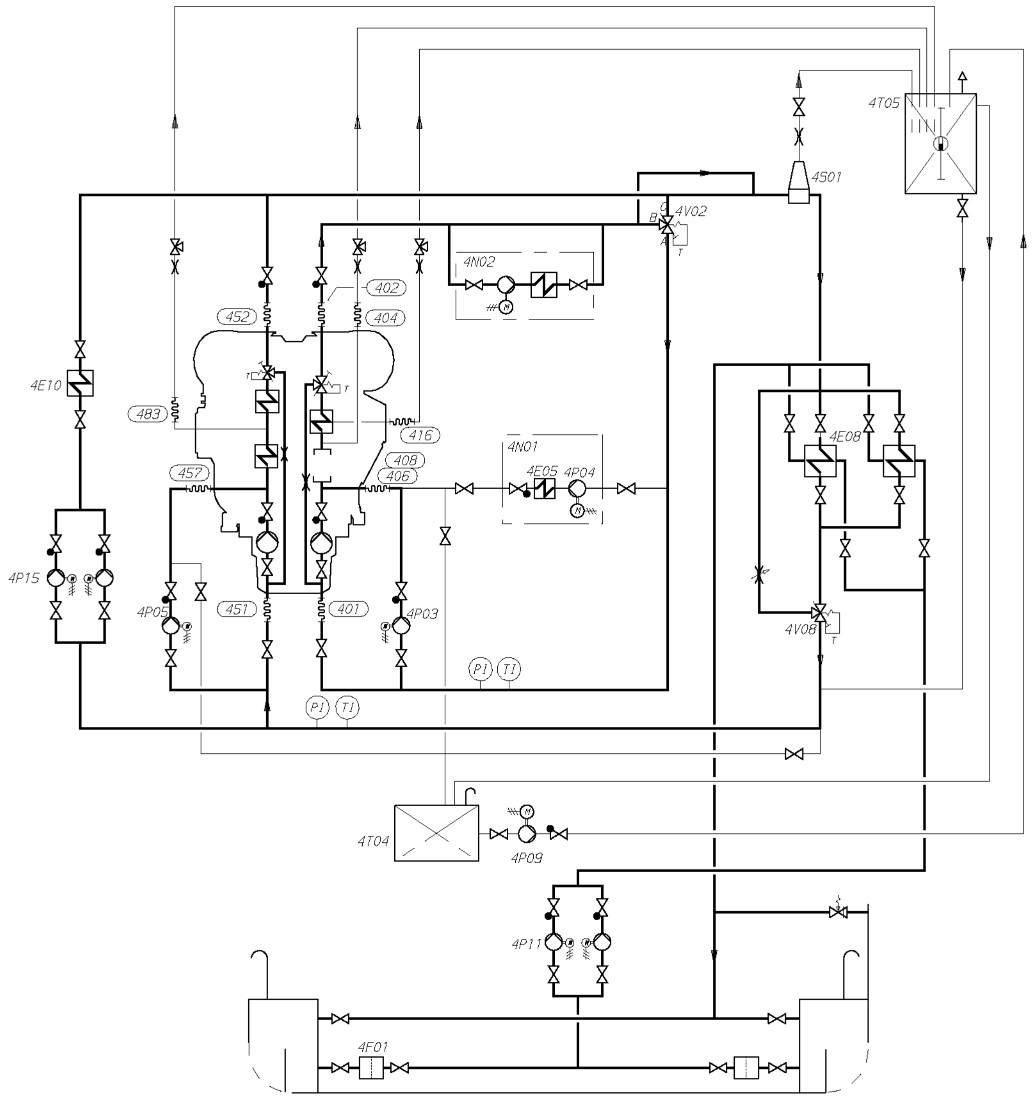


Fig 9.3.2 **Example diagram for single main engine (HFO), reduction gear fresh water cooled (3V76C5262b)**

System components:			
4E05	Heater (preheating unit)	4P09	Transfer pump
4E08	Central cooler	4P11	Circulating pump (sea water)
4E10	Cooler (reduction gear)	4P15	Circulating pump (LT)
4F01	Suction strainer (sea water)	4S01	Air venting
4N01	Preheating unit	4T04	Drain tank
4N02	Evaporator unit	4T05	Expansion tank
4P03	Stand-by pump (HT)	4V02	Temperature control valve (heat recovery)
4P04	Circulating pump (preheater)	4V08	Temperature control valve (central cooler)
4P05	Stand-by pump (LT)		

Pipe connections:			
401	HT-water inlet	416	HT-water airvent from air cooler
402	HT-water outlet	451	LT-water inlet
404	HT-water air vent	452	LT-water outlet
406	Water from preheater to HT-circuit	457	LT-water from stand-by pump
408	HT-water from stand-by pump	483	LT-water air vent

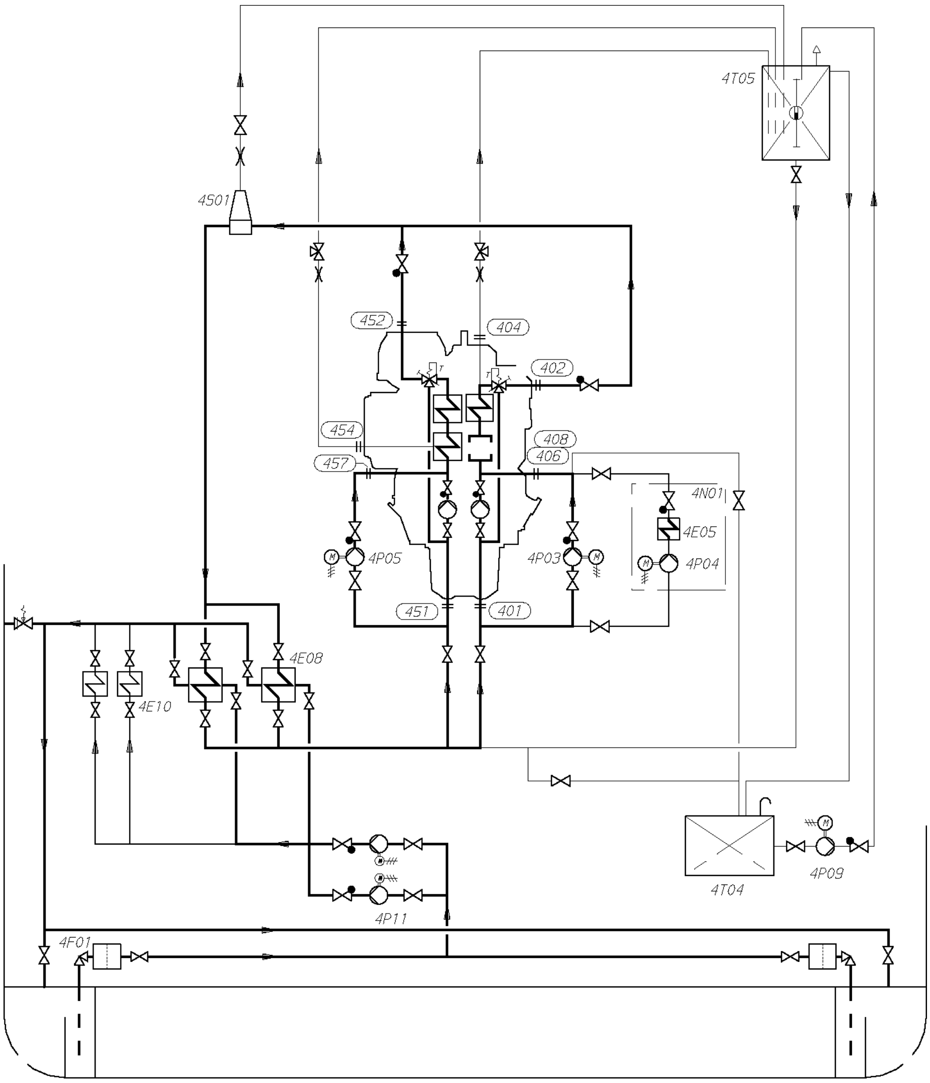


Fig 9.3.3 Example diagram for single main engine (HFO) reduction gear sea water cooled (3V76C5791a)

System components:			
4E05	Heater (preheater)	4P05	Stand-by pump (LT)
4E08	Central cooler	4P09	Transfer pump
4E10	Cooler (reduction gear)	4P11	Circulating pump (sea water)
4F01	Suction strainer (sea water)	4S01	Air venting
4N01	Preheating unit	4T04	Drain tank
4P03	Stand-by pump (HT)	4T05	Expansion tank
4P04	Circulating pump (preheater)		

Pipe connections:			
401	HT-water inlet	451	LT-water inlet
402	HT-water outlet	452	LT-water outlet
404	HT-water air vent	454	LT-water air venting from air cooler
406	Water from preheater to HT-circuit	457	LT-water from stand-by pump
408	HT-water from stand-by pump		

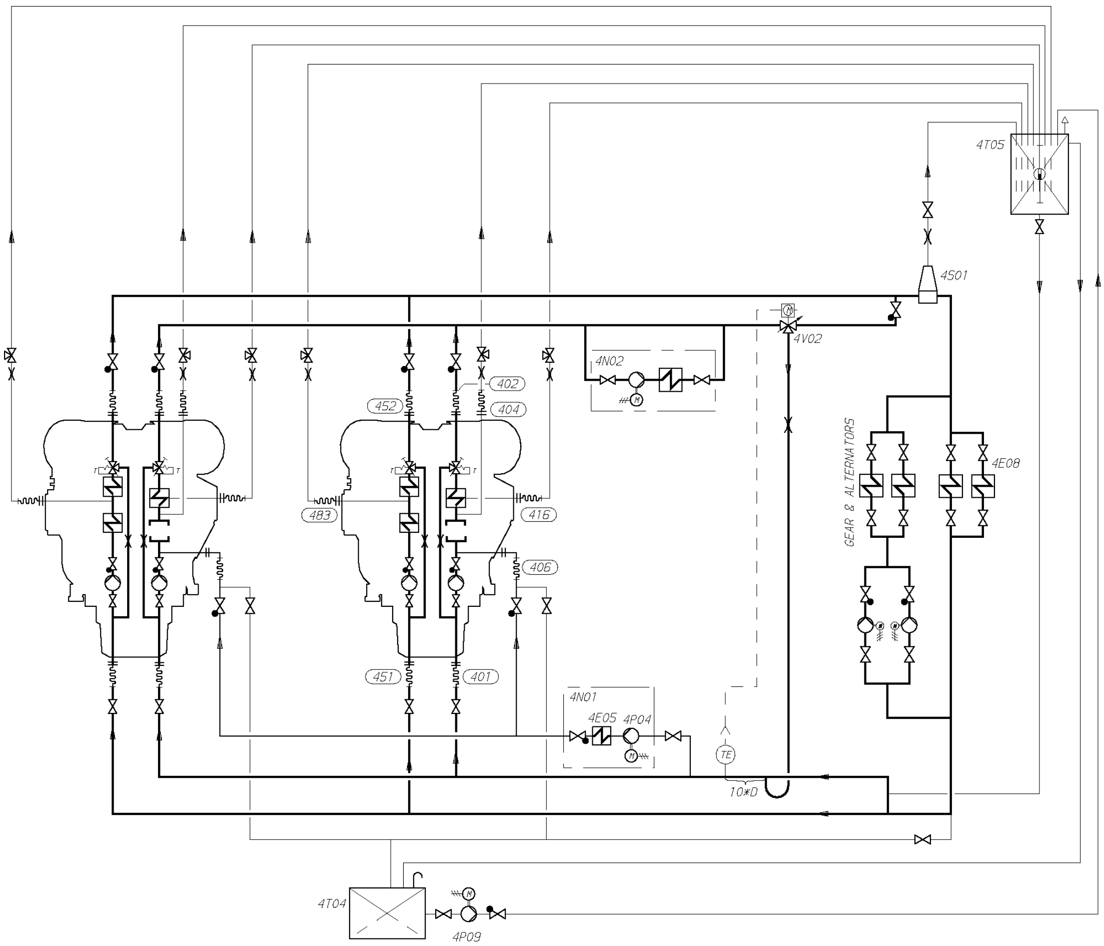


Fig 9.3.4 Example diagram for multiple main engines (3V76C5263b)

System components:			
4E05	Heater (preheater)	4P09	Transfer pump
4E08	Central cooler	4S01	Air venting
4N01	Preheating unit	4T04	Drain tank
4N02	Evaporator unit	4T05	Expansion tank
4P04	Circulating pump (preheater)	4V02	Temperature control valve (heat recovery)

Pipe connections:			
401	HT-water inlet	416	HT-water airvent from air cooler
402	HT-water outlet	451	LT-water inlet
404	HT-water air vent	452	LT-water outlet
406	Water from preheater to HT-circuit	483	LT-water air vent

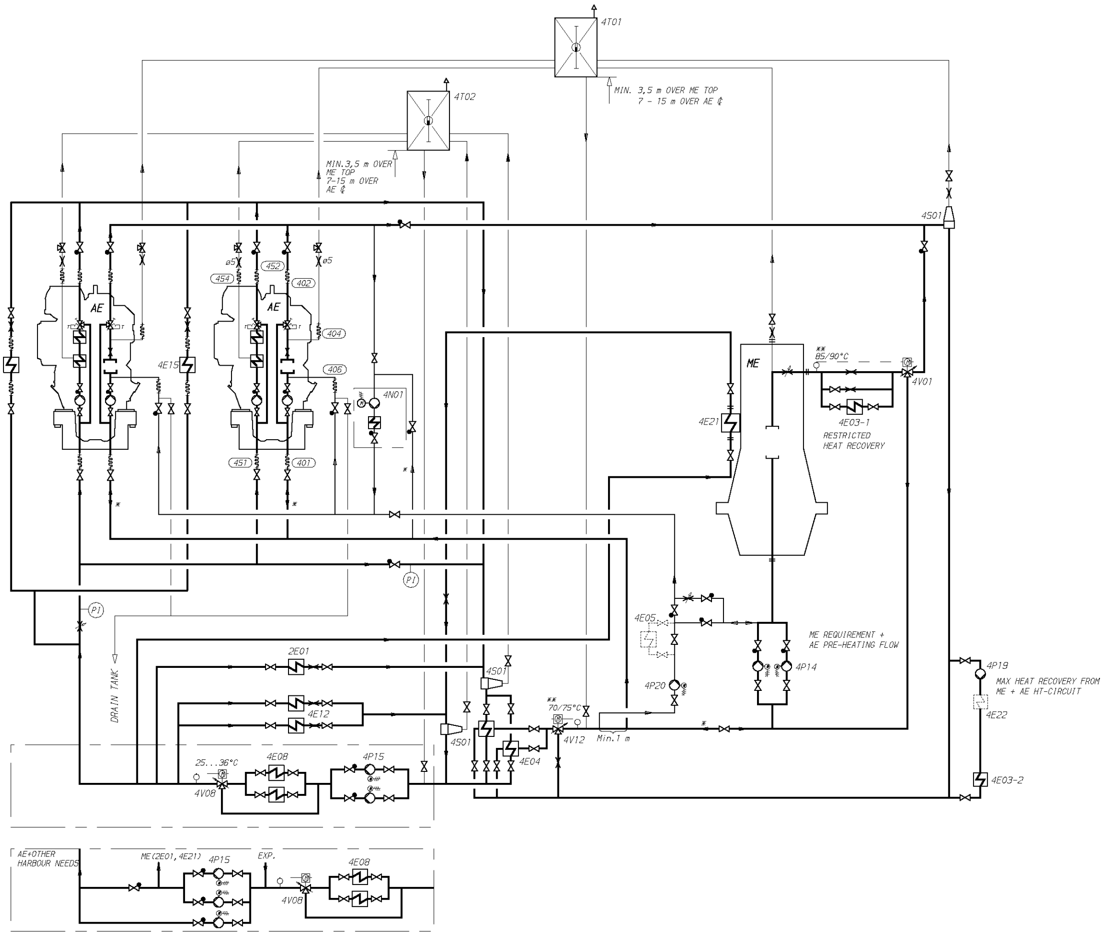


Fig 9.3.5 **Example diagram for common auxiliary engines and a low speed main engine with spilt LT and HT circuit (DAAE026913)**

Notes:

* Preheating

** Depending of Main engine type

The preheating unit (4N01) is needed for preheating before start of first auxiliary engine AE, if the heater (4E05) is not installed.

The pump (4P04) is used for preheating of stopped main engine and auxiliary engine with heat from running auxiliary engine.

The pump (4P14) preheats stopped auxiliary engine when main engine is running.

The heater (4E05) is only needed if the heat from the running auxiliary engine is not sufficient for preheating the main engine, e.g. in extreme winter conditions

It is not necessary to open/close valve when switching on the preheating of main engine or auxiliary engine.

The LT-circulating pump 4P15 can alternatively be mounted after the central coolers 4E08 and thermostatic valve 4V08 which gives possibility to use a smaller pump in harbour without clousing valves to main engine.

System components:			
2E01	Lubricating oil cooler	4P14	Circulating pump (HT)
4E03-1	Heat recovery (evaporator) ME	4P15	Circulating pump (LT)
4E03-2	Heat recovery (evaporator) ME + AE	4P19	Circulating pump (evaporator)
4E04	Raw water cooler (HT)	4P20	Circulating pump (preheating HT)
4E05	Heater (preheater), optional	4S01	Air venting
4E08	Central cooler	4T01	Expansion tank (HT)
4E12	Cooler (installation parts)	4T02	Expansion tank (LT)
4E15	Cooler (generator), optional	4V01	Temperature control valve (HT)
4E21	Cooler (scavenge air)	4V03	Temperature control valve (LT)

System components:			
4E22	Heater (booster), optional	4V12	Temperature control valve (heat recovery and preheating)
4N01	Preheating unit		

Pipe connections:			
401	HT-water inlet	451	LT-water inlet
402	HT-water outlet	452	LT-water outlet
404	HT-water air vent	454	LT-water air vent from air cooler
406	Water from preheater to HT-circuit		

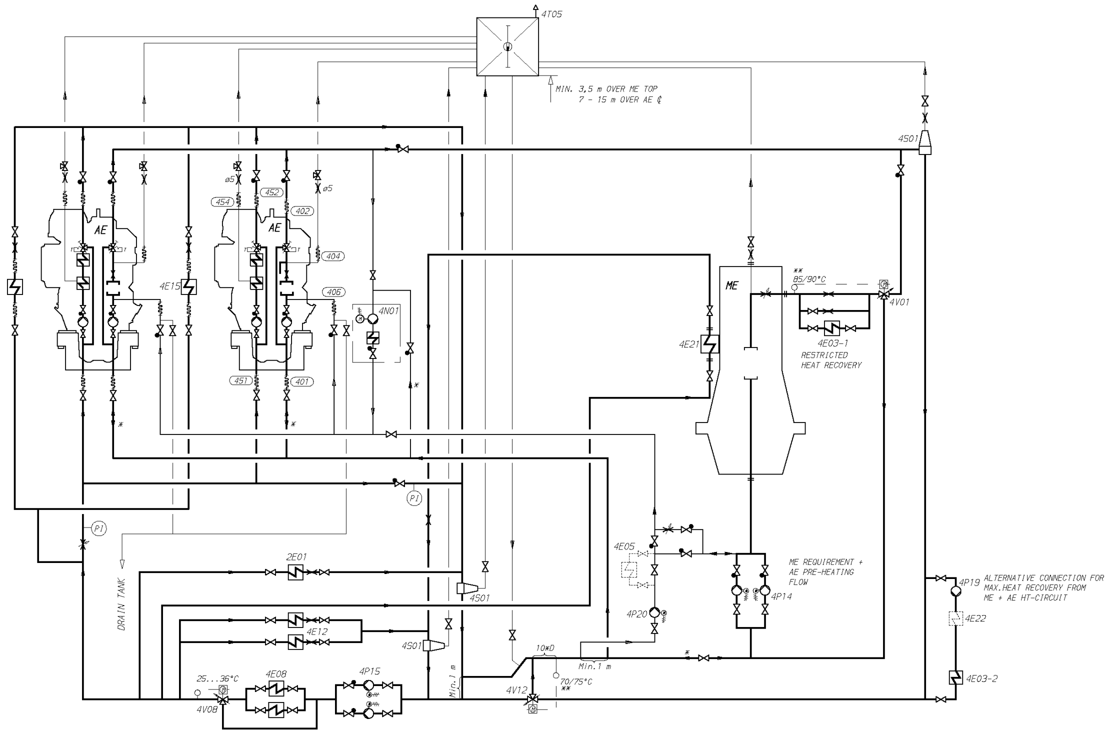


Fig 9.3.6 Example diagram for common auxiliary engines and a low speed main engine with mixed LT and HT circuit (DAAE026912)

Notes:

* Preheating flow

** Depending of ME type

The preheating unit (4N01) is needed for preheating before start of first auxiliary engine AE, if heater (4E05) is not installed.

The pump (4P04) is used for preheating of stopped main engine ME and auxiliary engine AE with heat from running auxiliary engine.

The pump (4P14) preheats the stopped auxiliary engine AE when main engine ME is running.

The heater (4E05) is only needed if the heat from the running auxiliary engine is not sufficient for preheating the main engine, e.g. in extreme winter conditions

It is not necessary to open/close valve when switching on the preheating of main engine or auxiliary engine.

System components:			
2E01	Lubriating oil cooler	4P14	Circulating pump (HT)
4E03-1	Heat recovery (evaporator) ME	4P15	Circulating pump (LT)
4E03-2	Heat recovery (evaporator) ME + AE	4P19	Circulating pump (evaporator)
4E05	Heater (preheater), optional	4P20	Circulating pump (preheating HT)
4E08	Central cooler	4S01	Air venting
4E12	Cooler (installation parts)	4T05	Expansion tank
4E15	Cooler (generator)	4V01	Temperature control valve (HT)
4E21	Cooler (scavenge air)	4V08	Temperature control valve (central cooler)
4E22	Heater (booster), optional	4V12	Temperature control valve (heat recovery and preheating)
4N01	Preheating unit		

Pipe connections:					
401	HT-water inlet	406	Water from preheater to HT-circuit	452	LT-water outlet
402	HT-water outlet	451	LT-water inlet	454	LT-water air vent from air cooler
404	HT-water air vent				

9.3.1 Cooling water system for arctic conditions

At low engine loads the combustion air is below zero degrees Celsius after the compressor stage, it cools down the cooling water and the engine instead of releasing heat to the cooling water in the charge air cooler. If the combustion air temperature reaching the cylinders is too cold, it can cause uneven burning of the fuel in the cylinder and possible misfires. Additionally overcooling the engine jacket can cause cold corrosion of the cylinder liners or even a stuck piston.

Thus maintaining nominal charge air receiver and HT-water inlet temperature are important factors, when designing the cooling water system for arctic conditions. Depending on the engine type an additional heater might be needed in the HT-water system as for some engine types the HT-charge air cooler is replaced with a double-stage cooler on the engine LT-water cooling water system. For other engine types the HT-water charge air cooler is kept as it is on a non-arctic package engine. If the setup is with additional HT-heater then the engine build-on self-sensing thermostatic control valve is removed and replaced with an external electrically controlled thermostatic control valve.

9.3.1.1 Dimensioning the HT water heaters

Dimensioning the arctic package HT water heaters is based on the number of cylinders and the minimum specified suction air temperature. The heater can be either electric, steam or thermal oil operated depending on the installation and customer preference. An example diagram for dimensioning the HT heater is shown in *9.3.1.1.1*.

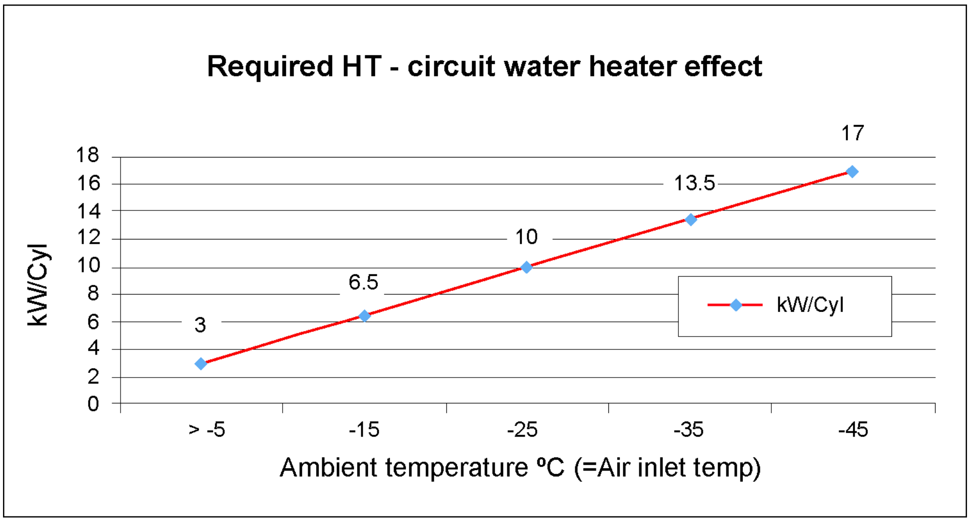


Fig 9.3.1.1.1 HT-circuit heating operational field

9.3.1.2 The arctic sea water cooling system

In arctic conditions, the hot sea water from the central cooler outlet is typically returned back to the sea chest in order to prevent ice slush from blocking the sea water filters. An example flow diagram of the arctic sea water system is shown in .

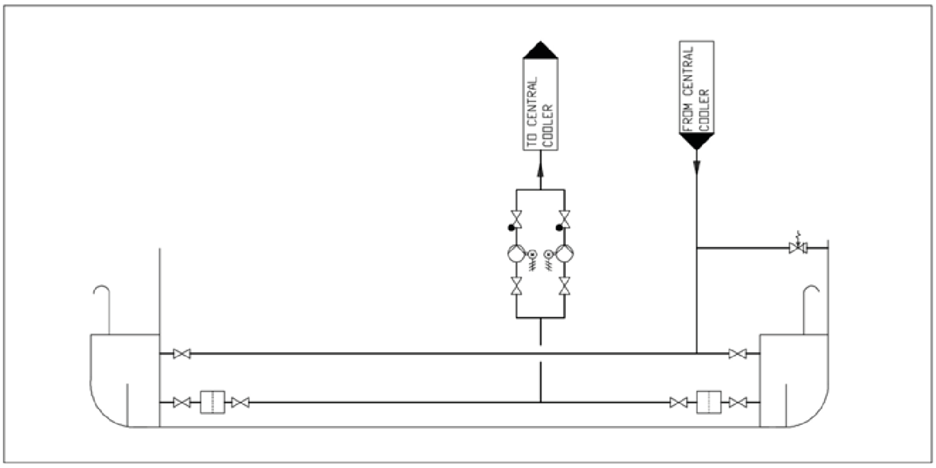


Fig 9.3.1.2.1 Example flow diagram of arctic sea water system

It is recommended to divide the engines into several circuits in multi-engine installations. One reason is of course redundancy, but it is also easier to tune the individual flows in a smaller system. Malfunction due to entrained gases, or loss of cooling water in case of large leaks can also be limited. In some installations it can be desirable to separate the HT circuit from the LT circuit with a heat exchanger.

The external system shall be designed so that flows, pressures and temperatures are close to the nominal values in *Technical data* and the cooling water is properly de-aerated.

Pipes with galvanized inner surfaces are not allowed in the fresh water cooling system. Some cooling water additives react with zinc, forming harmful sludge. Zinc also becomes nobler than iron at elevated temperatures, which causes severe corrosion of engine components.

Ships (with ice class) designed for cold sea-water should have provisions for recirculation back to the sea chest from the central cooler:

- For melting of ice and slush, to avoid clogging of the sea water strainer
- To enhance the temperature control of the LT water, by increasing the seawater temperature

9.3.2 Stand-by circulation pumps (4P03, 4P05)

Stand-by pumps should be of centrifugal type and electrically driven. Required capacities and delivery pressures are stated in *Technical data*.

> **NOTE**
>
> Some classification societies require that spare pumps are carried onboard even though the ship has multiple engines. Stand-by pumps can in such case be worth considering also for this type of application.

9.3.3 Sea water pump (4P11)

The sea water pumps are always separate from the engine and electrically driven.

The capacity of the pumps is determined by the type of coolers and the amount of heat to be dissipated.

Significant energy savings can be achieved in most installations with frequency control of the sea water pumps. Minimum flow velocity (fouling) and maximum sea water temperature (salt deposits) are however issues to consider.

9.3.4 Temperature control valve, HT-system (4V01)

External HT temperature control valve is an option for V-engines.

The temperature control valve is installed directly after the engine. It controls the temperature of the water out from the engine, by circulating some water back to the HT pump. The control valve can be either self-actuated or electrically actuated. Each engine must have a dedicated temperature control valve.

Set point	96°C

9.3.5 Temperature control valve for central cooler (4V08)

When it is desired to utilize the engine driven LT-pump for cooling of external equipment, e.g. a reduction or a generator, there must be a common LT temperature control valve in the external system, instead of an individual valve for each engine. The common LT temperature control valve is installed after the central cooler and controls the temperature of the water before the engine and the external equipment, by partly bypassing the central cooler. The valve can be either direct acting or electrically actuated.

The set-point of the temperature control valve 4V08 is 38 °C in the type of system described above.

Engines operating on HFO must have individual LT temperature control valves. A separate pump is required for the external equipment in such case, and the set-point of 4V08 can be lower than 38 °C if necessary.

9.3.6 Temperature control valve for heat recovery (4V02)

The temperature control valve after the heat recovery controls the maximum temperature of the water that is mixed with HT water from the engine outlet before the HT pump. The control valve can be either self-actuated or electrically actuated.

Especially in installations with dynamic positioning (DP) feature, installation of valve 4V02 is strongly recommended in order to avoid HT temperature fluctuations during low load operation.

The set-point is usually somewhere close to 75 °C.

9.3.7 Coolers for other equipment and MDF coolers

The engine driven LT circulating pump can supply cooling water to one or two small coolers installed in parallel to the engine, for example a MDF cooler or a reduction gear cooler. This is only possible for engines operating on MDF, because the LT temperature control valve cannot be built on the engine to control the temperature after the engine. Separate circulating pumps are required for larger flows.

Design guidelines for the MDF cooler are given in chapter *Fuel system*.

9.3.8 Fresh water central cooler (4E08)

The fresh water cooler can be of either plate, tube or box cooler type. Plate coolers are most common. Several engines can share the same cooler.

It can be necessary to compensate a high flow resistance in the circuit with a smaller pressure drop over the central cooler.

The flow to the fresh water cooler must be calculated case by case based on how the circuit is designed.

In case the fresh water central cooler is used for combined LT and HT water flows in a parallel system the total flow can be calculated with the following formula:

$$q = q_{LT} + \frac{3.6 \times \Phi}{4.15 \times (T_{OUT} - T_{IN})}$$

where:

q = total fresh water flow [m³/h]

q_{LT} = nominal LT pump capacity[m³/h]

Φ = heat dissipated to HT water [kW]

T_{out} = HT water temperature after engine (91°C)

T_{in} = HT water temperature after cooler (38°C)

Design data:

Fresh water flow	see chapter *Technical Data*
Heat to be dissipated	see chapter *Technical Data*
Pressure drop on fresh water side	max. 60 kPa (0.6 bar)
Sea-water flow	acc. to cooler manufacturer, normally 1.2 - 1.5 x the fresh water flow
Pressure drop on sea-water side, norm.	acc. to pump head, normally 80 - 140 kPa (0.8 - 1.4 bar)
Fresh water temperature after cooler	max. 38°C
Margin (heat rate, fouling)	15%

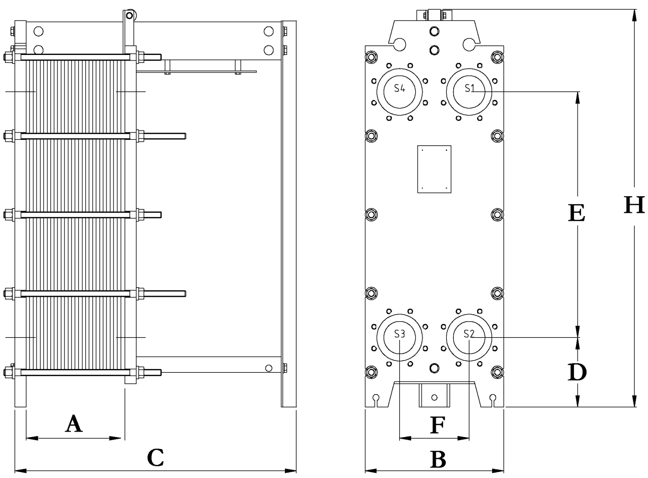


Fig 9.3.8.1 Main dimensions of the central cooler.

NOTE

The sizes are for guidance only. These central coolers are dimensioned to exchange the heat of the engine only, other equipment such as CPP, gearbox etc. is not taken into account.

Engine type	P [kW]	Weight [kg]	Dimension [mm]						
			A	B	C	D	E	F	H
1 x 6L32	1641	820	193	690	817	330	1057	380	1675

Engine type	P [kW]	Weight [kg]	Dimension [mm]						
			A	B	C	D	E	F	H
1 x 7L32	1914	830	227	690	817	330	1057	380	1675
1 x 8L32	2189	860	262	690	817	330	1057	380	1675
1 x 9L32	2462	880	296	690	817	330	1057	380	1675
1 x 12V32	3170	890	331	690	817	330	1057	380	1675
1 x 16V32	4227	960	448	690	817	330	1057	380	1675
1 x 18V32	4755	1000	524	690	817	330	1057	380	1730

As an alternative for the central coolers of the plate or of the tube type a box cooler can be installed. The principle of box cooling is very simple. Cooling water is forced through a U-tube-bundle, which is placed in a sea-chest having inlet- and outlet-grids. Cooling effect is reached by natural circulation of the surrounding water. The outboard water is warmed up and rises by its lower density, thus causing a natural upward circulation flow which removes the heat.

Box cooling has the advantage that no raw water system is needed, and box coolers are less sensitive for fouling and therefor well suited for shallow or muddy waters.

9.3.9 Waste heat recovery

The waste heat in the HT cooling water can be used for fresh water production, central heating, tank heating etc. The system should in such case be provided with a temperature control valve to avoid unnecessary cooling, as shown in the example diagrams. With this arrangement the HT water flow through the heat recovery can be increased.

The heat available from HT cooling water is affected by ambient conditions. It should also be taken into account that the recoverable heat is reduced by circulation to the expansion tank, radiation from piping and leakages in temperature control valves.

9.3.10 Air venting

Air may be entrained in the system after an overhaul, or a leak may continuously add air or gas into the system. The engine is equipped with vent pipes to evacuate air from the cooling water circuits. The vent pipes should be drawn separately to the expansion tank from each connection on the engine, except for the vent pipes from the charge air cooler on V-engines, which may be connected to the corresponding line on the opposite cylinder bank.

Venting pipes to the expansion tank are to be installed at all high points in the piping system, where air or gas can accumulate.

The vent pipes must be continuously rising.

9.3.11 Expansion tank (4T05)

The expansion tank compensates for thermal expansion of the coolant, serves for venting of the circuits and provides a sufficient static pressure for the circulating pumps.

Design data:	
Pressure from the expansion tank at pump inlet	70 - 150 kPa (0.7...1.5 bar)
Volume	min. 10% of the total system volume

NOTE

The maximum pressure at the engine must not be exceeded in case an electrically driven pump is installed significantly higher than the engine.

Concerning the water volume in the engine, see chapter *Technical data*.

The expansion tank should be equipped with an inspection hatch, a level gauge, a low level alarm and necessary means for dosing of cooling water additives.

The vent pipes should enter the tank below the water level. The vent pipes must be drawn separately to the tank (see air venting) and the pipes should be provided with labels at the expansion tank.

The balance pipe down from the expansion tank must be dimensioned for a flow velocity not exceeding 1.0...1.5 m/s in order to ensure the required pressure at the pump inlet with engines running. The flow through the pipe depends on the number of vent pipes to the tank and the size of the orifices in the vent pipes. The table below can be used for guidance.

Table 9.3.11.1 Minimum diameter of balance pipe

Nominal pipe size	Max. flow velocity (m/s)	Max. number of vent pipes with ø 5 mm orifice
DN 32	1.1	3
DN 40	1.2	6
DN 50	1.3	10
DN 65	1.4	17

9.3.12 Drain tank (4T04)

It is recommended to collect the cooling water with additives in a drain tank, when the system has to be drained for maintenance work. A pump should be provided so that the cooling water can be pumped back into the system and reused.

Concerning the water volume in the engine, see chapter *Technical data*. The water volume in the LT circuit of the engine is small.

9.3.13 Preheating

The cooling water circulating through the cylinders must be preheated to at least 60 °C, preferably 70 °C. This is an absolute requirement for installations that are designed to operate on heavy fuel, but strongly recommended also for engines that operate exclusively on marine diesel fuel.

The energy required for preheating of the HT cooling water can be supplied by a separate source or by a running engine, often a combination of both. In all cases a separate circulating pump must be used. It is common to use the heat from running auxiliary engines for preheating of main engines. In installations with several main engines the capacity of the separate heat source can be dimensioned for preheating of two engines, provided that this is acceptable for the operation of the ship. If the cooling water circuits are separated from each other, the energy is transferred over a heat exchanger.

9.3.13.1 Heater (4E05)

The energy source of the heater can be electric power, steam or thermal oil.

It is recommended to heat the HT water to a temperature near the normal operating temperature. The heating power determines the required time to heat up the engine from cold condition.

The minimum required heating power is 5 kW/cyl, which makes it possible to warm up the engine from 20 °C to 60...70 °C in 10-15 hours. The required heating power for shorter heating time can be estimated with the formula below. About 2 kW/cyl is required to keep a hot engine warm.

Design data:	
Preheating temperature	min. 60°C
Required heating power	5 kW/cyl
Heating power to keep hot engine warm	2 kW/cyl

Required heating power to heat up the engine, see formula below:

$$P = \frac{(T_1 - T_0)(m_{eng} \times 0.14 + V_{LO} \times 0.48 + V_{FW} \times 1.16)}{t} + k_{eng} \times n_{cyl}$$

where:

$P =$	Preheater output [kW]
$T_1 =$	Preheating temperature = 60...70 °C
$T_0 =$	Ambient temperature [°C]
$m_{eng} =$	Engine weight [ton]
$V_{LO} =$	Lubricating oil volume [m^3] (wet sump engines only)
$V_{FW} =$	HT water volume [m^3]
$t =$	Preheating time [h]
$k_{eng} =$	Engine specific coefficient = 1 kW
$n_{cyl} =$	Number of cylinders

The formula above should not be used for $P < 3.5$ kW/cyl

9.3.13.2 Circulation pump for preheater (4P04)

Design data:	
Capacity	0.4 m^3/h per cylinder
Delivery pressure	80...100 kPa (0.8...1.0 bar)

9.3.13.3 Preheating unit (4N01)

A complete preheating unit can be supplied. The unit comprises:

- Electric or steam heaters
- Circulating pump
- Control cabinet for heaters and pump
- Set of thermometers
- Non-return valve
- Safety valve

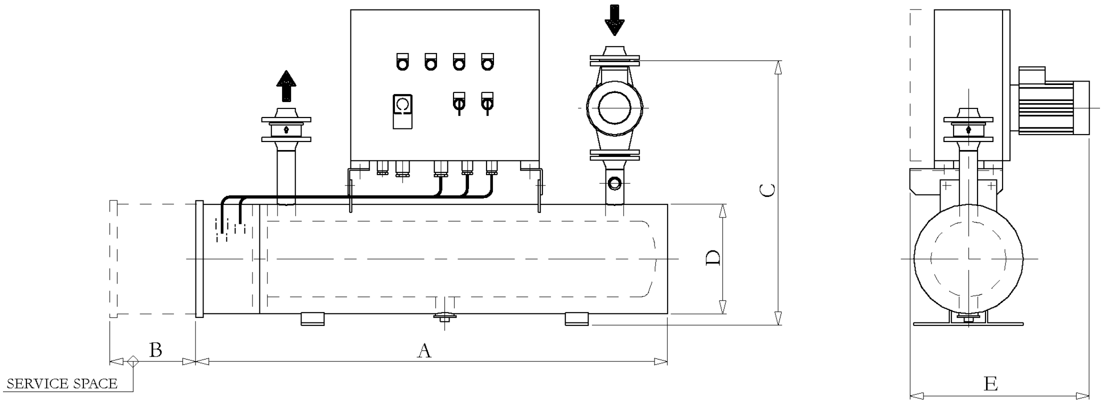


Fig 9.3.13.3.1 Preheating unit, electric (3V60L0562C).

Heater capacity [kW]	Pump capacity [m³/h]		Weight [kg]	Pipe conn.	Dimensions [mm]				
	50 Hz	60 HZ		In/outlet	A	B	C	D	E
18	11	13	95	DN40	1250	900	660	240	460
22.5	11	13	100	DN40	1050	720	700	290	480
27	12	13	103	DN40	1250	900	700	290	480
30	12	13	105	DN40	1050	720	700	290	480
36	12	13	125	DN40	1250	900	700	290	480
45	12	13	145	DN40	1250	720	755	350	510
54	12	13	150	DN40	1250	900	755	350	510
72	12	13	187	DN40	1260	900	805	400	550
81	12	13	190	DN40	1260	900	805	400	550
108	12	13	215	DN40	1260	900	855	450	575

9.3.14 Throttles

Throttles (orifices) are to be installed in all by-pass lines to ensure balanced operating conditions for temperature control valves. Throttles must also be installed wherever it is necessary to balance the waterflow between alternate flow paths.

9.3.15 Thermometers and pressure gauges

Local thermometers should be installed wherever there is a temperature change, i.e. before and after heat exchangers etc.

Local pressure gauges should be installed on the suction and discharge side of each pump.

ANEXO II

DATOS TÉCNICOS DEL GENERADOR DE EMERGENCIA

PROPULSION ENGINES

C12

RATINGS AND FUEL CONSUMPTION

	mhp	bhp	bkW	rpm	U.S. g/h	l/hr	EPA - IMO - EU
A	345	340	254	1800	16.6	62.9	T2C - II - IW
B	390	385	287	1800	18.6	70.4	T2C - II - IW
C	460	454	339	2100	22.0	83.1	T2C - II - IW
C	497	490	366	2300	24.0	91.0	T1 - II - RCD
D	578	570	425	2300	27.9	105.8	T1 - II - RCD
E	609	600	448	2300	29.3	111.0	T1 - I - RCD

Click image for larger view
of the Cat C12 Propulsion Engine

	LE	H	WE
min.	62 in/1574 mm	39.5 in/1005 mm	38.1 in/969 mm
max.	62 in/1574 mm	39.5 in/1005 mm	38.1 in/969 mm

In-line 6, 4-Stroke-Cycle Diesel

Aspiration	TA	
Bore x Stroke	5.1 x 5.9 in	130 x 150 mm
Displacement	732 cu in	12 liter
Rotation (from flywheel end)	Counterclockwise	
Engine dry weight (approx)	2588 lb	1174 kg

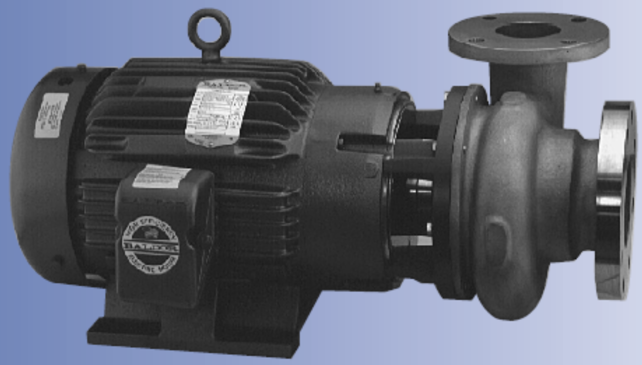
ANEXO III

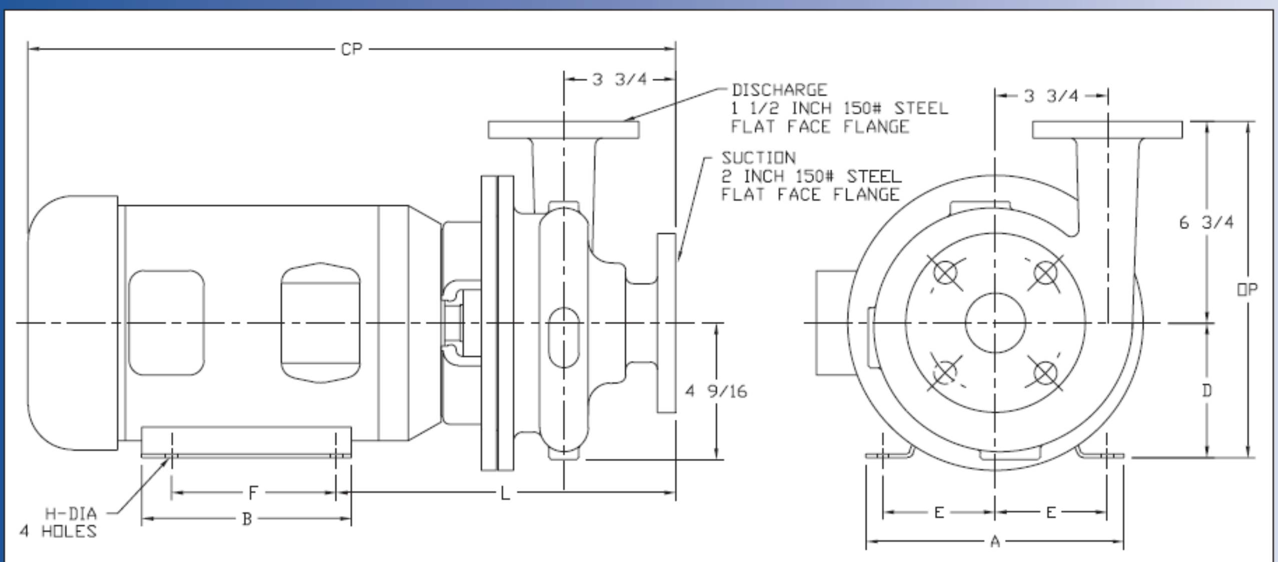
CARACTERÍSTICAS DE LAS BOMBAS DE LOS SISTEMAS AUXILIARES DE PROPULSIÓN

Ampco Centrifugal Pumps

Data Sheet

Model ZC2 2 x 1½





TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
HP	RPM	FRAME	A (max)	B (max)	D	E	F	H	L	CP	OP	
1	1750	143JM	6-1/2	6	3-1/2	2-3/4	4	11/32	10-3/16	19-1/8	10-1/4	112
1-1/2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	10-3/16	19-1/8	10-1/4	116
2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	10-13/16	19-1/8	10-1/4	122
2	3500	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	10-13/16	19-1/8	10-1/4	122
3	3500	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	10-13/16	19-1/8	10-1/4	148
5	3500	184JM	8-5/8	6-1/2	4-1/2	3-3/4	5-1/2	13/32	11-7/16	21-15/16	11-1/4	161
7-1/2	3500	213JM	9-5/8	8-1/8	5-1/4	4-1/4	5-1/2	13/32	12-3/16	24-3/4	12	229
10	3500	215JM	9-5/8	8-1/8	5-1/4	4-1/4	7	13/32	12-3/16	24-3/4	12	247

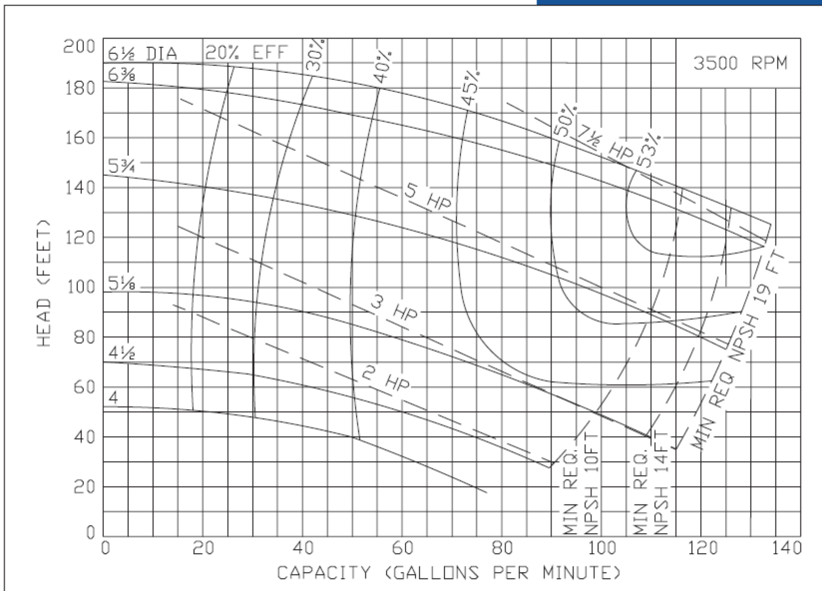
MATERIAL SPECIFICATIONS

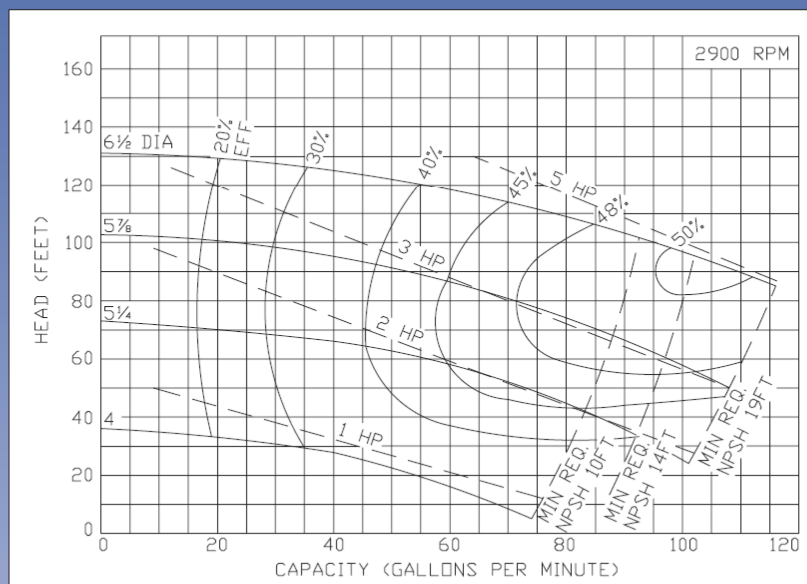
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO®483	316 Stainless	Duplex 2205
Wear Ring	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron

Ampco Centrifugal Pumps

Model ZC2 2 x 1½

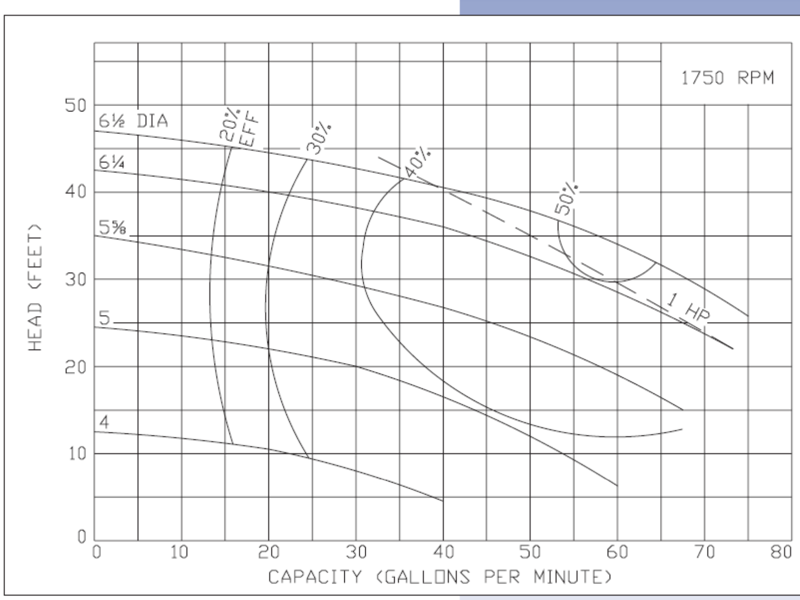
Curves show approximate characteristics based on clear 68° water.
Rated point is guaranteed.





Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



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RPH

DN	25 – 400
Q [m³/h]	max. 4150
H [m]	max. 270
p [bar]	max. 110
T [°C]	-70 to +450

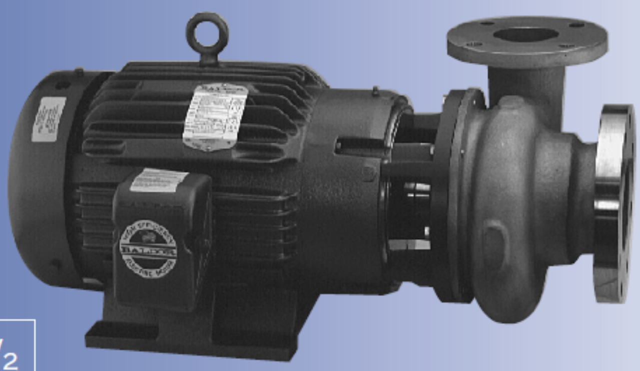
Data for 50 Hz operation

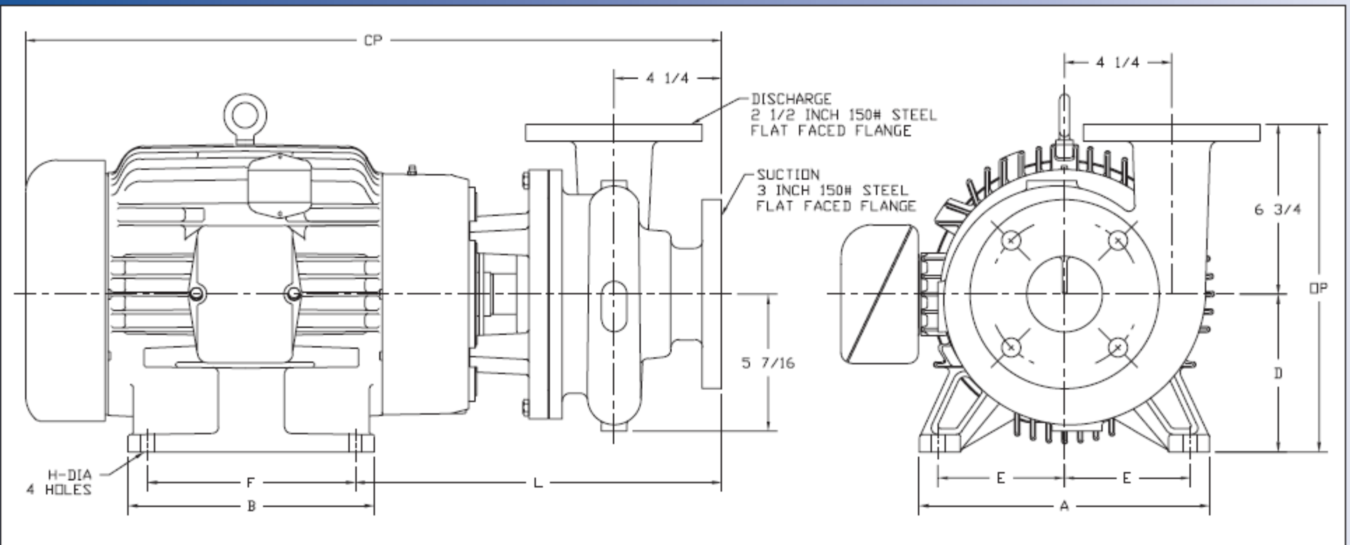
Also available for 60 Hz

Ampco Centrifugal Pumps

Data Sheet

Model ZC2/ZCH2 3X2 1/2

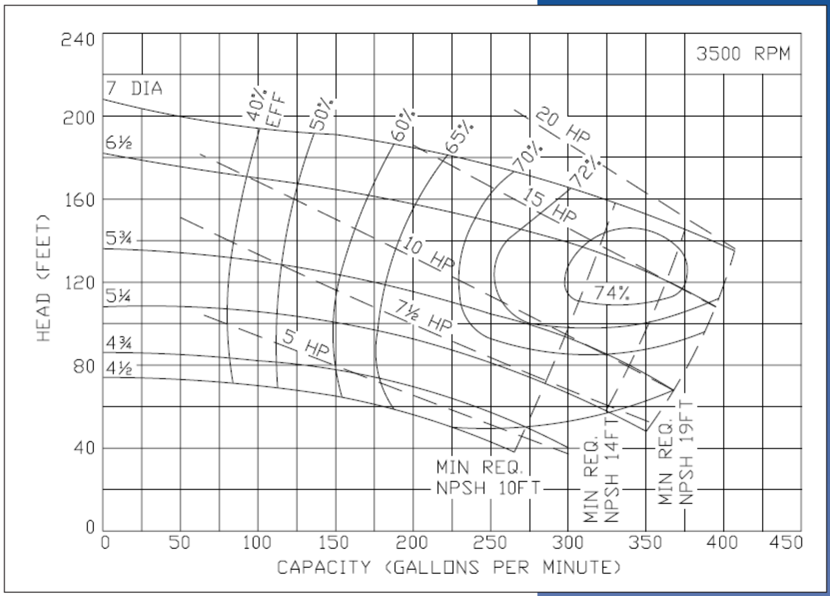




	TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
	HP	RPM	FRAME	A (max)	B (max)	D	E	F	H	L	CP	OP	
ZC2	1	1750	143JM	6-1/2	6	3-1/2	2-3/4	4	11/32	11-5/8	19-15/16	10-1/4	129
ZC2	1-1/2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	11-5/8	19-15/16	10-1/4	133
ZC2	2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	11-5/8	19-15/16	10-1/4	139
ZC2	3	1750	182JM	8-5/8	6-1/2	4-1/2	3-3/4	4-1/2	13/32	12-1/4	21-5/16	11-1/4	165
ZC2	5	3500	184JM	8-5/8	6-1/2	4-1/2	3-3/4	5-1/2	13/32	12-1/4	22-11/16	11-1/4	178
ZC2	7-1/2	3500	213JM	9-5/8	8-1/8	5-1/4	4-1/4	5-1/2	13/32	13-1/4	25-9/16	12	246
ZC2	10	3500	215JM	9-5/8	8-1/8	5-1/4	4-1/4	7	13/32	13-1/4	25-9/16	12	264
ZCH2	15	3500	254JM	11-1/2	9-3/4	6-1/4	5	8-1/4	17/32	14-1/2	27-9/16	13	361
ZCH2	20	3500	256JM	11-1/2	11-1/2	6-1/4	5	10	17/32	14-1/2	29-3/8	13	399
ZCH2	25	3500	284JM	12-3/4	12-3/4	7	5-1/2	9-1/2	9/16	14-1/2	32-15/16	13-3/4	529

MATERIAL SPECIFICATIONS

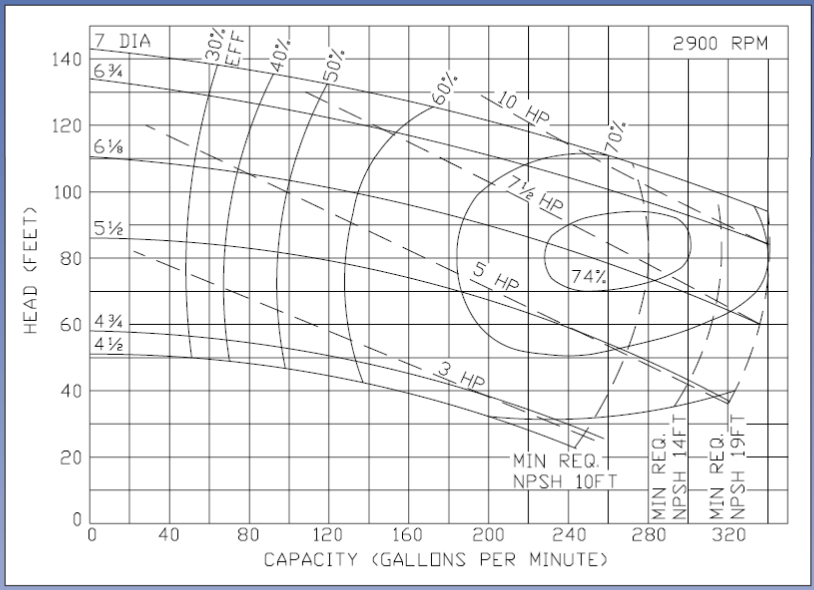
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO® 483	316 Stainless	Duplex 2205
Wear Ring	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron



Ampco Centrifugal Pumps

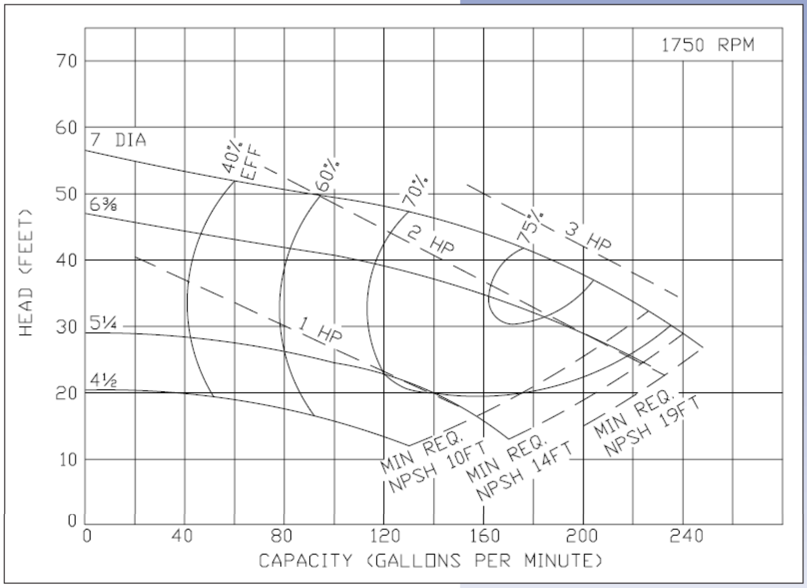
Model ZC2/ZCH2 3X2½

Curves show approximate characteristics
based on clear 68° water.
Rated point is guaranteed.



Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



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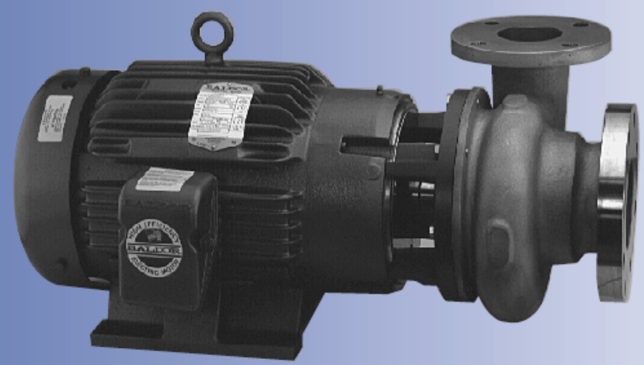
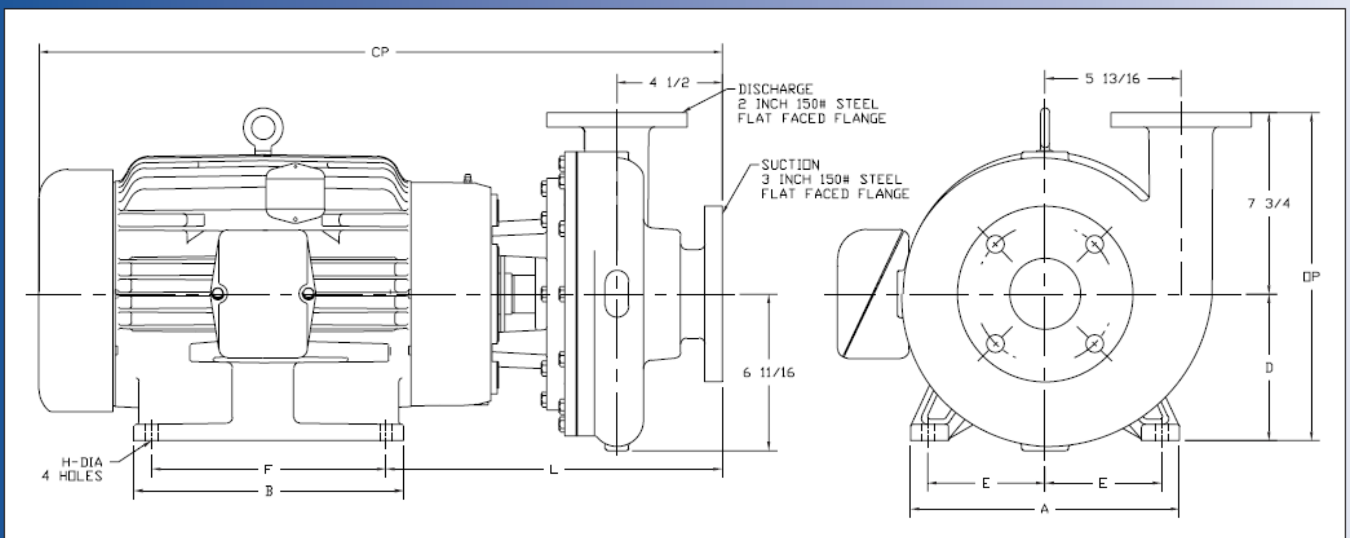
Ampco Centrifugal Pumps

Data Sheet

Model ZC2/ZCH2 3x2

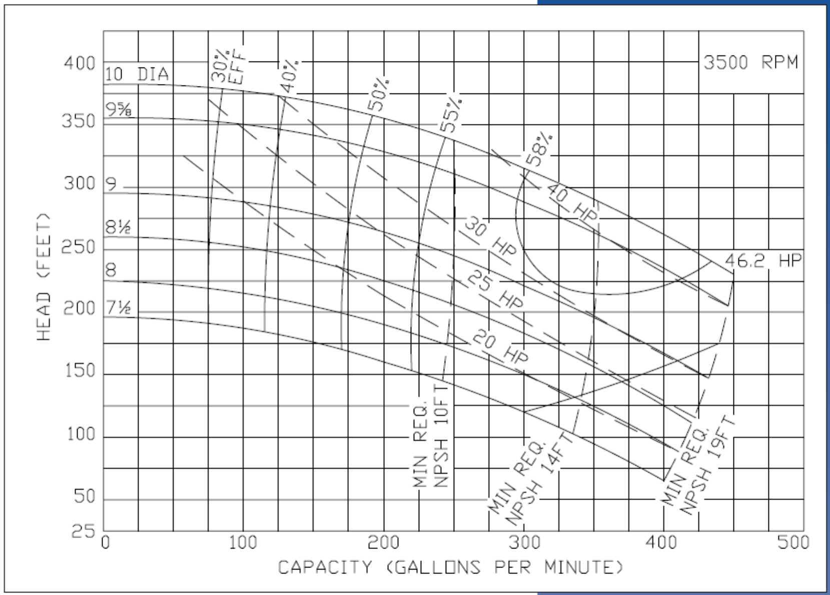




TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
HP	RPM	FRAME	A (typ)	B (typ)	D	E	F	H	L	CP	OP	
3	1750	182JM	8-5/8	6-1/2	4-1/2	3-3/4	4-1/2	13/32	12-1/8	21-1/4	12-1/4	179
5	1750	184JM	8-5/8	6-1/2	4-1/2	3-3/4	5-1/2	13/32	12-1/8	22-3/4	12-1/4	203
7-1/2	1750	213JM	9-1/2	8	5-1/4	4-1/2	5-1/2	13/32	13-1/8	24-1/4	13	254
10	1750	215JM	9-1/2	8	5-1/4	4-1/4	7	13/32	13-1/8	25-3/8	13	266
20	3500	256JM	11-1/2	11-1/2	6-1/4	5	10	17/32	14-3/8	29-1/4	14	433
25	3500	284JM	12-3/4	12-3/4	7	5-1/2	9-1/2	17/32	14-3/8	32-7/8	14-3/4	599
30	3500	286JM	12-3/4	12-3/4	7	5-1/2	11	17/32	14-3/8	33-7/16	14-3/4	660
40	3500	324JM	14	12	8	6-1/4	10-1/2	21/32	14-7/8	34-3/4	15-3/4	755
50	3500	326JM	14-1/2	14	8	6-1/4	12	21/32	14-7/8	34-3/4	15-3/4	773

MATERIAL SPECIFICATIONS

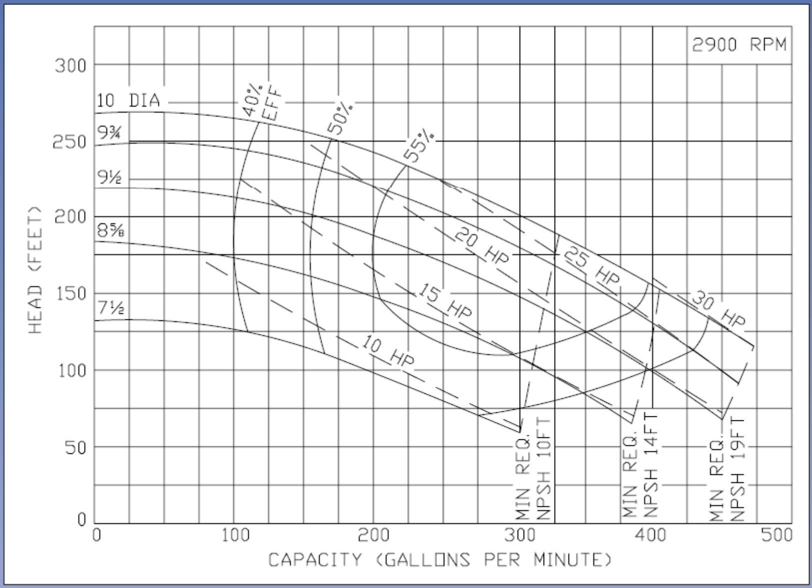
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO®483	316 Stainless	Duplex 2205
Wear Rings	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron



Ampco Centrifugal Pumps

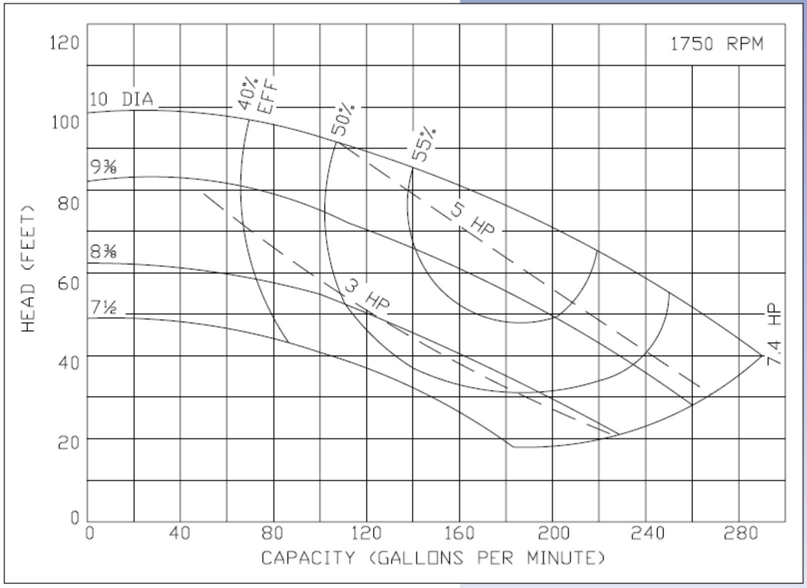
Model ZC2/ZCH2 3x2

Curves show approximate characteristics based on clear 68° water. Rated point is guaranteed.



Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



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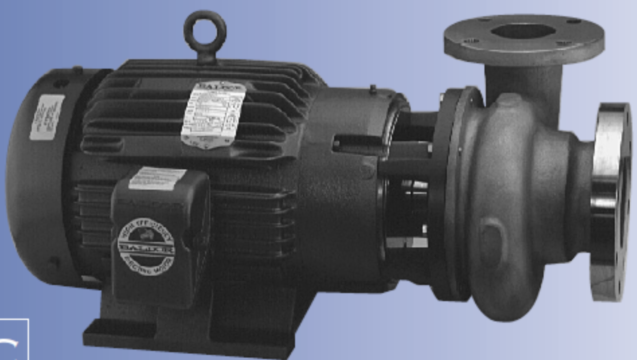
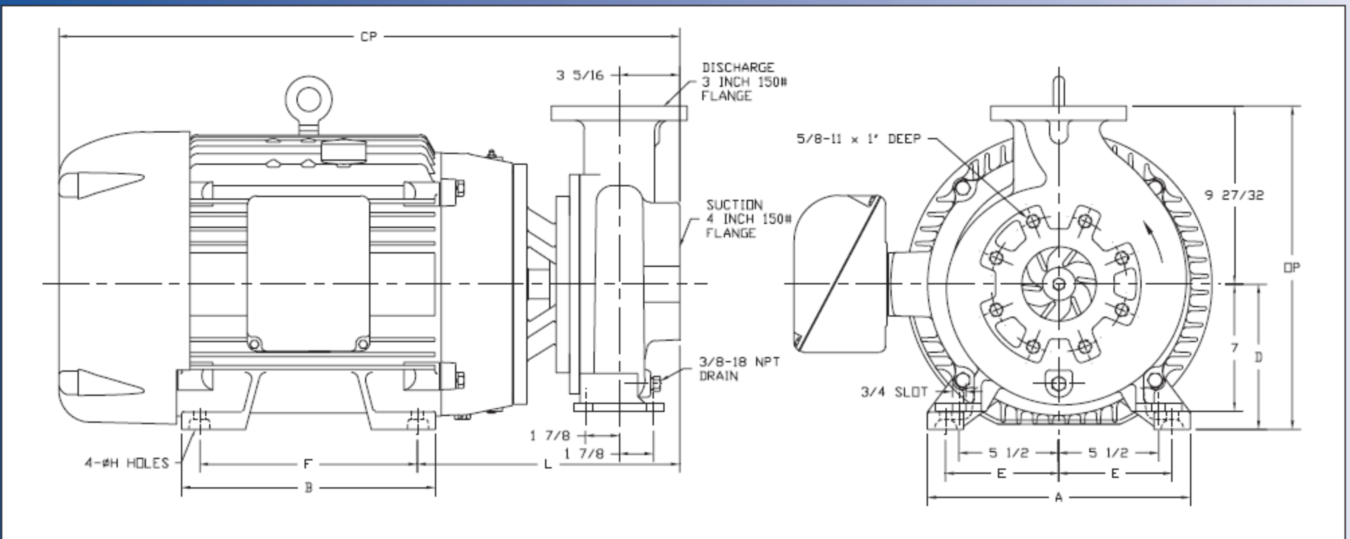
Ampco Centrifugal Pumps

Data Sheet

Model ZC2/ZCH2 4X3C

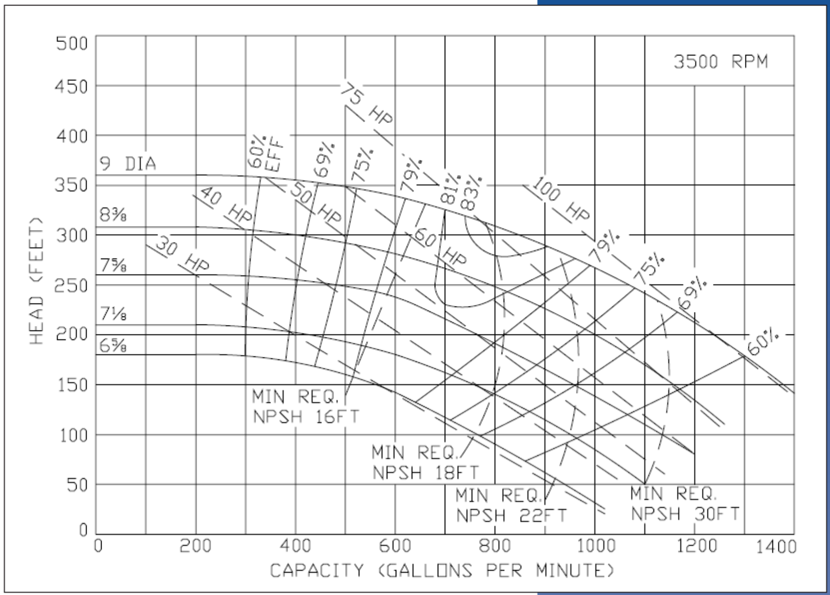




	TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
	HP	RPM	FRAME	A (max)	B (max)	D	E	F	H	L	CP	OP	
ZC2	3	1750	182JM	8-5/8	6-1/2	4-1/2	3-3/4	4-1/2	13/32	11-15/32	20-17/32	14-11/32	204
ZC2	5	1750	184JM	8-5/8	6-1/2	4-1/2	3-3/4	5-1/2	13/32	11-15/32	22-1/16	14-11/32	228
ZC2	7-1/2	1750	213JM	9-1/2	8	5-1/4	4-1/4	5-1/2	13/32	12-15/32	23-17/32	15-3/32	279
ZC2	10	1750	215JM	9-1/2	8	5-1/4	4-1/4	7	13/32	12-15/32	24-21/32	15-3/32	293
ZC2	15	1750	254JM	11-1/2	9-3/4	6-1/4	5	8-1/4	17/32	13-23/32	26-13/16	16-3/32	456
ZCH2	30	3500	286JM	12-3/4	12-3/4	7	5-1/2	11	9/16	13-31/32	32-25/32	16-27/32	685
ZCH2	40	3500	324JM	14-1/2	14	8	6-1/4	10-1/2	21/32	14-15/32	34-1/4	17-27/32	780
ZCH2	50	3500	326JM	14-1/2	14	8	6-1/4	12	21/32	14-15/32	34-1/4	17-27/32	789

MATERIAL SPECIFICATIONS

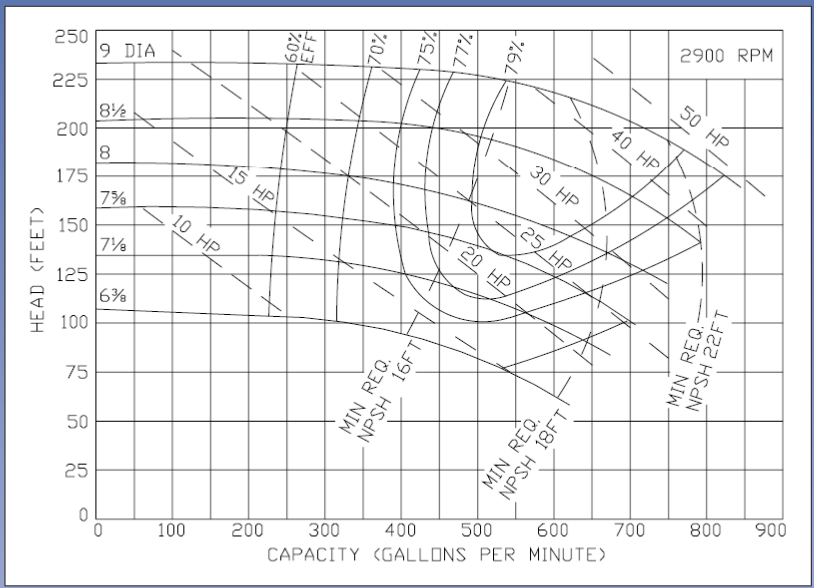
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO®483	316 Stainless	Duplex 2205
Wear Ring	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron



Ampco Centrifugal Pumps

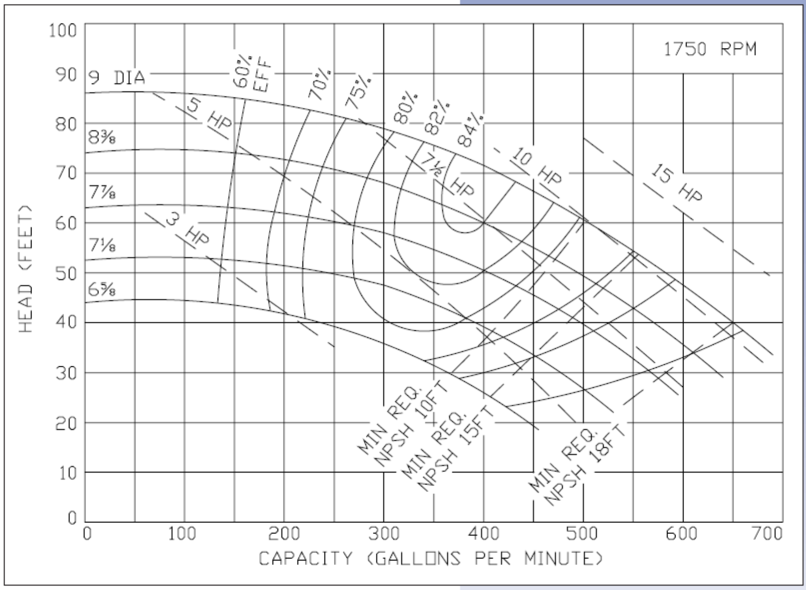
Model ZC2/ZCH2 4X3C

Curves show approximate characteristics
based on clear 68° water.
Rated point is guaranteed.



Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



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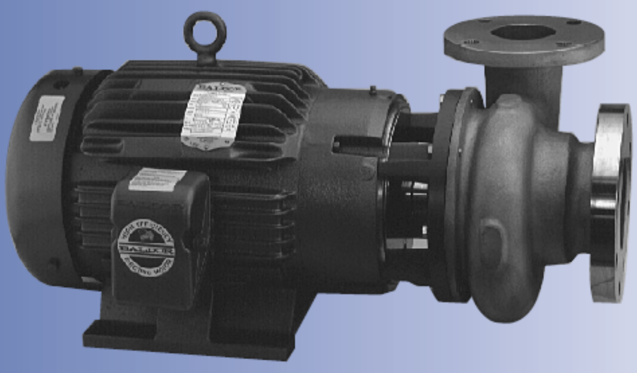
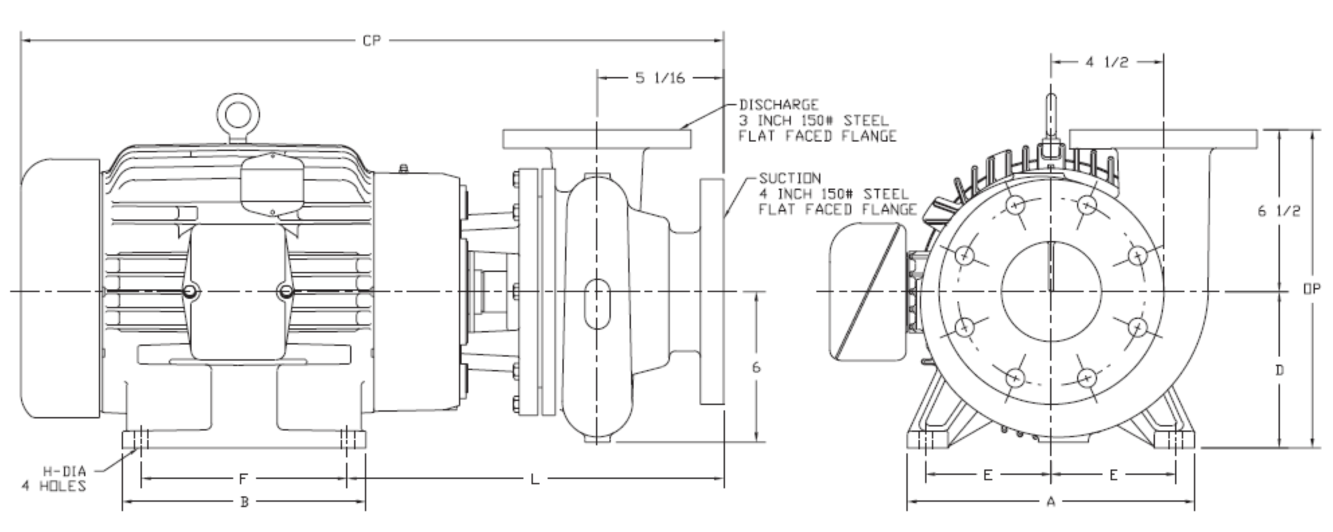
Ampco Centrifugal Pumps

Data Sheet

Model ZC2/ZCH2 4X3





	TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
	HP	RPM	FRAME	A (max)	B (max)	D	E	F	H	L	CP	OP	
ZC2	1-1/2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	12-3/16	20-1/2	10	152
ZC2	2	1750	145JM	6-1/2	6	3-1/2	2-3/4	5	11/32	12-3/16	20-1/2	10	158
ZC2	3	1750	182JM	8-5/8	6-1/2	4-1/2	3-3/4	4-1/2	13/32	12-13/16	21-7/8	11	184
ZC2	5	1750	184JM	8-5/8	6-1/2	4-1/2	3-3/4	5-1/2	13/32	12-13/16	23-7/16	11	197
ZC2	10	3500	215JM	9-5/8	8-1/8	5-1/4	4-1/4	7	13/32	13-9/16	26-1/8	11-3/4	283
ZCH2	15	3500	254JM	11-1/2	9-3/4	6-1/4	5	8-1/4	17/32	15-1/16	28-1/8	12-3/4	391
ZCH2	20	3500	256JM	11-1/2	11-1/2	6-1/4	5	10	17/32	15-1/16	29-15/16	12-3/4	429
ZCH2	25	3500	284JM	12-3/4	12-3/4	7	5-1/2	9-1/2	9/16	15-1/16	33-1/2	13-1/2	559
ZCH2	30	3500	286JM	12-3/4	12-3/4	7	5-1/2	11	9/16	15-1/16	34-1/8	13-1/2	688

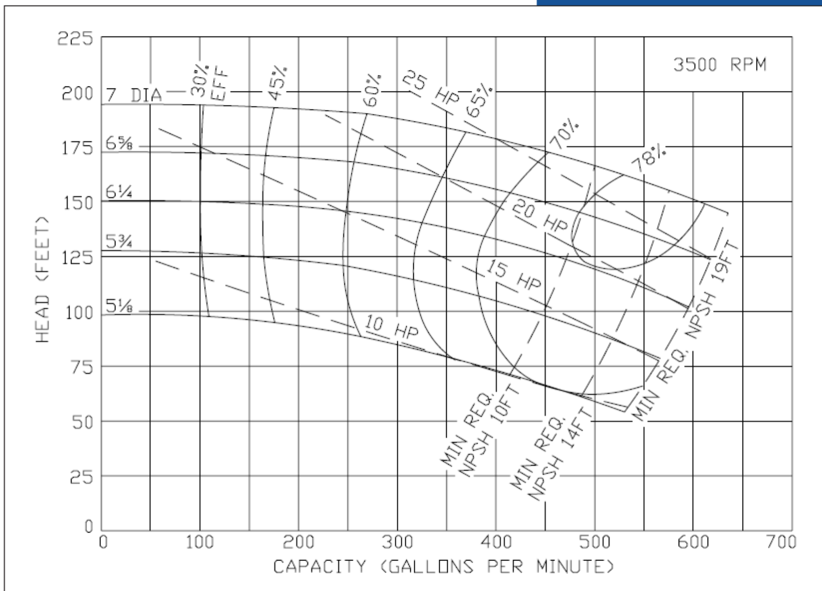
MATERIAL SPECIFICATIONS

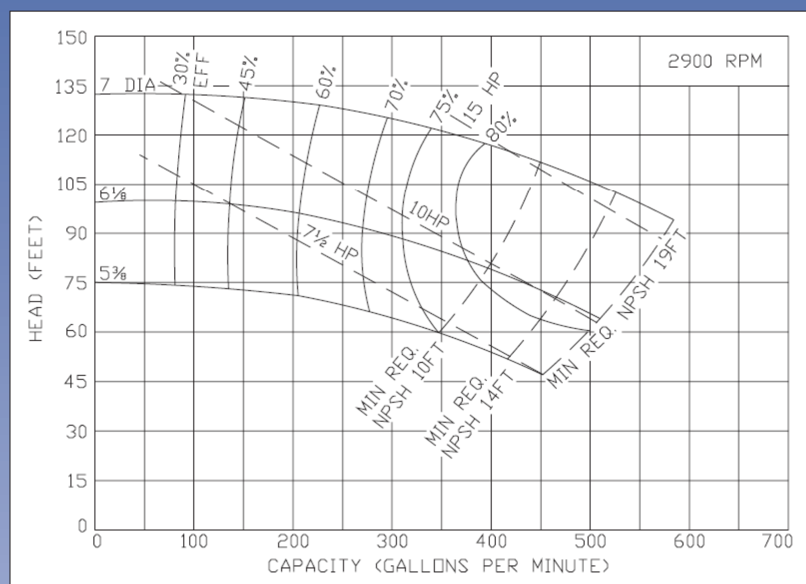
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO®483	316 Stainless	Duplex 2205
Wear Ring	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron

Ampco Centrifugal Pumps

Model ZC2/ZCH2 4X3

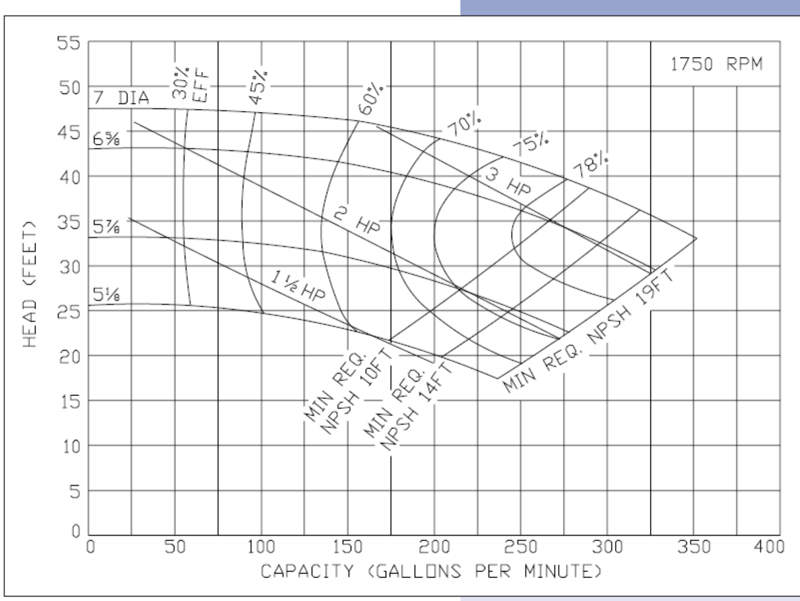
Curves show approximate characteristics
based on clear 68° water.
Rated point is guaranteed.





Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



Ampco Pumps Company

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Milwaukee, Wisconsin 53214
PHONE (414) 643-1852
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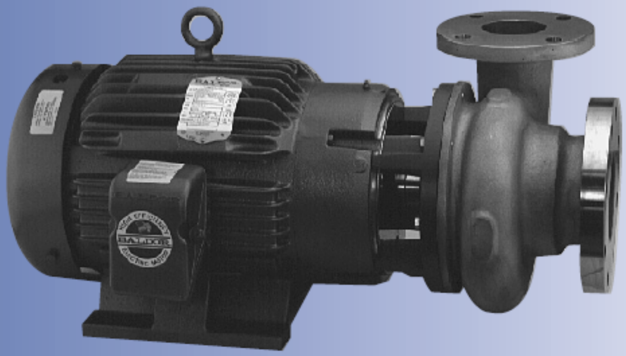
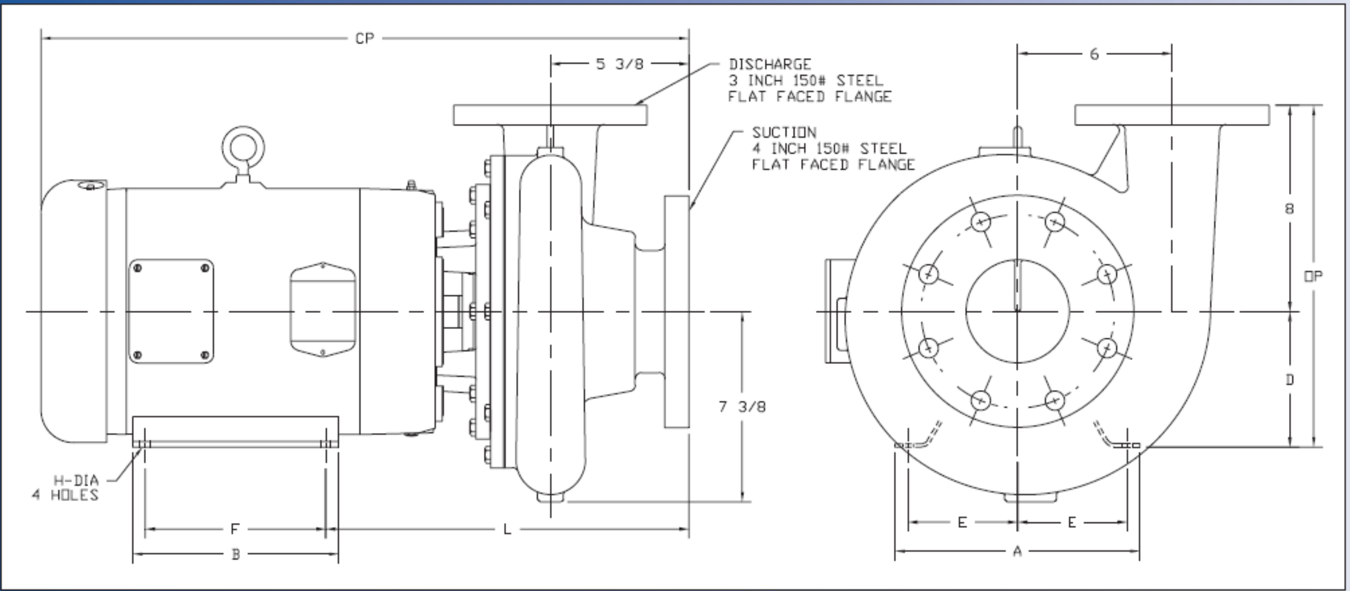
Ampco Centrifugal Pumps

Data Sheet

Model ZC2/ZCH2 4x3L

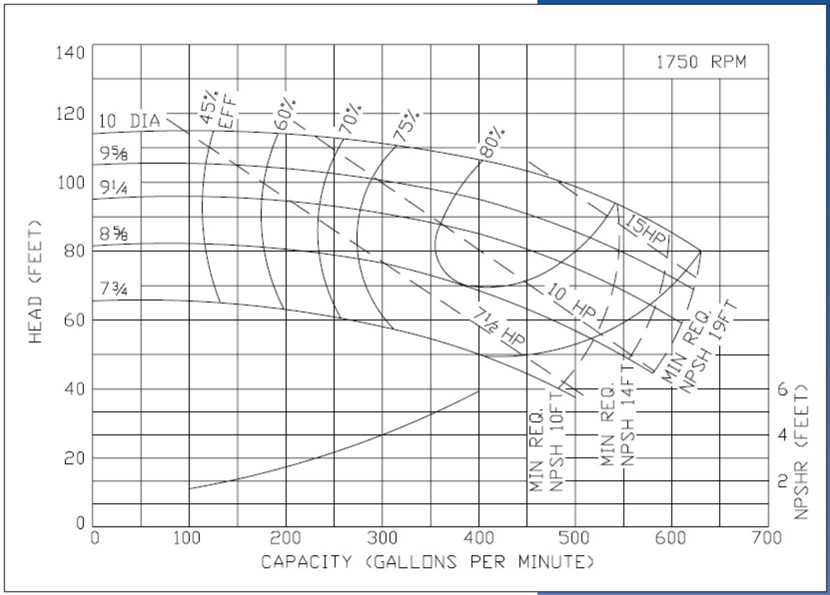




TEFC MOTOR			DIMENSIONS IN INCHES (For Reference Only)									APPROX. WEIGHT (LBS)
HP	RPM	FRAME	A (typ)	B (typ)	D	E	F	H	L	CP	OP	
7-1/2	1750	213JM	9-1/2	8	5-1/4	4-1/4	5-1/2	13/32	14-1/8	25-1/8	13-1/4	296
10	1750	215JM	9-1/2	8	5-1/4	4-1/4	7	13/32	14-1/8	26-5/16	13-1/4	314
15	1750	254JM	11-1/2	9-3/4	6-1/4	5	8-1/4	17/32	15-3/8	28-7/16	14-1/4	477
20	1750	256JM	11-1/2	11-1/2	6-1/4	5	10	17/32	15-3/8	30-1/2	14-1/4	525

MATERIAL SPECIFICATIONS

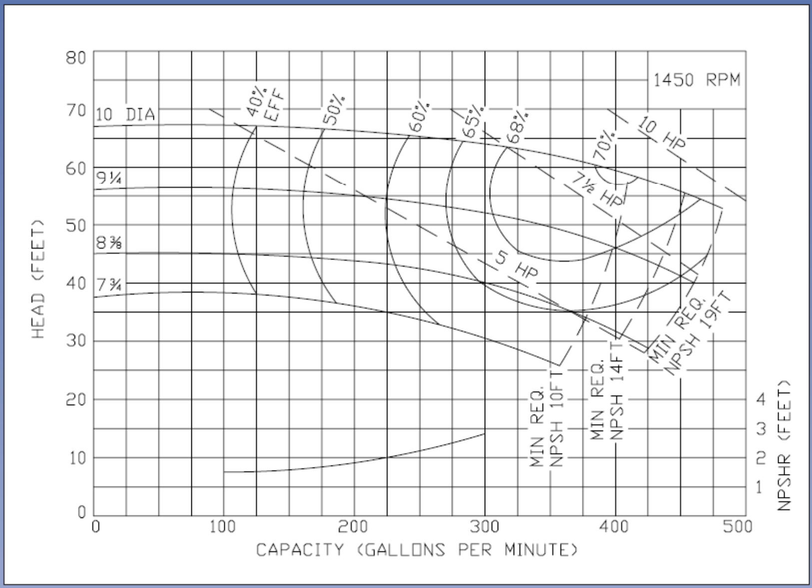
PART NAME	NICKEL ALUMINUM BRONZE	STAINLESS STEEL	DUPLEX 2205
Casing, Cover, & Impeller	AMPCO®483	316 Stainless	Duplex 2205
Wear Rings	AMPCO® 18	316 Stainless	Duplex 2205
Motor Shaft	Steel	Steel	Steel
Shaft Sleeve	AMPCO® 18	316 Stainless	Duplex 2205
Adapter	Cast Iron	Cast Iron	Cast Iron



Ampco Centrifugal Pumps

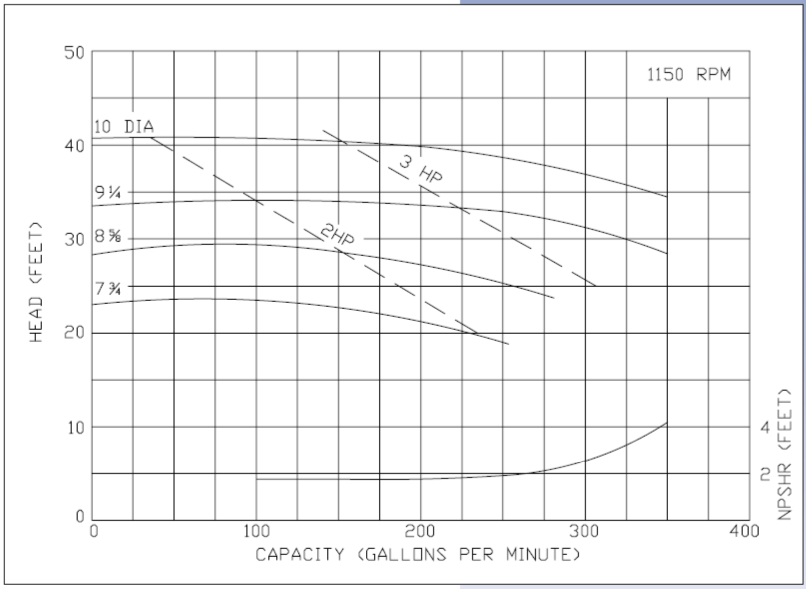
Model ZC2/ZCH2 4x3L

Curves show approximate characteristics
based on clear 68° water.
Rated point is guaranteed.



Heavy-duty Z Series pumps have maximum wall thickness and 150 lb. flat faced flanged connections.

Seal options include Type 21, Type 1 and Type 9 with choice of sealing materials.



Ampco Pumps Company

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ANEXO IV

CARACTERÍSTICAS DEL COMPRESOR DE AIRE DE ARRANQUE

Electrically Driven Compressors

Technical specifications

Nominal working pressure	30 bar
Revolutions	1500 rpm (50 Hz) and 1800 rpm (60 Hz)
Sound level unsilenced	79-88 dB(A)
Sound level silenced version	63-68 dB(A)
Ambient temperature	55°C
Two cylinder-two stage air-cooled version	

Compressor type	FAD*	Charging capacity**	Power	Dimensions			Weight
	m³/h	m³/h	kW	L (mm)	W (mm)	H (mm)	kg
50 Hz							
LT 3-30 KE	9.10	10.5	3	827	553	620	94
LT 5-30 KE	15.80	19.5	4	827	553	620	115
LT 7-30 KE	23.40	26.5	5.5	1016	619	699	152
LT 10-30 KE	30.60	33	7.5	1016	619	699	166
LT 15-30 KE	33.40	43.5	11	1268	682	815	260
LT 20-30 KE	61.20	71	15	1268	682	815	290
60 Hz							
LT 3-30 KE	11.17	13	3.4	827	553	620	94
LT 5-30 KE	19.80	24.5	4.6	827	553	620	115
LT 7-30 KE	28.80	32.5	6.3	1016	619	699	152
LT 15-30 KE	39.90	51.5	12.5	1268	682	815	260
LT 20-30 KE	70.90	82	17.3	1268	682	815	290

* According to ISO 1217, latest edition.
** In accordance with shipbuilding regulations. For further information, please refer to page 74.

ANEXO V

CARACTERÍSTICAS TÉCNICAS DE LA VENTILACIÓN DE CÁMARA DE MÁQUINAS

HGT HGTX

HGT: Ventiladores helicoidales tubulares de gran diámetro, con motor directo
HGTX: Ventiladores helicoidales tubulares de gran diámetro, con motor exterior

Ventiladores helicoidales tubulares, equipados con hélices de aluminio de 3, 6 ó 9 álabes con diversos ángulos de inclinación.

Ventilador:
- Dirección aire motor-hélice
- Hélices en fundición de aluminio de 3, 6 ó 9 álabes, con ángulo de inclinación ajustable.
- Envolvente tubular en chapa de acero
- HGT: La versión standard es de carcasa corta. La versión en carcasa larga está equipada con trampilla de inspección.
- HGTX: Versión standard en carcasa larga, equipada con trampilla de inspección

HGT

HGTX

Motor:
- Motores trifásicos IE2
- Motores clase F, con rodamientos a bolas, protección IP55
- Trifásicos 230/400V-50Hz (hasta 5,5CV) y 400/690V-50Hz(potencias superiores a 5,5CV)
- Temperatura de trabajo: -25ºC+ 50ºC (HGT), -25ºC+ 120ºC (HGTX)

Acabado:
- Anticorrosivo en resina de poliester polimerizada a 190ºC, previo desengrase alcalino y pretratamiento libre de fosfatos.

Bajo demanda:
- Dirección aire hélice-motor.
- Hélices reversibles 100%.
- Bobinados especiales para diferentes tensiones.
- Certificación ATEX Categoría 2
- HGT: Ventiladores con carcasa larga equipada con trampilla de inspección
- Motores de dos velocidades

Código de pedido

HGT	—	125	—	4T		—	6-20		—	10º	—	PV
HGT: Ventiladores helicoidales tubulares de gran diámetro, con motor directo HGTX: Ventiladores helicoidales tubulares de gran diámetro, con motor exterior		Diámetro hélice en cm		Número de polos motor 4=1400 r/min. 50 Hz 6=900 r/min. 50 Hz 8=750 r/min. 50 Hz	T=Trifásico		Número de palas 3 palas 6 palas 9 palas	Potencia motor (CV)		Ángulo inclinación palas		PV=Pabellón de aspiración

Características técnicas

Modelo		Velocidad (r/min)	Intensidad máxima admisible (A) 230V	400V	690V	Potencia instalada (kW)	Caudal máximo (m³/h)	Nivel presión sonora dB(A)	Peso aprox. (Kg) HGT Larga	HGT Corta	HGTX
HGT-125-4T/3-10	HGTX-125-4T/3-10	1455		14,10	8,14	7,50	58150	88	211	178	342
HGT-125-4T/3-15	HGTX-125-4T/3-15	1455		21,20	12,24	11,00	77450	89	249	221	369
HGT-125-4T/3-20	HGTX-125-4T/3-20	1465		29,80	17,21	15,00	91400	91	268	240	388
HGT-125-4T/3-25	HGTX-125-4T/3-25	1470		35,60	20,55	18,50	98350	91	331	288	418
HGT-125-4T/3-30	HGTX-125-4T/3-30	1465		40,10	23,15	22,00	110500	92	348	305	435
HGT-125-4T/3-40	HGTX-125-4T/3-40	1475		56,30	32,50	30,00	120850	93	440	397	529
HGT-125-4T/3-50	HGTX-125-4T/3-50	1470		69,20	39,95	37,00	129000	94	474	418	545
HGT-125-4T/3-60	HGTX-125-4T/3-60	1470		81,41	47,00	45,00	140000	95	489	433	560
HGT-125-4T/6-20	HGTX-125-4T/6-20	1465		29,80	17,21	15,00	78300	89	277	249	397
HGT-125-4T/6-25	HGTX-125-4T/6-25	1470		35,60	20,55	18,50	92000	90	340	297	427
HGT-125-4T/6-30	HGTX-125-4T/6-30	1465		40,10	23,15	22,00	98100	90	357	314	444
HGT-125-4T/6-40	HGTX-125-4T/6-40	1475		56,30	32,50	30,00	117000	92	449	405	538
HGT-125-4T/6-50	HGTX-125-4T/6-50	1470		69,20	39,95	37,00	123700	93	483	427	554
HGT-125-4T/6-60	HGTX-125-4T/6-60	1470		81,41	47,00	45,00	136000	94	498	442	569
HGT-125-4T/6-75	HGTX-125-4T/6-75	1475		98,73	57,00	55,00	148000	95	549	499	635
HGT-125-4T/6-100	HGTX-125-4T/6-100	1480		133,37	77,00	75,00	161000	96	598	548	684
HGT-125-4T/9-25	HGTX-125-4T/9-25	1470		35,60	20,55	18,50	79750	88	349	306	436
HGT-125-4T/9-30	HGTX-125-4T/9-30	1465		40,10	23,15	22,00	97000	89	366	323	453

Características técnicas

Modelo		Velocidad	Intensidad máxima admisible (A)			Potencia instalada	Caudal máximo	Nivel presión sonora	Peso aprox. (Kg)		
									HGT		HGTX
		(r/min)	230V	400V	690V	(kW)	(m^3/h)	dB(A)	Larga	Corta	
HGT-125-4T/9-40	HGTX-125-4T/9-40	1475		56,30	32,50	30,00	111200	91	458	414	547
HGT-125-4T/9-50	HGTX-125-4T/9-50	1470		69,20	39,95	37,00	118350	93	492	436	563
HGT-125-4T/9-60	HGTX-125-4T/9-60	1470		81,41	47,00	45,00	127000	94	507	451	578
HGT-125-4T/9-75	HGTX-125-4T/9-75	1475		98,73	57,00	55,00	142000	95	558	508	644
HGT-125-4T/9-100	HGTX-125-4T/9-100	1480		133,37	77,00	75,00	155000	99	607	557	693
HGT-125-6T/3-4	HGTX-125-6T/3-4	960	12,70	7,33		3,00	46550	79	204	171	335
HGT-125-6T/3-5,5	HGTX-125-6T/3-5,5	960	16,50	9,53		4,00	55300	80	209	176	340
HGT-125-6T/3-7,5	HGTX-125-6T/3-7,5	975		11,50	6,64	5,50	64450	81	217	184	348
HGT-125-6T/3-10	HGTX-125-6T/3-10	965		15,20	8,78	7,50	76400	83	262	234	382
HGT-125-6T/3-15	HGTX-125-6T/3-15	965		22,60	13,05	11,00	87050	84	276	248	396
HGT-125-6T/3-20	HGTX-125-6T/3-20	970		27,90	16,11	15,00	91700	85	358	315	445
HGT-125-6T/6-5,5	HGTX-125-6T/6-5,5	960	16,50	9,53		4,00	51300	77	218	185	349
HGT-125-6T/6-7,5	HGTX-125-6T/6-7,5	975		11,50	6,64	5,50	60300	77	226	193	357
HGT-125-6T/6-10	HGTX-125-6T/6-10	965		15,20	8,78	7,50	72250	79	271	243	391
HGT-125-6T/6-15	HGTX-125-6T/6-15	965		22,60	13,05	11,00	85450	81	285	257	405
HGT-125-6T/6-20	HGTX-125-6T/6-20	970		27,90	16,11	15,00	92850	82	367	324	454
HGT-125-6T/6-25	HGTX-125-6T/6-25	970		34,64	20,00	18,50	103000	84	409	365	498
HGT-125-6T/9-10	HGTX-125-6T/9-10	965		15,20	8,78	7,50	68200	78	280	252	400
HGT-125-6T/9-15	HGTX-125-6T/9-15	965		22,60	13,05	11,00	77550	81	294	266	414
HGT-125-6T/9-20	HGTX-125-6T/9-20	970		27,90	16,11	15,00	92900	84	376	333	463
HGT-125-6T/9-25	HGTX-125-6T/9-25	970		34,64	20,00	18,50	98700	85	418	374	507
HGT-125-6T/9-30	HGTX-125-6T/9-30	970		41,57	24,00	22,00	104000	87	438	394	527
HGT-125-8T/3-3	HGTX-125-8T/3-3	705	9,53	5,50		2,20	48800	71	209	176	340
HGT-125-8T/3-4	HGTX-125-8T/3-4	705	12,82	7,40		3,00	54900	71	216	183	347
HGT-125-8T/3-5,5	HGTX-125-8T/3-5,5	710	16,11	9,30		4,00	62100	73	249	221	369
HGT-125-8T/3-7,5	HGTX-125-8T/3-7,5	725		12,70	7,33	5,50	69500	75	262	234	382
HGT-125-8T/6-3	HGTX-125-8T/6-3	705	9,53	5,50		2,20	45700	69	218	185	349
HGT-125-8T/6-4	HGTX-125-8T/6-4	705	12,82	7,40		3,00	51800	71	225	192	356
HGT-125-8T/6-5,5	HGTX-125-8T/6-5,5	710	16,11	9,30		4,00	61500	72	258	230	378
HGT-125-8T/6-7,5	HGTX-125-8T/6-7,5	725		12,70	7,33	5,50	67500	73	271	243	391
HGT-125-8T/6-10	HGTX-125-8T/6-10	725		17,00	9,81	7,50	75500	75	301	273	421
HGT-125-8T/9-4	HGTX-125-8T/9-4	705	12,82	7,40		3,00	48200	70	234	201	365
HGT-125-8T/9-5,5	HGTX-125-8T/9-5,5	710	16,11	9,30		4,00	55200	73	267	239	387
HGT-125-8T/9-7,5	HGTX-125-8T/9-7,5	725		12,70	7,33	5,50	67000	75	280	252	400
HGT-125-8T/9-10	HGTX-125-8T/9-10	725		17,00	9,81	7,50	74750	76	310	282	430
HGT-125-8T/9-15	HGTX-125-8T/9-15	725		21,70	12,53	11,00	80800	79	372	329	459
HGT-140-6T/3-4		960	12,70	7,33		3,00	51000	82	251	214	
HGT-140-6T/3-5,5		960	16,50	9,53		4,00	56700	83	258	221	
HGT-140-6T/3-7,5		975		11,50	6,64	5,50	67900	84	266	229	
HGT-140-6T/3-10		965		15,20	8,78	7,50	80100	85	320	281	
HGT-140-6T/3-15		965		22,60	13,05	11,00	96900	86	334	295	
HGT-140-6T/3-20		970		27,90	16,11	15,00	106000	88	414	364	
HGT-140-6T/6-5,5		960	16,50	9,53		4,00	58000	82	268	231	
HGT-140-6T/6-7,5		975		11,50	6,64	5,50	66000	84	276	239	
HGT-140-6T/6-10		965		15,20	8,78	7,50	80700	85	330	291	
HGT-140-6T/6-15		965		22,60	13,05	11,00	96700	86	344	305	
HGT-140-6T/6-20		970		27,90	16,11	15,00	104000	87	423	374	
HGT-140-6T/6-25		970		34,64	20,00	18,50	115000	88	466	417	
HGT-140-6T/6-30		970		41,57	24,00	22,00	119000	89	486	437	
HGT-140-6T/9-10		965		15,20	8,78	7,50	70000	84	339	300	
HGT-140-6T/9-15		965		22,60	13,05	11,00	86000	86	353	314	
HGT-140-6T/9-20		970		27,90	16,11	15,00	97500	87	433	383	
HGT-140-6T/9-25		970		34,64	20,00	18,50	111000	88	475	427	
HGT-140-6T/9-30		970		41,57	24,00	22,00	118500	89	495	447	
HGT-140-6T/9-40		973		53,69	31,00	30,00	132000	91	561	499	
HGT-140-6T/9-50		975		65,82	38,00	37,00	139000	92	623	568	
HGT-140-8T/3-3		705	9,53	5,50		2,20	50000	78	258	221	
HGT-140-8T/3-4		705	12,82	7,40		3,00	57000	78	265	228	
HGT-140-8T/3-5,5		710	16,11	9,30		4,00	65400	79	307	268	
HGT-140-8T/3-7,5		725		12,70	7,33	5,50	77500	81	320	281	
HGT-140-8T/3-10		725		17,00	9,81	7,50	86000	82	350	311	
HGT-140-8T/6-3		705	9,53	5,50		2,20	47500	78	268	231	
HGT-140-8T/6-4		705	12,82	7,40		3,00	57600	79	275	238	

Características técnicas

Modelo	Velocidad (r/min)	Intensidad máxima admisible (A) 230V	400V	690V	Potencia instalada (kW)	Caudal máximo (m³/h)	Nivel presión sonora dB(A)	Peso aprox. (Kg) HGT Larga	HGT Corta	HGTX
HGT-140-8T/6-5,5	710	16,11	9,30		4,00	65200	80	317	278	
HGT-140-8T/6-7,5	725		12,70	7,33	5,50	73300	81	330	291	
HGT-140-8T/6-10	725		17,00	9,81	7,50	82200	82	360	321	
HGT-140-8T/6-15	725		21,70	12,53	11,00	94200	83	419	370	
HGT-140-8T/9-4	705	12,82	7,40		3,00	47200	79	284	247	
HGT-140-8T/9-5,5	710	16,11	9,30		4,00	64400	79	326	287	
HGT-140-8T/9-7,5	725		12,70	7,33	5,50	69200	81	339	300	
HGT-140-8T/9-10	725		17,00	9,81	7,50	78700	82	369	330	
HGT-140-8T/9-15	725		21,70	12,53	11,00	94300	83	429	379	
HGT-140-8T/9-20	725		31,70	18,30	15,00	103000	86	485	437	
HGT-160-6T/3-5,5	960	16,50	9,53		4,00	66000	81	327	275	
HGT-160-6T/3-7,5	975		11,50	6,64	5,50	76100	82	335	283	
HGT-160-6T/3-10	965		15,20	8,78	7,50	84000	83	393	339	
HGT-160-6T/3-15	965		22,60	13,05	11,00	102000	85	407	353	
HGT-160-6T/3-20	970		27,90	16,11	15,00	127000	86	500	431	
HGT-160-6T/3-25	970		34,64	20,00	18,50	136700	87	543	473	
HGT-160-6T/3-30	970		41,57	24,00	22,00	145000	89	563	493	
HGT-160-6T/6-10	965		15,20	8,78	7,50	75000	83	404	350	
HGT-160-6T/6-15	965		22,60	13,05	11,00	93500	85	418	364	
HGT-160-6T/6-20	970		27,90	16,11	15,00	120500	86	510	441	
HGT-160-6T/6-25	970		34,64	20,00	18,50	130000	87	553	484	
HGT-160-6T/6-30	970		41,57	24,00	22,00	140000	88	573	504	
HGT-160-6T/6-40	973		53,69	31,00	30,00	158000	89	656	557	
HGT-160-6T/6-50	975		65,82	38,00	37,00	171000	91	714	629	
HGT-160-6T/9-15	965		22,60	13,05	11,00	87000	85	428	374	
HGT-160-6T/9-20	970		27,90	16,11	15,00	104000	86	520	451	
HGT-160-6T/9-25	970		34,64	20,00	18,50	127000	87	563	494	
HGT-160-6T/9-30	970		41,57	24,00	22,00	135000	88	583	514	
HGT-160-6T/9-40	973		53,69	31,00	30,00	147000	89	666	567	
HGT-160-6T/9-50	975		65,82	38,00	37,00	165000	90	724	640	
HGT-160-6T/9-60	980		84,80	48,96	45,00	177000	91	844	745	
HGT-160-6T/9-75	980		96,99	56,00	55,00	193000	92	932	833	
HGT-160-6T/9-100	985		131,64	76,00	75,00	207500	93	1002	903	
HGT-160-8T/3-3	705	9,53	5,50		2,20	54000	76	327	275	
HGT-160-8T/3-4	705	12,82	7,40		3,00	57500	77	334	282	
HGT-160-8T/3-5,5	710	16,11	9,30		4,00	74000	79	380	326	
HGT-160-8T/3-7,5	725		12,70	7,33	5,50	83500	80	393	339	
HGT-160-8T/3-10	725		17,00	9,81	7,50	97500	81	423	369	
HGT-160-8T/3-15	725		21,70	12,53	11,00	115000	83	496	427	
HGT-160-8T/6-4	705	12,82	7,40		3,00	70900	76	344	292	
HGT-160-8T/6-5,5	710	16,11	9,30		4,00	84500	77	391	337	
HGT-160-8T/6-7,5	725		12,70	7,33	5,50	77000	79	404	350	
HGT-160-8T/6-10	725		17,00	9,81	7,50	95000	80	434	380	
HGT-160-8T/6-15	725		21,70	12,53	11,00	109000	82	506	437	
HGT-160-8T/6-20	725		31,70	18,30	15,00	123000	83	563	494	
HGT-160-8T/6-25	725		35,85	20,70	18,50	130000	84	641	542	
HGT-160-8T/9-7,5	725		12,70	7,33	5,50	70000	79	414	360	
HGT-160-8T/9-10	725		17,00	9,81	7,50	87000	80	444	390	
HGT-160-8T/9-15	725		21,70	12,53	11,00	103000	82	516	447	
HGT-160-8T/9-20	725		31,70	18,30	15,00	117000	83	573	504	
HGT-160-8T/9-25	725		35,85	20,70	18,50	133000	84	651	552	
HGT-160-8T/9-30	725		41,60	24,02	22,00	140000	85	666	567	
HGT-160-8T/9-40	730		60,79	35,10	30,00	151000	86	724	640	

Características acústicas

Los valores indicados, se determinan mediante medidas de nivel de presión y potencia sonora en dB(A) obtenidas en campo libre a una distancia equivalente a dos veces la envergadura del ventilador más el diámetro de la hélice, con un mínimo de 1,5 mts.

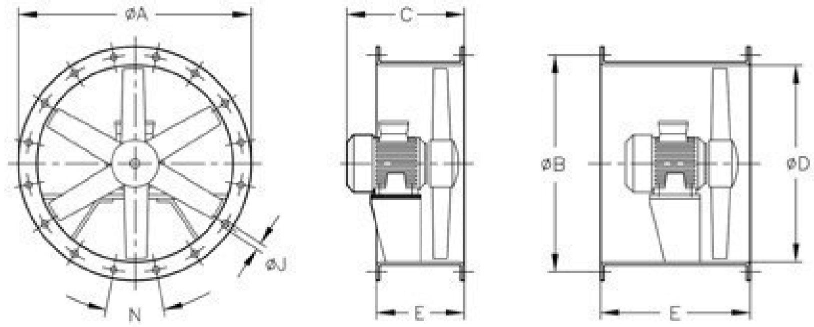
Espectro de potencia sonora Lw(A) en dB(A) por banda de frecuencia en Hz

Modelo	63	125	250	500	1000	2000	4000	8000
125-4T/3-10	70	76	88	98	98	94	86	82
125-4T/3-15	71	77	89	99	99	95	87	83
125-4T/3-20	72	78	90	100	100	96	88	84
125-4T/3-25	73	79	91	101	101	97	89	85
125-4T/3-30	74	80	92	102	102	98	90	86
125-4T/3-40	75	81	93	103	103	99	91	87
125-4T/3-50	76	82	94	104	104	100	92	88
125-4T/3-60	77	83	95	105	105	101	93	89
125-4T/6-20	66	74	90	97	99	94	88	84
125-4T/6-25	67	75	91	98	100	95	89	85
125-4T/6-30	68	76	92	99	101	96	90	86
125-4T/6-40	69	77	93	100	102	97	91	87
125-4T/6-50	71	79	95	102	104	99	93	89
125-4T/6-60	72	80	96	103	105	100	94	90
125-4T/6-75	72	80	96	103	105	100	94	90
125-4T/6-100	74	82	98	105	107	102	96	92
125-4T/9-25	66	74	91	97	98	93	88	84
125-4T/9-30	67	75	92	98	99	94	89	85
125-4T/9-40	68	76	93	99	100	95	90	86
125-4T/9-50	70	78	95	101	102	97	92	88
125-4T/9-60	72	80	97	103	104	99	94	90
125-4T/9-75	72	80	97	103	104	99	94	90
125-4T/9-100	74	82	99	105	106	101	96	92
125-6T/3-4	64	72	84	88	86	81	72	68
125-6T/3-5,5	66	74	86	90	88	83	74	70
125-6T/3-7,5	67	75	87	91	89	84	75	71
125-6T/3-10	68	76	88	92	90	85	76	72
125-6T/3-15	69	77	89	93	91	86	77	73
125-6T/3-20	71	79	91	95	93	88	79	75
125-6T/6-5,5	59	68	81	84	85	82	71	67
125-6T/6-7,5	60	69	82	85	86	83	72	68
125-6T/6-10	61	70	83	86	87	84	73	69
125-6T/6-15	63	72	85	88	89	86	75	71
125-6T/6-20	65	74	87	90	91	88	77	73
125-6T/6-25	66	75	88	91	92	89	78	74
125-6T/9-10	57	67	82	86	85	84	73	69
125-6T/9-15	59	69	84	88	87	86	75	71
125-6T/9-20	62	72	87	91	90	89	78	74
125-6T/9-25	64	74	89	93	92	91	80	76
125-6T/9-30	66	76	91	95	94	93	82	78
125-8T/3-3	56	63	74	78	77	70	61	57
125-8T/3-4	59	66	77	81	80	73	64	60
125-8T/3-5,5	60	67	78	82	81	74	65	61
125-8T/3-7,5	62	69	80	84	83	76	67	63
125-8T/6-3	53	61	73	78	77	72	61	57
125-8T/6-4	54	62	74	79	78	73	62	58
125-8T/6-5,5	56	64	76	81	80	75	64	60
125-8T/6-7,5	58	66	78	83	82	77	66	62
125-8T/6-10	59	67	79	84	83	78	67	63
125-8T/9-4	51	62	72	78	79	74	63	59
125-8T/9-5,5	53	64	74	80	81	76	65	61
125-8T/9-7,5	56	67	77	83	84	79	68	64
125-8T/9-10	58	69	79	85	86	81	70	66
125-8T/9-15	59	70	80	86	87	82	71	67
140-6T/3-4	66	76	84	89	88	87	74	74
140-6T/3-5,5	69	79	87	92	91	90	77	77
140-6T/3-7,5	69	79	87	92	91	90	77	77
140-6T/3-10	70	80	88	93	92	91	78	78
140-6T/3-15	71	81	89	94	93	92	79	79
140-6T/3-20	73	83	91	96	95	94	81	81
140-6T/6-5,5	66	81	90	92	89	83	75	71
140-6T/6-7,5	67	82	91	93	90	84	76	72
140-6T/6-10	68	83	92	94	91	85	77	73
140-6T/6-15	69	84	93	95	92	86	78	74
140-6T/6-20	71	86	95	97	94	88	80	76
140-6T/6-25	72	87	96	98	95	89	81	77
140-6T/6-30	73	88	97	99	96	90	82	78

Modelo	63	125	250	500	1000	2000	4000	8000
140-6T/9-10	66	84	93	92	91	87	78	73
140-6T/9-15	67	85	94	93	92	88	79	74
140-6T/9-20	69	87	96	95	94	90	81	76
140-6T/9-25	70	88	97	96	95	91	82	77
140-6T/9-30	70	88	97	96	95	91	82	77
140-6T/9-40	71	89	98	97	96	92	83	78
140-6T/9-50	74	92	101	100	99	95	86	81
140-8T/3-3	60	70	78	83	82	81	68	63
140-8T/3-4	64	74	82	87	86	85	72	67
140-8T/3-5,5	65	75	83	88	87	86	73	68
140-8T/3-7,5	66	76	84	89	88	87	74	69
140-8T/3-10	68	78	86	91	90	89	76	71
140-8T/6-3	61	73	82	86	84	78	68	65
140-8T/6-4	63	75	84	88	86	80	70	67
140-8T/6-5,5	64	76	85	89	87	81	71	68
140-8T/6-7,5	65	77	86	90	88	82	72	69
140-8T/6-10	66	78	87	91	89	83	73	70
140-8T/6-15	68	80	89	93	91	85	75	72
140-8T/9-4	61	72	83	88	86	82	72	67
140-8T/9-5,5	62	73	84	89	87	83	73	68
140-8T/9-7,5	63	74	85	90	88	84	74	69
140-8T/9-10	64	75	86	91	89	85	75	70
140-8T/9-15	65	76	87	92	90	86	76	71
140-8T/9-20	67	78	89	94	92	88	78	73
160-6T/3-5,5	67	77	85	90	89	88	75	70
160-6T/3-7,5	68	78	86	91	90	89	76	71
160-6T/3-10	69	79	87	92	91	90	77	72
160-6T/3-15	70	80	88	93	92	91	78	73
160-6T/3-20	72	82	90	95	94	93	80	75
160-6T/3-25	73	83	91	96	95	94	81	76
160-6T/3-30	74	84	92	97	96	95	82	77
160-6T/6-10	67	82	91	93	90	84	76	72
160-6T/6-15	68	83	92	94	91	85	77	73
160-6T/6-20	70	85	94	96	93	87	79	75
160-6T/6-25	71	86	95	97	94	88	80	76
160-6T/6-30	71	86	95	97	94	88	80	76
160-6T/6-40	72	87	96	98	95	89	81	77
160-6T/6-50	74	89	98	100	97	91	83	79
160-6T/9-15	67	85	94	93	92	88	79	74
160-6T/9-20	68	86	95	94	93	89	80	75
160-6T/9-25	69	87	96	95	94	90	81	76
160-6T/9-30	70	88	97	96	95	91	82	77
160-6T/9-40	71	89	98	97	96	92	83	78
160-6T/9-50	72	90	99	98	97	93	84	79
160-6T/9-60	72	90	99	98	97	93	84	79
160-6T/9-75	73	91	100	99	98	94	85	80
160-6T/9-100	75	93	102	101	100	96	87	82
160-8T/3-3	61	71	79	84	83	82	69	64
160-8T/3-4	63	73	81	86	85	84	71	66
160-8T/3-5,5	64	74	82	87	86	85	72	67
160-8T/3-7,5	65	75	83	88	87	86	73	68
160-8T/3-10	66	76	84	89	88	87	74	69
160-8T/3-15	68	78	86	91	90	89	76	71
160-8T/6-4	60	75	84	86	83	77	69	65
160-8T/6-5,5	61	76	85	87	84	78	70	66
160-8T/6-7,5	62	77	86	88	85	79	71	67
160-8T/6-10	63	78	87	89	86	80	72	68
160-8T/6-15	65	80	89	91	88	82	74	70
160-8T/6-20	66	81	90	92	89	83	75	71
160-8T/6-25	68	83	92	94	91	85	77	73
160-8T/9-7,5	60	78	87	86	85	81	72	67
160-8T/9-10	62	80	89	88	87	83	74	69
160-8T/9-15	63	81	90	89	88	84	75	70
160-8T/9-20	64	82	91	90	89	85	76	71
160-8T/9-25	65	83	92	91	90	86	77	72
160-8T/9-30	66	84	93	92	91	87	78	73
160-8T/9-40	68	86	95	94	93	89	80	75

Dimensiones mm

HGT



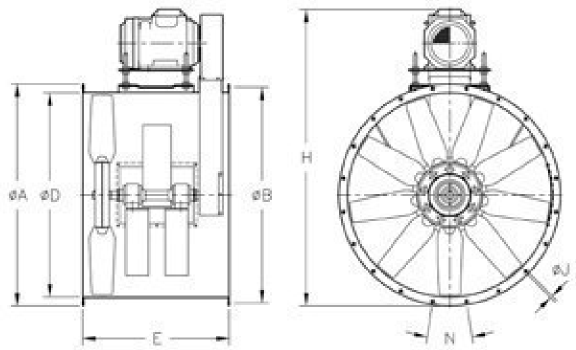
Modelo	ØA	ØB	C (Consultar tamaño constructivo motor) 132	160	180	200	225	250	280	ØD	E* larga	E* corta(Std)	ØJ	N
HGT-125	1365	1320	570	-	-	-	-	-	-	1250	500	700	15	20x18º
HGT-125	1365	1320	-	700	-	-	-	-	-	1250	500	700	15	20x18º
HGT-125	1365	1320	-	-	765	825	-	-	-	1250	500	900	15	20x18º
HGT-125	1365	1320	-	-	-	-	910	-	-	1250	500	1000	15	20x18º
HGT-125	1365	1320	-	-	-	-	-	985	-	1250	600	1000	15	20x18º
HGT-125	1365	1320	-	-	-	-	-	-	1190	1250	700	1200	15	20x18º
HGT-140	1515	1470	570	-	-	-	-	-	-	1400	400	650	15	20x18º
HGT-140	1515	1470	-	700	-	-	-	-	-	1400	450	700	15	20x18º
HGT-140	1515	1470	-	-	765	825	-	-	-	1400	550	900	15	20x18º
HGT-140	1515	1470	-	-	-	-	910	-	-	1400	550	1000	15	20x18º
HGT-140	1515	1470	-	-	-	-	-	985	-	1400	600	1000	15	20x18º
HGT-160	1735	1680	570	-	-	-	-	-	-	1600	400	650	19	24x15º
HGT-160	1735	1680	-	700	-	-	-	-	-	1600	450	700	19	24x15º
HGT-160	1735	1680	-	-	765	825	-	-	-	1600	550	900	19	24x15º
HGT-160	1735	1680	-	-	-	-	910	-	-	1600	550	1000	19	24x15º
HGT-160	1735	1680	-	-	-	-	-	985	-	1600	600	1000	19	24x15º
HGT-160	1735	1680	-	-	-	-	-	-	1190	1600	700	1200	19	24x15º

* Versión estándar suministrada en carcasa corta. Bajo demanda carcasa larga con trampilla de inspección.

Tamaños constructivos motores según potencia

Polos	r/min	CV	3	4	5,5	7,5	10	15	20	25	30	40	50	60	75	100
4T	1500		-	-	-	-	132	160	160	180	180	200	225	225	250	280
6T	1000		-	132	132	132	160	160	180	200	200	225	250	280	280	280
8T	750		132	132	160	160	160	180	200	225	225	250	-	-	-	-

HGTX



Modelo	ØA	ØB	ØD	E	H (Consultar tamaño constructivo motor) 132	160	180	200	225	250	280	ØJ	N
HGT-X 125	1365	1320	1250	900	1743	1815	1850	-	-	-	-	15	20x18º
HGT-X 125	1365	1320	1250	960	-	-	-	1930	1995	-	-	15	20x18º
HGT-X 125	1365	1320	1250	1100	-	-	-	-	-	2060	-	15	20x18º
HGT-X 125	1365	1320	1250	1100	-	-	-	-	-	-	2090	15	20x18º

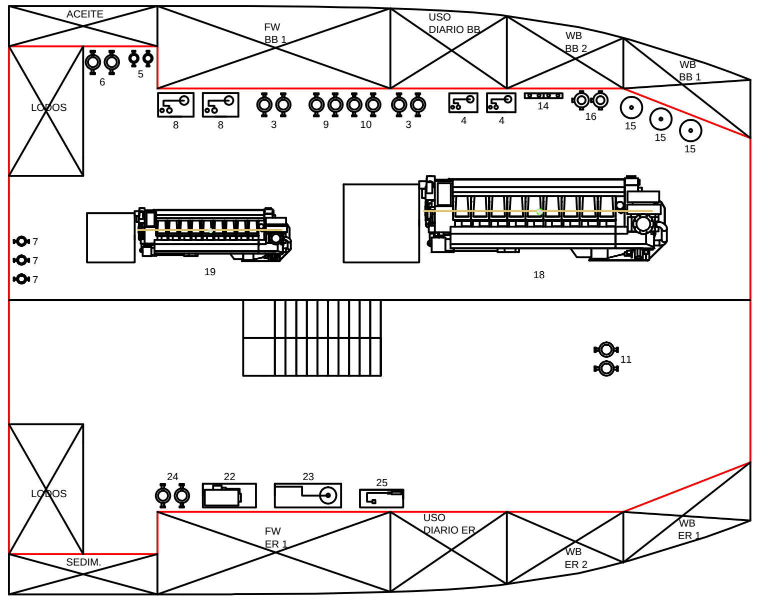
Tamaños constructivos motores según potencia

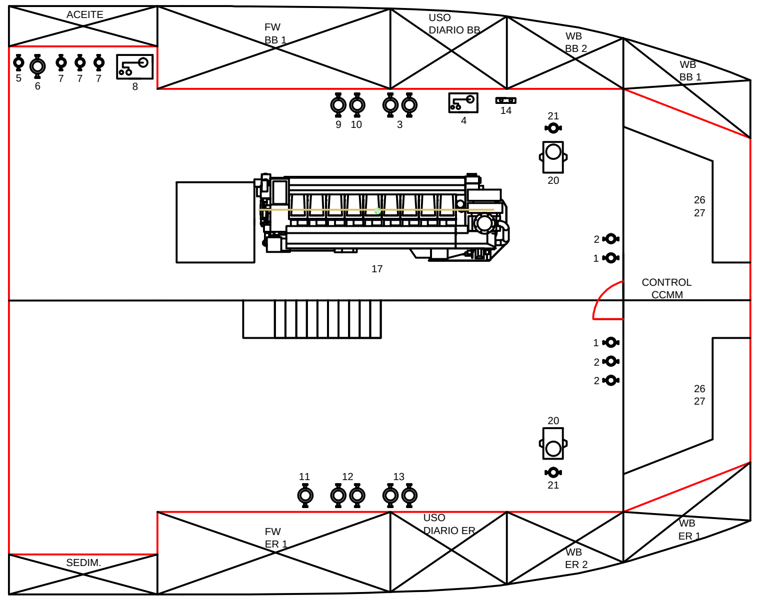
Polos	r/min	CV	3	4	5,5	7,5	10	15	20	25	30	40	50	60	75	100
4T	1500		-	-	-	-	132	160	160	180	180	200	225	225	250	280
6T	1000		-	132	132	132	160	160	180	200	200	225	250	280	280	280
8T	750		132	132	160	160	160	180	200	225	225	250	-	-	-	-

ANEXO VI

PLANO DE LA CÁMARA DE MÁQUINAS

LEYENDA
1.Bombas trasiego DO SED.
2.Bombas trasiego DO UD.
3.Bombas circulación DO.
4.Separadoras DO.
5.Bombas prelubricación.
6.Bombas lubricación principales.
7.Bombas trasiego LO.
8.Separadora LO.
9.Bombas refrigeración HT
10.Bombas refrigeración LT.
11.Bombas Agua salada.
12.Bombas Lastre.
13.Bombas Sentinas.
14.Precalentadores refrigeración.
15.Botellas aire de arranque.
16.Compresores de aire de arranque.
17.Diésel generador W9L32.
18.Diésel generador 8L26.
19.Diésel generador 6L26.
20.Bombas CI.
21.Bombas CI emergencia.
22.Generador AD.
23.Tanque Hidróforo.
24.Bomba suministro AD.
25.Calentador AD
26.Cuadro eléctrico principal.
27.Transformadores y convertidores.





ESCALA	SISTEMA	FORMATO	
1 : 200		UNE A-3	UNIVERSIDADE DA CORUÑA ESCOLA POLITÉCNICA SUPERIOR DE FERROL GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

	AUTOR	FECHA	FIRMA
DIBUJADO	Mario Teijeiro Prieto	12/2015	
COMPROBADO			
Vº Bº NORMAS			
TUTOR DEL PROYECTO	Don Raul Villa Caro		

PROYECTO
Remolcador de altura polivalente

PLANO	REV.	HOJA
Plano de cámara de máquinas		**1 DE 1**

ARCHIVO	SUSTITUIDO POR	SUSTITUYE A