UNIVERSIDADE DA CORUÑA

CUADERNO 10:

DEFINICIÓN DE LA PLANTA PROPULSORA Y SUS AUXILIARES

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PROYECTO:

TÍTULO: Remolcador de puerto de 55 TPF

ÍNDICE

PROYECTO

REMOLCADOR DE PUERTO

CARACTERÍSTICAS PRINCIPALES

Tiro a punto fijo ..... 55 tn
Eslora total..... 25 m
Manga de trazado ..... 11,0 m
Puntal a la cubierta principal ..... 5,00 m
Velocidad ..... 10 nudos
Tripulación ..... 6 personas
Autonomía ..... 2.000 millas

1. INTRODUCCIÓN

El fin del presente cuaderno, es perfilar y definir la cámara de máquinas del buque objeto de este proyecto, cumpliendo los requerimientos tanto de la Sociedad Clasificadora como del SOLAS.

Para tal fin, se procederá a describir detalladamente tanto el equipo propulsor principal, como los servicios y elementos auxiliares, así como su disposición en cámara de máquinas.

Como criterios de diseño de la planta propulsora de un remolcador, no se deberán perder de vista las siguientes características:

- Disponibilidad
- Redundancia
- Maniobrabilidad
- Seguridad

Otros aspectos de importancia a tener en cuenta son:

- El limitado espacio de la cámara de máquinas;
- El nivel máximo de vibraciones que soporta la estructura;
- El buen control de revoluciones; y
- Un deseable bajo nivel de gases de exhaustación

La Cámara de Máquinas se compone de (por duplicado):

- Un motor principal y sus auxiliares (diseñados para trabajar con gasoil)
- Grupo diesel-alternador para la generación de energía eléctrica (para trabajar con gasoil)
- Una unidad azimutal schottel de popa
- Por proa del motor dispondrá de una toma de fuerza con acoplamiento elástico, caja multiplicadora, bomba del equipo Fi-Fi
- Aire comprimido (para el arranque de motores)
- Ventilación y extracción
- Acoplamiento elástico principal
- Ejes intermedios con los cojinetes requeridos y cárdanes
- Grupo de “agua dulce”
- Servicio de combustible
- Engrase y lubricación.

Estos elementos ya no por duplicado:

- Servicios hidráulicos de operación
- Servicios de habilitación
- Local de control

2. JUSTIFICACIÓN Y SELECCIÓN DE MOTORES PRINCIPALES

En los cálculos realizados en el Cuaderno 6 “Predicción de Potencia, Diseño de Propulsores y Timones”, se concluyó tal como se introdujo en las necesidades de potencia para cumplir con la condición de 55 T.P.F. superan ampliamente las requeridas para alcanzar la velocidad de 10 nudos; siendo, la primera condición la que prevalecerá a la hora de elegir y justificar los motores adecuados.

La elección de propulsión con motores diesel es la elección más sensata a la vista de los buques de la base de datos, ya que todos utilizan este tipo de propulsión por resultar la más rentable y de menor empacho en un buque de nuestras características. La instalación de turbinas no es viable en un buque de estas características y los motores diesel eléctricos dependen de la planta eléctrica de a bordo, lo que resta fiabilidad frente a un sistema en que los sistemas esenciales de la propulsión están acoplados mecánicamente, por lo que el buque puede navegar sin energía eléctrica principal. Esto es posible gracias a los propulsores Shottel que tampoco dependen de un servomotor eléctrico como en la propulsión convencional.

La elección del combustible Diesel se ha hecho por su menor grado de contaminación, y ya que dentro del rango de potencias en que nos movíamos permitía también la elección de un combustible pesado. Puede ser más caro que el fuel, pero los motores serán lo suficientemente pequeños como para poder admitir esa diferencia entre ambos carburantes. Además el sistema necesario para la calefacción del fuel aumentaría la complejidad de la instalación y su empacho de modo que no resultaría lo más aconsejable.

La potencia necesaria para dar el tiro a punto fijo es de 3300 kW, si dividimos esta potencia entre dos líneas de ejes obtenemos una potencia necesaria por motor de 1650 kW. El motor escogido es un Caterpillar 3512C HD que a 1800 r.p.m. desarrolla una potencia de 2541 bhp. Aunque la potencia es ligeramente superior a la demandada, se quiere asegurar el tiro a punto fijo. Se elige el motor con más próximo a esa potencia pero siempre por encima de ella.

Se adjunta como anexo el Project Guide (Anexo I) de dicho motor con sus características principales así como su croquis.

En la elección de los motores se ha tenido en cuenta:

- Serán motores diesel semi-rápidos de 4 tiempos dada la potencia necesaria que habrán de combinar eficiencia y seguridad con tamaño y peso.

Además:

1. El grado de maniobrabilidad y seguridad aumenta ostensiblemente, frente la opción de instalar un solo motor propulsor y/o único eje.
2. El buque en proyecto deberá adaptarse y responder de forma adecuada a los dos regímenes de trabajo diferenciados, el remolque y la aproximación al buque averiado. El funcionamiento en carga parcial reducida durante períodos largos es poco recomendable para los grandes motores.
3. Atender correctamente la limitación de altura en Cámara de Máquinas. De hecho, al subdividir la potencia, se reduce el volumen unitario ocupado por los motores sobre todo en cuanto a altura.

3. JUSTIFICACIÓN POTENCIA MOTOR PROPULSOR

Para comprobar que la potencia real es la que nos indica el fabricante, calculamos la potencia por cilindro del motor partiendo de la presión media efectiva, el volumen de los cilindros, las revoluciones del motor y de si este es de dos (a=1) o de cuatro tiempos (a=2). Los valores que tenemos son los siguientes:

$$\text{Volumen cilindro } (cm^3) = \pi \cdot D^2 \cdot h/4 = \pi \cdot 17^2 \cdot 21{,}5/4 = 4880\ cm^3 = 4{,}880\ l$$

$$\text{Volumen total (cilindrada)} = V_{cilindro} \cdot n_{cilindros} = 4{,}880\ 12 = 58{,}56\ l$$

$$\text{Presión Media Efectiva (pme)} = 20{,}08\ bar$$

$$BHP_{cil} = N(rpm) \cdot pme(bar) \cdot V_{cil}(cm^3) / a \cdot 450000 = 196\ hp/cil.$$

$$\text{Potencia total} = BHP_{cil} \cdot n_{cilindros} = 195{,}2 \cdot 12 = 2351hp = 1753\ kw$$

Ligeramente inferior al indicado por el fabricante (1895 kw), aunque superior al requerido y por tanto válido para el buque proyectado.

4. LISTA MAQUINARIA AUXILIAR RELACIONADA CON LA PROPULSIÓN Y OTROS EQUIPOS AUXILIARES

- Reductora
- Servicios de Combustible
- Servicios de Lubricación
- Servicios de Agua Dulce
- Servicios de Agua Salada
- Servicios de Ventilación y Aire de Arranque

4.1 Reductoras

Las reductoras van incorporadas en los propulsores Shottel, de modo que no será necesaria la instalación a bordo y por tanto no se calcularán.

4.2 Servicios de combustible

El servicio de combustible del buque sirve para almacenar y suministrar a los motores el combustible libre de impurezas y en las condiciones óptimas de presión y temperatura.

Este servicio está compuesto de los siguientes elementos principales:

- Toma de combustible en cubierta;
- Nueve tanques almacén;
- Dos tanques de Servicio Diario;
- Una bomba de trasiego;
- Tanque de reboses;
- Bombas de reserva de alimentación del motor principal,
- Separadoras;
- Filtros,
- Tuberías; y

- Válvulas y reguladores de presión.

Tanto motores principales como los auxiliares, utilizan el mismo combustible ligero o destilado pero las líneas de tuberías de ambos se dispondrán de manera independiente.

4.2.1 Servicio de trasiego y purificación

Se compone de los siguientes elementos:

- Tomas de combustible
- Tanques de reboses
- Tanques almacén
- Tanques de servicio diario
- Bomba de trasiego
- Separadora centrífuga
- Filtros dúplex
- Tuberías

4.2.2 *Tomas de combustible*

La entrada de combustible al buque se realiza mediante dos tomas situadas en cubierta, localizados una a cada banda.

El combustible, pasa a través de un filtro, al piano de válvulas desde dónde se controla a qué tanque irá dirigido. Cada toma de combustible dispone de una bandeja para la recogida de derrames evitando de este modo el vertido accidental al mar de hidrocarburos. De esta bandeja pasan al tanque de reboses.

4.2.3 *Tanques*

Tres tipos de tanques:

- Tanques de almacenamiento,
- Tanques de servicio diario, y
- Tanque de rebose

Todos los tanques deben disponer de los siguientes elementos que aseguran la eficiencia y seguridad del servicio:

- Tuberías de aireación y aspiración con pantalla antillanas y bandejas de rebose;
- Alarmas de alto y bajo nivel;
- Niveles y mirillas de nivel;
- Registros de purgas empernados; y
- Válvula de cierre rápido.

4.2.4 *Tanque de rebose*

Los reboses de todos los tanques, las pérdidas en la bomba de alta y el retorno de los inyectores tanto de principales como de auxiliares, van a parar al tanque de reboses.

Además, dicho tanque comunicarán con los de Servicio Diario mediante la bomba de trasiego.

4.2.5 *Bomba de trasiego*

Dispondremos dos bombas de trasiego, siendo cada una de ellas capaz de llenar los dos tanques de uso diario en 8h, de modo que siempre tendremos una de seguridad en caso de fallo de alguna de ellas.

$$\text{Volumen a llenar} = 18{,}537 \cdot 2 = 37{,}074\ m^3$$

$$\text{Caudal} = 37{,}074\ (m^3) / 8\ h = 4{,}64\ m^3/h$$

Será una bomba de tornillo. Si estimamos su rendimiento en 0,65 y con una presión de descarga de 3 bar = 30 m.c.a., suficiente para este servicio, la potencia necesaria en el accionamiento será:

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{4{,}64 \cdot 30 \cdot 850}{75 \cdot 3600 \cdot 0{,}65} = 0{,}67hp = 0{,}50kW$$

4.2.6 *Separadora Centrífuga*

Dispondremos una separadora con la misma capacidad que las bombas de trasiego, de modo que pudiese ser posible la separación del combustible que se introduce.

Por lo tanto, la separadora tendrá una capacidad de al menos 4 m^3/h. Además dispondremos de una de reserva.

4.2.7 Alimentación

Según nos especifica el fabricante del motor en la guía de instalación que se adjunta como Anexo, el motor lleva incluida una bomba de alimentación. Sin embargo, deberemos disponer una bomba de emergencia para cada motor. Su caudal y presión necesaria nos la da también el fabricante del motor. Será una bomba de tornillo, con rendimiento 0,5, y las siguientes características:

Caudal = 1,26 m^3/h

Presión = 4,15 bar = 41,5 mca

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{1{,}26 \cdot 41{,}5 \cdot 850}{75 \cdot 3600 \cdot 0{,}5} = 0{,}33hp = 0{,}25kW$$

4.3 Servicio de lubricación

Este servicio es el encargado de proporcionar el aceite lubricante necesario a los motores, para protegerlos de las fricciones excesivas, de las altas temperaturas y de las posibles corrosiones químicas consecuencia de los productos resultantes de la combustión.

Existen otros elementos a bordo como reductoras, bocinas, etc. que también deben ser lubricados, pero al disponer dichos elementos de sus cárteres, la lubricación de cada uno de ellos se hará de manera independiente.

4.3.1 Sistema de lubricación de MMPP y MMAA

Tanto los motores principales como los auxiliares, son de émbolo buzo, por tanto al haber comunicación entre el espacio de cilindros y el cárter, el aceite de camisas y de cojinetes es el mismo.

Siguiendo las recomendaciones del fabricante, el aceite utilizado será mineral ligeramente aditivado (SAE 40).

Así en la lubricación de los motores principales podemos distinguir dos subsistemas:

1. Sistema de lubricación externo
2. Sistema de lubricación interno del motor

4.3.2 Comprobación de Consumos

El consumo de aceite de los motores es de 0,6 g/kWh, según datos del fabricante. El consumo total será:

$$\text{Consumo aceite} = 0{,}6 g/kWh \cdot \frac{2000 millas}{10(millas/hora)} \cdot 1895 kW \cdot 10^{-6} = 0{,}23\,\text{t} = 0{,}25\ \text{m}^3$$

$$V_{necesario} = 0{,}25\ \text{m}^3$$

Nuestros tanques son suficientes.

4.3.3 Bombas de Trasiego Aceite

Cada una de las bombas de trasiego de aceite será capaz de llenar el carter del motor (0,625 m^3) en media hora. Dispondremos una bomba para cada motor y una de reserva para cada uno. Serán bombas de tornillo con un rendimiento de 0,5 y una presión de descarga de 2 bar.

$$Caudal\ (Q) = \frac{0{,}625(m^3)}{0{,}5h} = 1{,}25 m^3/h$$

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{1{,}25 \cdot 20 \cdot 920}{75 \cdot 3600 \cdot 0{,}5} = 0{,}17 hp = 0{,}13 kW$$

4.3.4 Bombas alimentación de aceite

Como ya dijimos, el sistema de alimentación de aceite ya va incorporado en el motor. Sin embargo, debemos disponer una bomba de emergencia para cada motor. Su caudal y su presión de descarga nos las da el fabricante del motor. Será una bomba de tornillo, con rendimiento 0,5, y:

Caudal = 50 m^3/h

Presión = 10 bar = 100 mca

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{50 \cdot 100 \cdot 920}{75 \cdot 3600 \cdot 0{,}5} = 34hp = 25{,}41kW$$

4.4 Servicios de agua dulce

El agua dulce se utiliza en el buque, además de para el consumo, como refrigeración para el motor propulsor. En nuestro caso, el sistema de refrigeración de agua dulce se divide en dos circuitos independientes: el circuito de baja y el de alta temperatura.

El circuito de baja temperatura es el encargado de enfriar el aceite de refrigeración en el enfriador del aceite. El de alta es el encargado de la refrigeración de las camisas y las cabezas de los cilindros y de la turbosoplante. El agua del circuito de baja temperatura sale del intercambiador principal, en el que se enfría con agua salada. Del intercambiador pasa a un tanque de expansión y de él impulsada por una bomba pasa al intercambiador de aceite. Tras salir de este, y antes de regresar al intercambiador principal, una parte de esta agua se mezcla con el agua del circuito de alta, disminuyendo su temperatura. El agua de este circuito es impulsada por una bomba, refrigera el bloque motor y la turbo, se mezcla con parte del agua del circuito de baja y continúa su ciclo.

Este sistema se llama de “circuito combinado” y permite, además del intercambio de calor en el intercambiador principal, la instalación de un calderín auxiliar como toma de calor para otros servicios.

Se adjunta esquema en el Project Guide.

4.4.1 Bombas de circulación de agua dulce

Aunque el motor principal ya equipa sus propias bombas de circulación debemos disponer una bomba de reserva para cada motor, tanto para el circuito de alta como para el de baja. Las características necesarias de estas bombas nos las da el fabricante en su guía de instalación del motor. Todas

ellas serán bombas centrífugas, cuyos rendimientos se estiman en función del caudal. Las bombas necesarias son las siguientes:

Dos para el circuito de alta:

Presión = 300 kPa = 3 bar

Caudal = 26,1 m^3/h

Rendimiento = 0,65

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{26{,}1 \cdot 30 \cdot 1000}{75 \cdot 3600 \cdot 0{,}65} = 4{,}46hp = 3{,}33kW$$

Dos para el circuito de baja:

Presión = 250 kPa = 2,5 bar

Caudal = 52,2 m^3/h

Rendimiento = 0,65

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{52{,}2 \cdot 25 \cdot 1000}{75 \cdot 3600 \cdot 0{,}65} = 7{,}44hp = 5{,}55kW$$

4.4.2 Enfriadores

En el manual del motor se muestra el balance térmico del motor, con los correspondientes valores de los calores intercambiados, los caudales, las temperaturas y las presiones en cada uno de los elementos, lo cual se adjunta como anexo.

4.5 Servicio de agua salada

Utilizaremos el agua salada de refrigeración para extraer en el intercambiador, el calor del agua dulce de refrigeración del motor.

4.5.1 Bombas de Agua Salada

Las bombas encargadas de tomar el agua de los colectores e impulsarla a través de los intercambiadores, deberán mover al menos el caudal indicado en

el manual del motor. Dispondremos una bomba de agua salada junto con otra de reserva por cada motor. Sus características serán las siguientes:

Presión = 2 bar

Caudal = 94,5 m^3/h

Rendimiento = 0,71

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{94{,}5 \cdot 20 \cdot 1025}{75 \cdot 3600 \cdot 0{,}71} = 10{,}11hp = 7{,}54kW$$

4.5.2 Tomas de mar

Son las encargadas de permitir la toma de agua salada del mar. Deben admitir el caudal máximo del servicio de agua salada, el de contra incendios interior y el de lastre funcionando simultáneamente. Estos caudales son los siguientes:

Caudal Servicio Refrigeración Agua Salada = 94,5 m^3/h

- Bombas contra incendios

Al menos, debemos disponer dos bombas. Su caudal total deberá superar en 1/3 el caudal de cada bomba de sentinas para un buque de pasaje de iguales dimensiones, según la regla II-1.21, y nunca superior en total a 180 m^3/h, ni cada una con un caudal inferior a 25 m^3/h. Estas bombas son del tipo centrífugo. Además, al menos una de las bombas de sentinas será capaz de actuar como bomba contra incendios (en el apartado de sentinas veremos que esto se cumple).

Por lo tanto:

Diámetro (d) colector achique $d = 25+1{,}68\cdot(L\cdot(B+D)^{1/2}$

$= 25+1.68\cdot(25\cdot(11+5))^{1/2} = 58{,}6$ mm

con (L=eslora entre PP (m), B =manga (m), D= puntal (m))

Capacidad bomba sentinas = $\pi\cdot (d^2/4)\cdot v = 0{,}005\ m^3/s = 19{,}41\ m^3/h$

En esta fórmula, d es el diámetro del colector de sentinas visto antes, en m, y v es la velocidad del agua en el interior de las tuberías, que por problemas de ruidos y cavitación no debe superar los 2 m/s.

Cada bomba de sentinas debe ser capaz de suministrar todo el caudal que permite el colector a esa velocidad.

Capacidad total bombas C.I. = (4/3) Capacidad bomba sentinas = 25,88 m^3/h

Ya que vamos a disponer de dos bombas iguales. La presión mínima de estas bombas va a ser de 7 bar, lo que nos aseguraría obtener la presión requerida en cada boca (suponiendo unas pérdidas de carga de más de la mitad de la presión de salida).

La potencia de las bombas seria:

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{25{,}88 \cdot 70 \cdot 1025}{75 \cdot 3600 \cdot 0{,}66} = 10{,}42hp = 7{,}77kW$$

Por tanto:

Caudal Servicio Contra Incendios Interior = 25,88 m^3/h

4.6 Servicios de Ventilación y Aire de Arranque

4.6.1 Aire de Arranque

La capacidad del sistema de aire arranque nos la da la Sociedad de Clasificación, en este caso el DNV-GL. Nos indica que debemos disponer al menos dos botellas de aire comprimido, capaces de realizar al menos 6 arrancadas consecutivas (para motores no reversibles), y además debemos disponer dos compresores como mínimo, uno de ellos, al menos, independiente de los motores principales, y capaces de llenar, cada uno, estas botellas en 1 hora; se entiende por llenado el paso de 0 a 30 bar, es decir, la presión de trabajo.

Según indica el fabricante el volumen de cada una de las botellas para una planta con dos motores, es de 570 l. En el manual del motor se indica así mismo las dimensiones y peso aproximado de dichas botellas (ver página 158 Starting air system design considerations):

Número de botellas de aire comprimido = 2

Capacidad = 570 l

Longitud = 3470 mm

Diámetro = 480 mm

Peso aproximado = 320 kg

4.6.2 Compresores de Aire de Arranque

Son necesarios dos compresores, siendo cada uno capaz de llenar las dos botellas en una hora. La capacidad de cada uno de estos compresores se calcula mediante la fórmula que propone el fabricante, en función del volumen total a llenar (página 57 Project guidar):

$$\text{Caudal} = \Sigma V_{\text{botellas}} \cdot 30 = 2 \cdot 0{,}57 \cdot 30 = 34{,}2 \text{ m}^3/\text{h}$$

Para el cálculo de la potencia de los compresores suponemos su compresión adiabática (coeficiente k= 1,4) y un rendimiento total η = 0,65.

La fórmula aplicada es la siguiente:

$$\text{Pot} = (k/k-1) \cdot (P_1(\text{bar}) \cdot \text{caudal}(\text{m}^3/\text{h})/27) \cdot [(P_2/P_1)^{(k-1/k)} - 1]/\eta =$$

$$= (1{,}4/0{,}4) \cdot (1 \cdot 30/27) \cdot [(34{,}2/1)^{0.4/1.4} - 1]/0{,}65 = 10{,}43 \text{ hp} = 7{,}77 \text{ kw}$$

4.7 Aire de ventilación de Cámara de Máquinas

El aire que debemos introducir en la cámara de máquinas va a ser necesario para distintos usos, que son los siguientes:

- Aire de combustión de motores (propulsores y generadores).
- Aire de evacuación de calor generado por motores y resto de equipos.

El aire necesario se calcula según norma UNE-EN ISO 8861 para "Ventilación de la sala de máquinas de barcos de motor diesel".

4.7.1 Aire de combustión de motores (propulsores y generadores)

La cantidad de flujo de aire para la combustión, q_c, se calcula en metros cúbicos por segundo, de la siguiente forma:

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

q_{dp}: es el flujo de aire para la combustión de los motores principales diesel, en metro cúbicos por segundo.

q_{dg}: es el flujo de aire para la combustión de los motores diesel de los generadores, en metros cúbicos por segundo.

q_b: es el flujo de aire para la combustión de las calderas, en metros cúbicos por segundo.

q_{dp}: es el flujo de aire para la combustión de los motores principales diesel

$$q_{dp} = \frac{P_{dp} \cdot m_{ad}}{\rho} = \frac{(1895 \cdot 2) \cdot 0{,}0020}{1{,}13} = 6{,}71 m^3/s$$

P_{dp}: es la potencia normalizada de servicio de los motores principales diesel a la máxima potencia de salida continua, en kW.

m_{ad}: es el aire necesario para la cumbistión de los motores diesel, en kg por kw segundo. Para motores de 4 tiempos se puede tomar: 0,0020 kg/(kW·s)

ρ: 1,13 kg/m^3 (es decir, la densidad del aire, a +35ºC, 70 RH y 101,3 kPa)

q_{dg}: es el flujo de aire para la combustión de los motores diesel generadores

$$q_{dg} = \frac{P_{dg} \cdot m_{ad}}{\rho} = \frac{520 \cdot 0{,}0020}{1{,}13} = 0{,}92\ m^3/s$$

Por lo tanto:

$$\boldsymbol{q_c = q_{dp} + q_{dg} + q_b = 6{,}71 + 0{,}92 + 0 = 7{,}63\ m^3/s}$$

4.7.2 *Aire de evacuación de calor generado por motores y resto de Equipos*

$$q_h = \frac{\phi_{dp} + \phi_{dg} + \phi_b + \phi_g + \phi_{el} + \phi_{ep} + \phi_t + \phi_O}{\rho \cdot c \cdot \Delta t} - 0{,}4 \cdot (q_{dp} + q_{dg}) - q_b$$

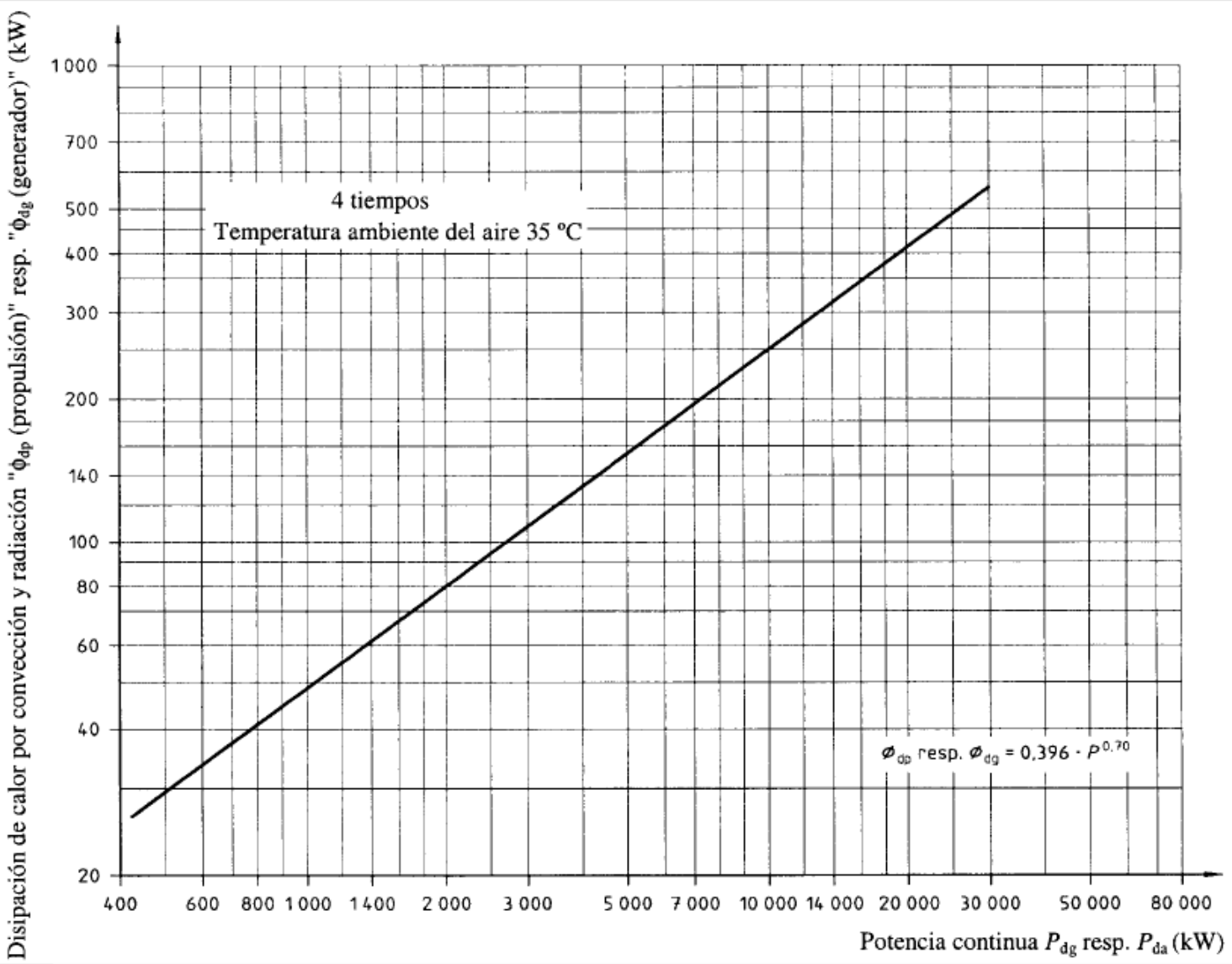
Dónde:

- ϕ_{dp}: es la emisión de calor de los motores diesel de propulsión principal, en kW

$$\phi_{dp} = P_{dp} \cdot \frac{\Delta h_d}{100} = 3790 \cdot \frac{3{,}17}{100} = 120{,}14\ kW$$

P_{dp}: potencia normalizada de servicio de los motores principales diesel de propulsión al máximo régimen continuo, en kW. 1895·2 = 3790kW

Δh_d: es la pérdida de calor de los motores diesel en porcentaje. Se tomará



Nuestros motores tienen una potencia total de 3790 kW, por lo que disipan aproximadamente 120kW,

$$\Delta h_d = \left(\frac{120}{3790}\right) \cdot 100 = 3{,}17\%$$

- ϕ_{dg}: es la emisión de calor de los motores diesel generadores, en kW

$$\phi_{dg} = P_{dp} \cdot \frac{\Delta h_{dg}}{100} = 520 \cdot \frac{5{,}77}{100} = 30\ kW$$

$$\Delta h_g = \left(\frac{30}{520}\right) \cdot 100 = 5{,}77\%$$

- ϕ_b: es la emisión de calor de las calderas y los calentadores de fluido térmico, en kW

$$\phi_b = 0\ kW$$

- ϕ_p: es la emisión de calor de las tuberías de vapor y condensación, en kW

$$\phi_p = m_{sc} \cdot \frac{\Delta h_p}{100} = 0$$

- ϕ_g: es la emisión de calor de los generadores eléctricos refrigerados por aire, en kW

$$\phi_g = P_g \cdot \left(1 - \frac{\eta}{100}\right) = 384 \cdot \left(1 - \frac{94}{100}\right) = 23\ kW$$

Pg: es la potencia de los generadores instalados refrigerados por aire, en kW

η: rendimiento de los generadores en porcentaje

- ϕ_{el}: es la emisión de calor de las instalaciones eléctricas, en kW

$$\phi_{el} = 0{,}2 \cdot 2{,}3 = 0{,}46 kW$$

- ϕ_{ep}: es la emisión de calor de las tuberías de escape incluidas en las calderas alimentadas por llama de gas

$$\phi_{ep} = 0$$

- ϕ_t: es la emisión de calor de los tanques de calefacción, en kW

$$\phi_t = 0$$

- ϕ_O: es la emisión de calor de otros componentes, en kW

$$\phi_O = 0$$

- q_{dp}: es el flujo de aire para la combustión de los motores principales diesel principales, en m^3/s

$$q_{dp} = 6{,}71\ m^3/s$$

- q_{dg}: es el flujo de aire para la combustión de los motores diesel generadores, en m^3/s

$$q_{dg} = 0{,}92 m^3/s$$

- q_b: es el flujo de aire para combustión de la caldera, en m^3/s

$$q_b = 0$$

- ρ: 1,13 kg/m^3 (es decir, la densidad del aire, a +35ºC, 70 RH y 101,3 kPa)
- c: 1,01 kJ/(kg·K), la capacidad de calor específico del aire
- Δt: 12,5 K, el aumento de la temperatura del aire en la sala de máquinas es decir, la diferencia entre la temperatura de entrada y la de salida medida en las condiciones de diseño. La temperatura de la salida debe medirse a la salida de la sala de máquinas al guardacalor o chimenea sin instalaciones sensibles al calor.

$$\boldsymbol{q_h = \frac{120,14 + 30 + 0 + 23 + 0,46}{1,13 \cdot 1,01 \cdot 12,5} - 0,4 \cdot (6,71 + 0,92) - 0 = 9,12\ m^3/s}$$

4.7.3 *Caudal Total de Aire Necesario*

Será el mayor de:

a. $Q = q_c + q_h = 7{,}63 + 9{,}12 = 16{,}75 m^3/s = 60300\ m^3/h$

b. $Q = 1{,}5 \cdot q_c = 1{,}5 \cdot 7{,}63 = 11{,}45\ m^3/s$

$$\mathbf{Q = 60300\ m^3/h}$$

Aproximadamente el 50% del aire de ventilación se suministrará al nivel de la parte superior de los motores principales diesel de propulsión, cerca de las aspiraciones de la turbosoplante, teniendo cuidado para asegurarse de que el agua de mar no pueda aspirarse de esta toma de aire. Nada de aire se debe proyectar directamente sobre los componentes emisores de calor o directamente sobre aparatos eléctricos o de otro tipo sensibles al agua.

El sistema de evacuación de aire deberá diseñarse para mantener una ligera presión positiva en la sala de máquinas. Esta no deberá exceder de 50 Pa.

Los ventiladores de evacuación se instalarán de tal forma que el aire de evacuación no pueda dirigirse a través de las chimeneas o de las aberturas del extractor.

Para éste volumen de aire necesitamos dos ventiladores de 32.000 m^3/h a 45 mm.c.a. El volumen de aire que extraído por los extractores será 7,88 m^3/s (28368 m^3/h), por lo que se instalarán dos extractores de 14.250 m^3/h a 45 mm.c.a.

La potencia se calcula por medio de la misma fórmula usada para las bombas, considerando un rendimiento similar al de las axiales que tomaremos igual a 0,66. Así:

$$Pot = \frac{Q(m^3/h) \cdot H(m.c.a.) \cdot \rho(kg/m^3)}{75 \cdot 3600 \cdot \eta}$$

$$Pot = \frac{60300 \cdot 0{,}045 \cdot 1200}{75 \cdot 3600 \cdot 0{,}66} = 18{,}27hp = 13{,}63kW$$

El aire extraído será:

$$Pot = \frac{28368 \cdot 0{,}045 \cdot 1200}{75 \cdot 3600 \cdot 0{,}66} = 8{,}60hp = 6{,}32kW$$

5. ESTIMACIÓN DEL CONSUMO DEL MOTOR PROPULSOR

Las especificaciones de velocidad se dan al 85 % de la MCR del motor. Según los métodos de predicción de potencia nuestro buque desarrollará los, 10 nudos de velocidad con una potencia de 790 kW. Por lo tanto los motores tendrían que trabajar al 21% (estimamos 50%) para dar la velocidad requerida. Según estos datos, el consumo de nuestro buque en las 2.000 millas de autonomía requeridas será:

Potencia = 50 % MCR = 947,5 kW

Consumo motor principal (50% MCR) = 104,9 g/kWh

Velocidad = 10 nudos

Autonomía = 2000/10 = 200 h = 8 días

El consumo de los motores será:

$$\text{Consumo motores} = 2 \cdot 947{,}5 \cdot 104{,}9 \cdot 10^{-6} \cdot 24 = 4{,}77 \text{ tn/dia}$$

Por otro lado, como se verá en el balance eléctrico, se instalarán dos generadores del modelo Caterpillar C9, capaces de suministrar una potencia de 192 kW cada uno a 1500 rpm, cuyo consumo estimaremos en 3 t/día. Dichos generadores suministran el total de la energía requerida sin sobrepasar el 85% de su potencia, por lo que tendrán un consumo total de:

$$\text{Consumo generadores} = 3 \text{ tn/día}$$

$$\text{Consumo D.O.} = 4{,}77+3 = 7{,}77 \text{ tn/día}$$

Para el consumo total vamos a considerar un margen del 10 % por imbombables (el que queda en el fondo de los tanques que no es utilizable), con lo que el consumo total será:

$$\text{Consumo total propulsores} = 7{,}77 \cdot 1{,}10 = 8{,}547 \text{ tn/día}$$

$$\text{Consumo total propulsores} = 8{,}547 \cdot 8 = 68{,}376 \text{ tn}$$

El volumen de tanques necesario para alojar dicha cantidad de combustible será, tomando una densidad del diesel de 0,85 t/m^3:

$$V_{\text{mín uso diario}} = 8{,}547/0{,}85 = 10{,}06 \text{ m}^3$$

$$V_{\text{mín total}} = 68{,}376/0{,}85 = 80{,}44 \text{ m}^3$$

Valor que tomamos de referencia a la hora de diseñar los tanques.

Los tanques que se han diseñado corresponden:

TANQUE	APLICACIÓN	VOLUMEN (m^3)
4S-4P	Uso diario	37,074
2P-2S-7P-7S-12C-12P-12S-13P-13S	Almacenamiento de combustible	140,306

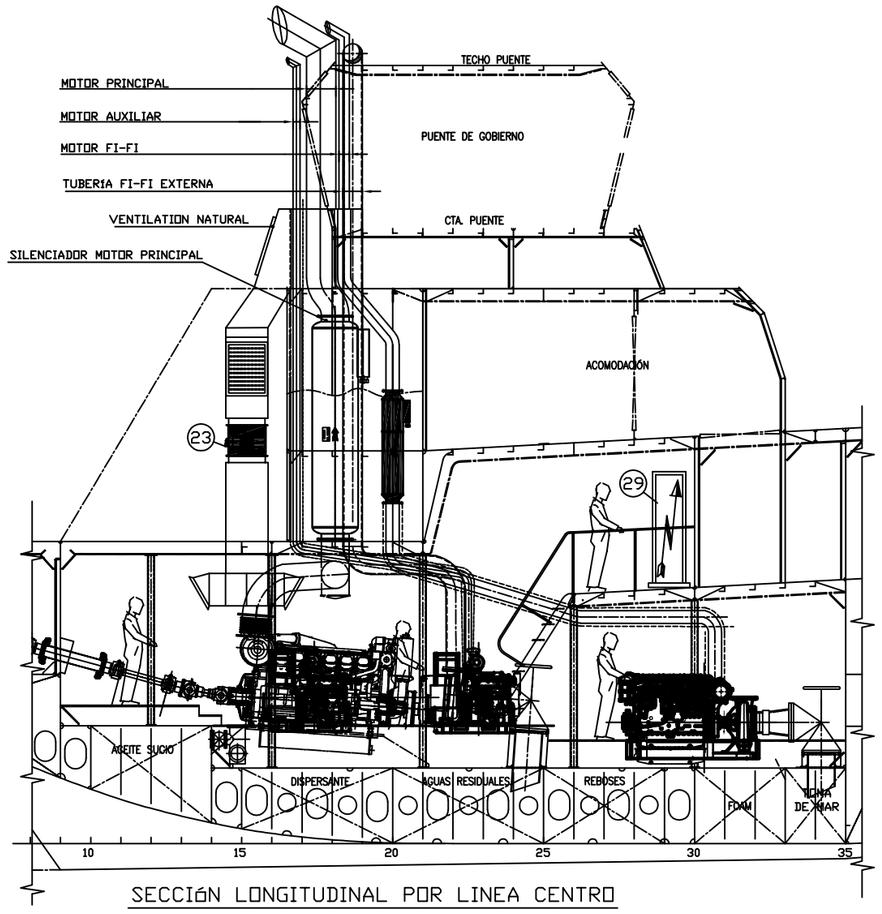
Además, como veremos en el balance eléctrico, la planta estará diseñada para ser capaz de suministrar el total de la potencia requerida en la condición de navegación más desfavorable con uno solo de los generadores. La carga máxima de los generadores nunca llegará al 85% utilizado en los cálculos, sino

que como máximo funcionarán alrededor del 40% en tareas de remolque y mucho menos en el resto de las condiciones estudiadas, reduciéndose por tanto su consumo a la mitad en el peor de los casos.

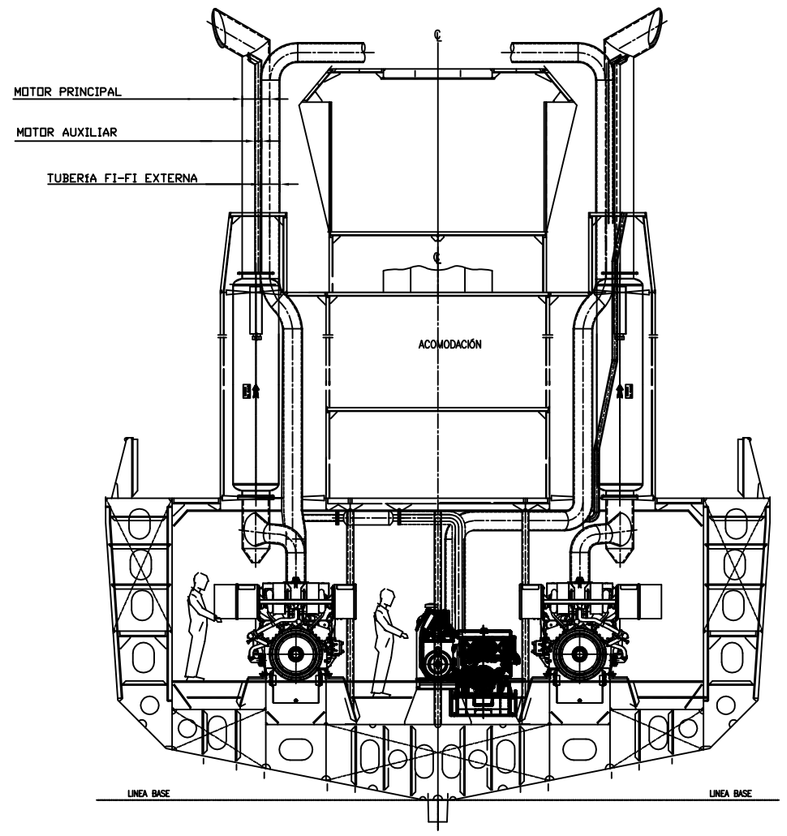
Tras todas estas consideraciones se llega a la conclusión de que la capacidad de los tanques es más que suficiente para garantizar el cumplimiento de los requerimientos exigidos, con lo que no tendremos ningún problema en este aspecto.

6. DISPOSICIÓN GENERAL DE CÁMARA DE MÁQUINAS

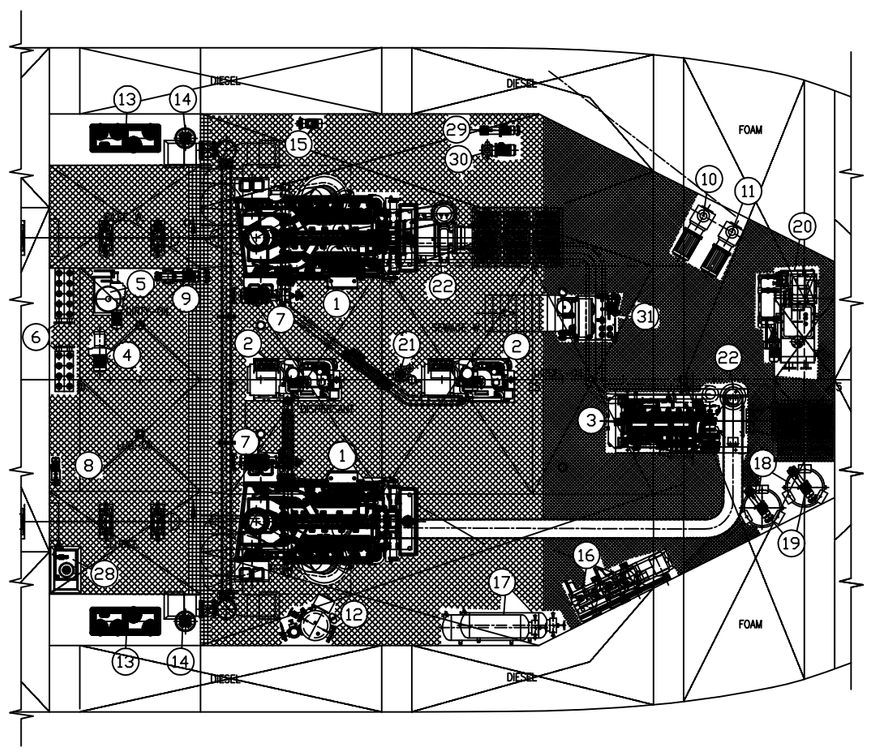
Por último se muestra un croquis de la disposición general de la cámara de máquinas de nuestro buque, a escala 1:100, donde se muestran las dimensiones aproximadas de los motores, tanto principales como auxiliares, y los distintos equipos que hemos mencionado.



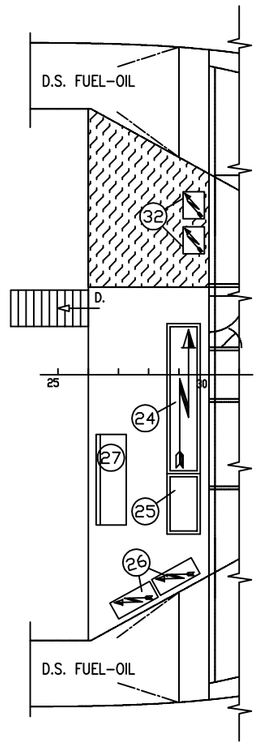
SECCIÓN LONGITUDINAL POR LINEA CENTRO



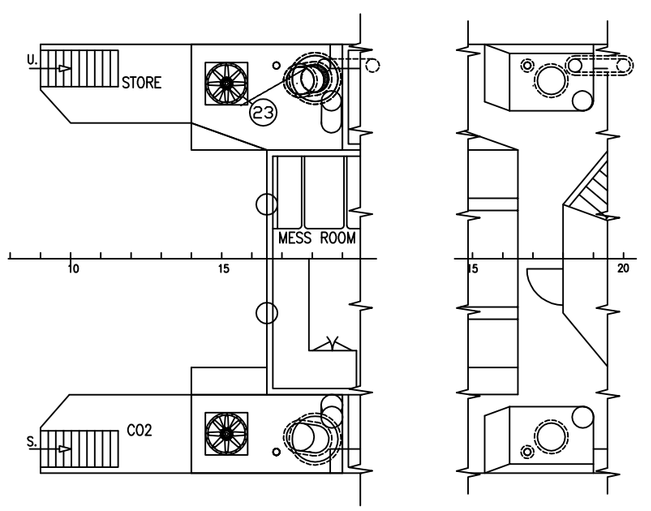
36				
35				
34				
33				
32	2	TRANSFORMADORES		380/220V 25 Kvas.
31	1	CENTRAL HIDRAULICA MAQUINILLA	---- ----	
30	1	BOMBA AGUA SALADA DISPERSANTE	ITUR AU-M2/14	----------
29	1	BOMBA DOSIFICADORA DE DISPERSANTE	ITUR EZ- 3/2	----------
28	1	PLANTA HIDRAULICA DE GRUAS Y PINES	----------	----------
27	1	PUPITRE DE CONTROL	----------	----------
26	2	INTERRUPTORES DE SCHOTTEL	----------	380/220V 25 Kvas.
25	1	CUADRO DE ALARMAS	----------	----------
24	1	CUADRO ELECTRICO	----------	----------
23	2	ELECTROVENTILADOR	----------	32.000 m3/h.
22	2	BOMBA FI-FI	FFS BOB 250/55	1.200 m3/h. x 1.800 r.p.m.
21	1	BOMBA ACHIQUE AGUAS NEGRAS	ITUR VRX-50/17	----------
SANITARI 20	1	PLANTA SEPTICA	----------	----------
SANITARI 19	1+1	BOMBA SANITARIA A.DULCE Y A.SALADA	ITUR EZ-2/3	2 m3/h. 2 bar.
SANITARI 18	2	GRUPO HIDROFORO A.DULCE Y A.SALADA	ITUR	200 Lts.
AIRE 17	2	BOTELLA DE AIRE DE ARRANQUE	----------	570 L.
AIRE 16	2	ELECTROCOMPRESOR	---- ----	30 bar.
COOLING 15	2	BOMBA AIRE ACONDICIONADO	---- --------	----------
COOLING 14	2	ENFRIADOR A. DULCE BAJA TEMPERAT.	BLOKSMA	K25/2P/2P-L=1450
COOLING 13	2	ENFRIADOR A. DULCE BAJA TEMPERAT.	BLOKSMA	K8-62/4P/2P-L=1150
GENER. SERV. 12	1	SEPARADOR DE SENTINAS	PETER TABOADA PETOIL	0.5 m3/h. a 10 m3/h.
GENER. SERV. 11	1	BOMBA DE SERVICIOS GENERALES Y C.I.	ITUR ILNCS-80/200B	70 m3/h. 1.5 bar.
GENER. SERV. 10	1	BOMBA DE SERVICIOS GENERALES Y C.I.	ITUR ILNCS-80/200B	40 m3/h. 4 bar.
L.O. 9	1	BOMBA DE LODOS	ITUR KF-42	----------
L.O. 8	1	BOMBA TRASIEGO ACEITE	ITUR KF-20	2 m3/h. 15 bar.
L.O. 7	2	BOMBA RESERVA LUBRICACION M.P.	ITUR -----	50 m3/h. 10 bar.
F.O. 6	2	CAJA DE VALVULAS COMBUSTIBLE	----------	----------
F.O. 5	2	PURIFICADORA DE COMBUSTIBLE	ALFA-LAVAL MAB-104	--------
F.O. 4	1	BOMBA TRASIEGO DE COMBUSTIBLE	ITUR KF-42	5 m3/h. 3 bar.
F.O. 3	1	MOTOR BOMBA FI-FI	CATERPILLAR C-18	----
2	2	MOTOR AUXILIAR	CATERPILLAR C9	192 Kw. 1.500 r.p.m.
1	2	MOTOR PRINCIPAL	CATERPILLAR 3512C HD	2541 C.v. 1.800 r.p.m.
REF.	Nº	DENOMINACION	MARCA Y TIPO	OBSERVACIONES



DOBLE FONDO DE CÁMARA DE MÁQUINAS



PLATFORM



MAIN DECK

BOATS DECK

UNIVERSIDADE DA CORUÑA

E.P.S.

GRADO EN PROPULSIÓN Y SERVICIOS

TRABAJO FIN DE GRADO

NÚMERO: ---

TÍTULO DEL PROYECTO:

REMOLCADOR DE PUERTO DE 55 TPF

TÍTULO DEL PLANO:

DISPOSICIÓN CÁMARA DE MÁQUINAS

FECHA: FEBRERO-2015

ESCALA: 1:100 / A2

AUTOR:

PABLO RODRÍGUEZ DÍAZ

FIRMA:

PLANO Nº: 003

ANEXO I

PROJECT GUIDE MOTOR PRINCIPAL

3500C

Marine Project Guide
EPA Marine Tier 3 / IMO Tier II Compliant

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

CMPS A&I team would like to recognize Steven Mabey from Finning UK for his contribution to this project guide.

IMPORTANT — PLEASE NOTE:

All dimensions and weights are given as dry weight references only, accurate dimensions and/or weights can be supplied once the engine spec has been defined.

Classification societies requirements that are referred to in the project guide are the typical requirements. These parameters can differ depending on installation type and arrangement. If unsure please consult the customer's classification society to ensure that any engines to be supplied meet the classification society's requirements. It should also be noted that classification societies' requirements are under constant review and are subject to change at any time.

GENERAL

BASIC 3500C DIESEL ENGINE DESIGN

The 3500C engine family for marine applications is a modern, highly efficient, EPA Marine Tier 3, IMO II certified engine series consisting of 12 and 16 cylinder V-engines. These are four stroke, non-reversible engines rated at speeds from 1600 to 1800 rpm and intended for use as main propulsion for vessels. The engines are turbocharged, charge air-cooled and with a direct injection fuel system with electronically controlled injectors. The use of individual fuel injectors eliminates the need for high-pressure piping and provides for an accurate, high injection pressure.

The 3500C platform was designed to meet the following requirements:

–Emissions flexibility and capability

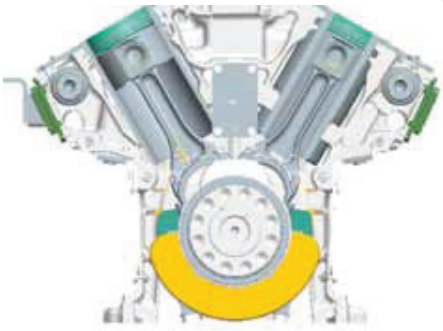
–High power density

–Improved reliability and durability

–Medium speed BSFC and reliability in a high-speed product

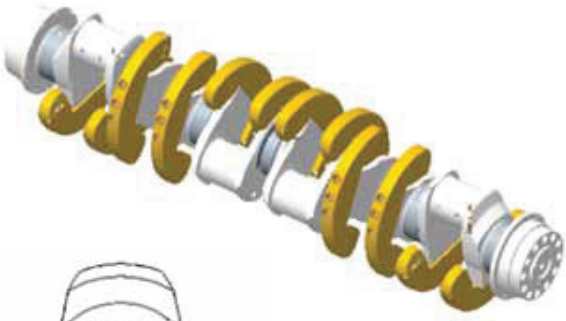
The engine block is made of cast ductile iron for increased strength and stiffness. This increased strength helped produce a higher power-to-weight engine. Coolant supply ducts and main oil galley are integrated into the cylinder block, eliminating parts and leak paths.

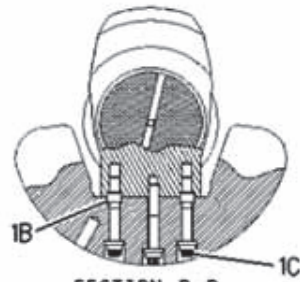
The engine block is designed as 60 degree Vee to ensure an ideal balance on the cylinders' performance. It presents dual camshafts and, to increase load capability, two vertical and two horizontal bearing cap fastenings holding the main bearings.



The crankshaft is made of steel forged material. It is a split-pin machined crankshaft to increase power capability. The large bearing journals provide the desired reliability and durability. The crankshaft features induction-hardened fillets and journals.

Its bolt-on counterweights reduce moment of inertia, and its wear-resistant sleeve bearings increase service life.



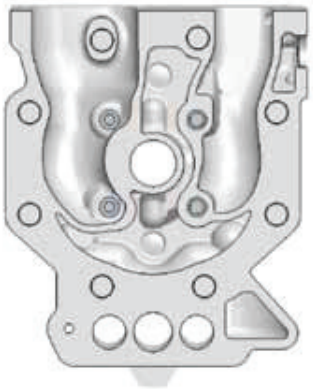


Main and rod bearings have been designed to sustain high loads. The bearing design provides a seizure resistance and tolerance of oil temperatures over a wide range. The Cat® 3500C engine's larger rod bearing and main bearing are more scuff and seizure resistant.

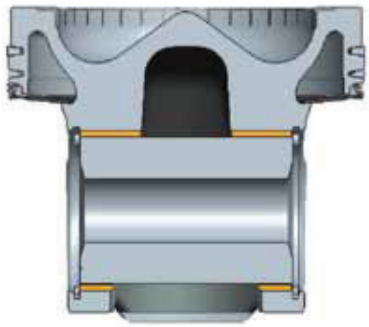
Cylinder liners are high-alloy gray iron; centrifugally cast, induction hardened, plateau honed, and water jacketed over their full length. The liners are equipped with an anti-polishing ring (cuff) to avoid piston/liner carbonizing, improving lube oil control and liner life. It is a fully replaceable wet cylinder liner.

Cylinder head is made of high strength cast iron to get improved durability, allowing high cylinder pressure (increased performance). It is a compact design due to its reverse flow. The mounting of individual cylinder heads promotes easy maintenance.

The intake channel is optimized for low-swirl combustion, which makes it possible to achieve low fuel consumption, low smoke, and low exhaust emissions.



Pistons. The latest generation of 3500s uses a robust steel "Monotherm" piston. It's a two-piece piston with forged steel crown and cast aluminum skirt, sealed by a three-piston ring pack. The C3500 features increased oil flow to pistons for better cooling and allows higher power ratings. Increased oil cooling allows the use of rectangular piston rings that provide a better seal and less motion than the traditional keystone rings. This results in less wear and longer life.

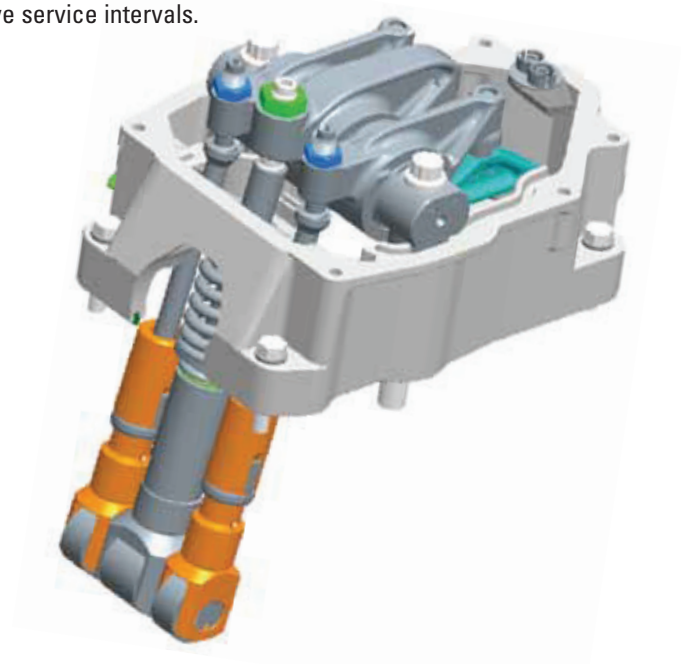


The piston, rod, and liner come out as one assembly, providing faster, easier service. Special tooling is required.

Connecting rods are forged, heat treated, and shot peened before machining. The special four-bolt design allows for an extra-large bearing which reduces bearing load and extends bearing life. The pin bore end taper increases strength in high-load areas.

The valve train system is moved back and forth by a dual camshaft outboard of heads (improved access/serviceability). The push rods are made of solid steel, which are linked to floating bridges, simplifying valve lash adjustment. The exhaust rocker is made of forged steel and the intake rocker is made of cast iron.

The 4-valve OHV design results in small packaging and improved serviceability. Mechanically adjusted valve clearance increases valve service intervals.



Valves. The seat on the replaceable inserts is induction-hardened. Positive rotators on all the valves maintain a uniform temperature and wear pattern across the valve face and seat.

Polished **camshaft** lobes and change to radius of curvature account for higher contact stresses driven by increased injection pressures.

Dual turbochargers are mounted on cast pedestals and center-positioned to eliminate external oil drain lines, reduce the chance of oil leaks, and improve turbo efficiency. The flexible elbow connections used on inlets/outlets of the turbine and compressor housings minimize leakage and provide isolation from external vibrations, motions, and thermal expansion. They are not cooled by water to improve heat rejection and the exhaust gases discharge is conducted in a parallel flow to the turbo. To simplify external piping layout in the engine room, both turbos' flows merge in a single exhaust connection.

IMO II EPA TIER 3 MAIN SPECIFICATIONS		
	3512C	**3516C**
Configuration	Vee-12 Cylinder	Vee-16 Cylinder
Bore x Stroke	170 x 215 mm (8.46 in)	170 x 215 mm (8.46 in)
Displacement	58.6 L (3,576 in^3)	78.08 L (4,765 in^3)
Rated Speed	1600 & 1800 rpm	1600 & 1800 rpm
Aspiration	Turbocharged-Aftercooled	Turbocharged-Aftercooled
Cooling System	Plate Hex, Keel Cooled	Plate Hex, Keel Cooled
Refill Capacity – Lube Oil System – Cooling System	 613.2 L (162.0 gal) 157 L (41.4 gal)	 779.8 L (206.0 gal) 234 L (61.6 gal)
Oil Change Interval	1000 hours	1000 hours
Rotation	Counterclockwise	Counterclockwise
Flywheel and Flywheel Housing	SAE No. 00	SAE No. 00
Flywheel Teeth	183 Teeth	183 Teeth
Engine Management System	A4 ECUs	A4 ECUs
Engine Diagnostic System	Datalink Messaging	Datalink Messaging

EXAMPLE ENGINE SCOPE OF SUPPLY

The following is a typical scope of supply for a C3500 marine main propulsion engine. This is an example only; the scope of supply varies with the application to meet specific customer needs, based on additional options discussed in the system sections.

Air Inlet System
- Corrosion-resistant separate circuit aftercooler core
- Regular duty air cleaners with service indicator
- Bearing housing mounted dual turbochargers

Communications
- J1939 data link

Cooling System
- Auxiliary fresh water pump (SCAC engines)
- Gear-driven centrifugal jacket water
- Centrifugal non-self priming auxiliary sea water pump
- Engine oil cooler
- Expansion tank
- Electronic thermostats
- Housing
- Two-pass aftercooler as opposed to single-pass aftercooler on 3500B

Engine Control System
- Dual engine control modules (A4 ECU) provide control and monitoring. Better combustion control with crank timing vs. cam timing
- Rigid wiring harness

Exhaust System
- Dry gas-tight exhaust manifolds with thermolaminated heat shields
- Dual turbochargers with thermolaminated heat shields
- Single exhaust outlet

Fuel System
- Electronically controlled unit injectors (MEUI™)
- Fuel filter with service indicators
- Fuel transfer pump

Lube System
- Top-mounted dual crankcase breathers
- Oil filter with service indicators
- Oil level gauge
- Oil filler
- Gear-type oil pump
- Rear-sump oil pump

Mounting System
- Front trunion
- Rear pads on sides of flywheel housing

Power Take-Offs
- Accessory drives – lower RH and lower LH for standard rotation
- Two-sided front housing

Instrumentation
- Engine-mounted instrument panel with Marine Power Display (MPD)
- Four-position engine control switch
- Alarm horn
- Overspeed shutdown notification light
- Emergency stop notification light
- Secondary ECU “Ready” light
- Secondary ECU “Active” light
- Graphic display unit for analog or digital display of oil and fuel pressure
- Oil and fuel filter differential
- System DC voltage
- Exhaust and water temperature
- Air inlet restriction
- Service meter
- Engine speed
- Fuel consumption (total and instantaneous)

PROTECTION SYSTEM

A4 ECU monitoring system provides engine deration, alarm, or shutdown strategies to protect against adverse operating conditions. Selected parameters are customer programmable. Initially set as follows:

Safety Shutoff Protection – electrical:
- Oil pressure
- Water temperature
- Overspeed
- Crankcase pressure
- Aftercooler temperature
- Air inlet shutoff activated on overspeed or emergency stop (optional)
- Oil pressure and water temperature (non-redundant, uses OP and WT sensors)
- Overspeed (redundant and independent of engine governing system)

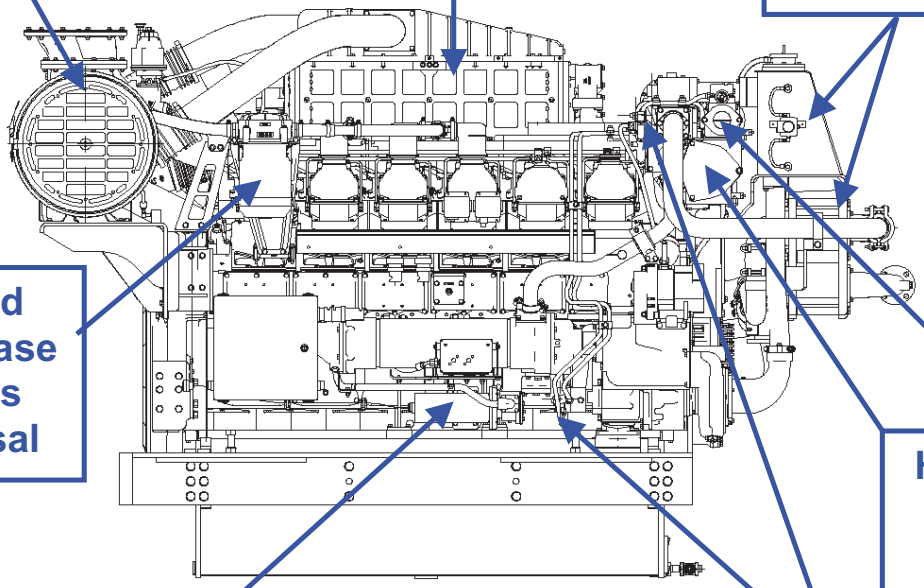
Alarms – electrical:
- ECU voltage
- Oil pressure
- Water temperature (low and high)
- Overspeed
- Crankcase pressure
- Aftercooler temperature low water level (sensor is optional attachment)
- Air inlet restriction
- Exhaust stack temperature
- Filter differential pressure (oil and fuel)

Derate – electrical:
- High water temperature
- Crankcase pressure
- Aftercooler temperature
- Air inlet restriction
- Altitude
- Exhaust temperature
- Alarm switches (oil pressure and water temperature), for connection to customer-supplied alarm panel

General
- Vibration damper and guard
- Caterpillar yellow paint
- Lifting eyes

Optional Equipment
- Cat engine-mounted plate-type heat exchanger with integrated fuel cooler
- Pilot house panel with Marine Power Display (MPD), remote start/stop, remote E-stop, remote alarm display, remote override
- Special appearance package with chrome plated covers
- Deep sump oil pan
- High capacity SW pump
- Spare parts kit

3500C EPA Tier 3 – Features Overview



RIGHT SIDE VIEW

Air Cleaner w/ Service Indicator

New Separate Circuit 2 Stage Aftercooler For Lower IMAT Temps

Titanium Plate-Type Heat Exchanger & Expansion Tank w/Level Switch

Housed Fuel Filter w/ Manual Priming & Optional Duplex

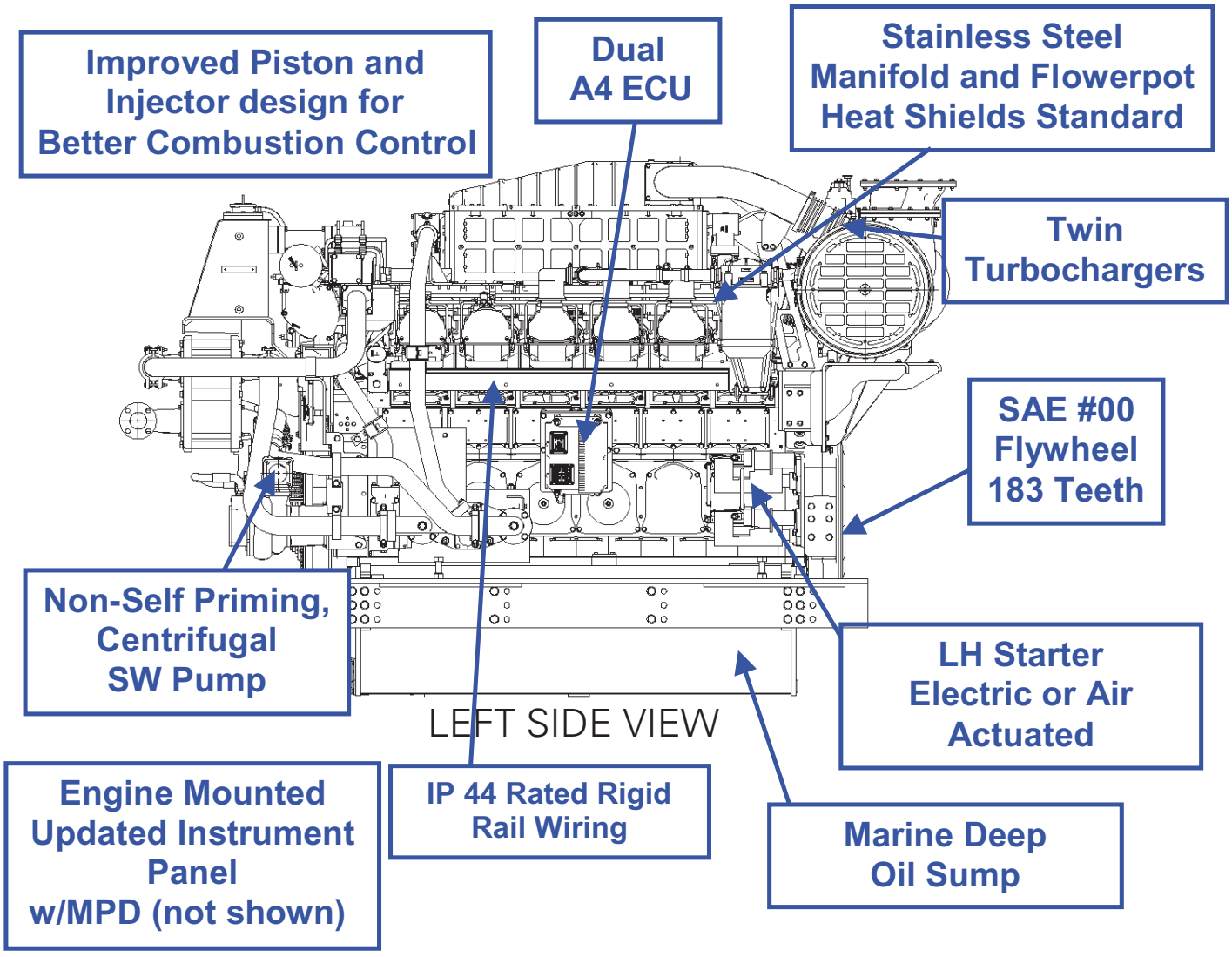
Closed Crankcase Fumes Disposal

Housed Oil Filter w/ Optional Duplex

Optional Electric Pre-Lube

Large Front RH Side Mounted Fuel Connections

3500C EPA Tier 3 – Features Overview



RATINGS

3512C PROPULSION ENGINES

A RATING (UNRESTRICTED CONTINUOUS)		
Engine Model	**3512C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	1381	1381
Rated Power (bhp)	1851	1851
Max. Air Temp. to Air Filters – °C (°F)	45°C (113°F)	45°C (113°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	50°C (122°F)	35°C (95°F)
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	89°C (192°F)

The above ratings are based on the following approximate load profile:

- For vessels operating at rated load and rated speed up to 100% of the time without interruption.
- Typical applications could include but are not limited to vessels such as freighters, tugboats, bottom drag trawlers, or deep river boats.
- Typical operation ranges from 5000 to 8000 hours per year.

B RATING (HEAVY DUTY)		
Engine Model	**3512C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	1425	1678
Rated Power (bhp)	1911	2250
Max. Air Temp. to Air Filters – °C (°F)	48°C (118°F)	45°C (113°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	35°C (95°F)	43°C (109°F)
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	89°C (192°F)

The above ratings are based on the following approximate load profile:

- 80% of the engine operating hours at 100% of rated power.
- 20% of the engine operating hours with some load cycling (40% to 80% load factor).
- Typical applications could include but are not limited to vessels such as mid-water trawlers, purse seiner, crew and supply boats, ferries, or towboats.
- Typical operation ranges from 3000 to 5000 hours per year.

C RATING (MAXIMUM CONTINUOUS)		
Engine Model	**3512C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	1500	1765
Rated Power (bhp)	2012	2365
Max. Air Temp. to Air Filters – °C (°F)	45°C (113°F)	45°C (113°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	35°C (95°F)	43°C (109°F)
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	89°C (192°F)

The above ratings are based on the following approximate load profile:

- 50% of the engine operating hours at 100% of rated power.
- 50% of the engine operating hours with some load cycling (20% to 80% load factor).
- Typical applications could include but are not limited to vessels such as ferries, harbor tugs, fishing boats, offshore service boats, displacement hull yachts, or short trip coastal freighters.
- Typical operation ranges from 2000 to 4000 hours per year.

3516C PROPULSION ENGINES

A RATING (UNRESTRICTED CONTINUOUS)		
Engine Model	**3516C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	1825	—
Rated Power (bhp)	1851	—
Max. Air Temp. to Air Filters – °C (°F)	45°C (113°F)	—
LTC Water Temp. Engine in (Max.) – °C (°F)	35°C (95°F)	—
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	—

The above ratings are based on the following approximate load profile:

- For vessels operating at rated load and rated speed up to 100% of the time without interruption.
- Typical applications could include but are not limited to vessels such as freighters, tugboats, bottom drag trawlers, or deep river boats.
- Typical operation ranges from 5000 to 8000 hours per year.

B RATING (HEAVY DUTY)		
Engine Model	**3516C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	1920	2240
Rated Power (bhp)	2575	3004
Max. Air Temp. to Air Filters – °C (°F)	50°C (122°F)	50°C (122°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	45°C (113°F)	43°C (109°F)
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	89°C (192°F)

The above ratings are based on the following approximate load profile:

- 80% of the engine operating hours at 100% of rated power.
- 20% of the engine operating hours with some load cycling (40% to 80% load factor).
- Typical applications could include but are not limited to vessels such as mid-water trawlers, purse seiner, crew and supply boats, ferries, or towboats.
- Typical operation ranges from 3000 to 5000 hours per year.

C RATING (MAXIMUM CONTINUOUS)		
Engine Model	**3516C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	2000	2350
Rated Power (bhp)	2682	3151
Max. Air Temp. to Air Filters – °C (°F)	50°C (122°F)	50°C (122°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	45°C (113°F)	43°C (109°F)
HTC Cooling Water Temp Engine Out – °C (°F)	89°C (192°F)	89°C (192°F)

The above ratings are based on the following approximate load profile:

- 50% of the engine operating hours at 100% of rated power.
- 50% of the engine operating hours with some load cycling (20% to 80% load factor).
- Typical applications could include but are not limited to vessels such as ferries, harbor tugs, fishing boats, offshore service boats, displacement hull yachts, or short trip coastal freighters.
- Typical operation ranges from 2000 to 4000 hours per year.

D RATING (INTERMITTENT DUTY)		
Engine Model	**3516C**	
Rated Speed (rpm)	1600	1800
Rated Power (bkW)	—	2525
Rated Power (bhp)	—	3386
Max. Air Temp. to Air Filters – °C (°F)	—	50°C (122°F)
LTC Water Temp. Engine in (Max.) – °C (°F)	—	35°C (95°F)
HTC Cooling Water Temp Engine Out – °C (°F)	—	89°C (192°F)

The above ratings are based on the following approximate load profile:

- 16% of the engine operating hours at 100% of rated power.
- 84% of the engine operating hours with some load cycling (up to 50% load factor).
- Typical applications could include but are not limited to vessels such as ferries, harbor tugs, fishing boats, offshore service boats, displacement hull yachts, or short trip coastal freighters.
- Typical operation ranges from 1000 to 3000 hours per year.

Ratings are based on SAE J1228 standard conditions of 29.61 in Hg (100 kPa) and 77°F (25°C). These ratings also apply at ISO3046-1:2002E, ISO8665, DIN6271-3, and BS5514 conditions of 29.61 in Hg (100 kPa), 81°F (27°C), and 60% relative humidity.

Caterpillar maintains ISO9001:2000 certified quality management systems for engine test facilities to assure accurate calibration of test equipment. Electronically controlled engines are set at the factory at the advertised power corrected to standard ambient conditions. The published fuel consumption rates are in accordance with ISO3046-1:2002E.

Fuel rates are based on fuel oil of 35° API [60°F (16°C)] gravity having an LHV of 18,390 Btu/lb (42 780 kJ/kg) when used at 85°F (29°C) and weighing 7.001 lbs/U.S. gal (838.9 g/liter).

Additional ratings may be available for specific customer requirements. Consult your Cat representative for additional information.

MATCHING OF PROPELLERS AND WATER JETS

Controllable Pitch (CP) propellers are normally designed so that 90 to 100% of the rated power is used when the ship is on trial at a specified speed and load. Overload protection or load control is necessary to protect the engine from overload in the event of heavy vessel loading weather conditions, sea state, or hull fouling.

Water jets approximate a fixed pitch propeller demand curve and can also be affected by vessel loading, weather conditions, sea state, and hull fouling. The water jet power demand should be matched so these conditions do not result in engine overload. The water jet-to-engine match should be based on expected heavy ship conditions, propulsion system power losses, reduction gear losses, etc.

SYSTEM RESPONSE

The water jet should be matched to the engine so the engine can smoothly reach its rated speed in a time frame that optimizes acceleration and fuel combustion (smoke). This optimized condition is frequently programmed into the electronic governing system and the water jet should not inhibit the programmed acceleration rate. An oversized water jet may result in engine lug (maximum fuel at less than rated rpm), resulting in owner dissatisfaction with vessel performance, as well as possible harm to the engine from excessive exhaust temperatures.

ENGINE AND WATER JET TOLERANCES

Engine and water jet tolerances should be taken into account in the propulsion system design. Water jets typically have a rated speed tolerance of +/- 0.5% to +/- 1.5%. Thus, the water jets will absorb the rated power somewhere within this speed band tolerance. If the situation arises where the water jet is supplied within these specifications, but at the lower limit of the speed tolerance, it could mean that the propeller demand would require 4.5% more power at the nominal rated speed. If the water jet is supplied with the ability to absorb the power only at the upper limit of the speed tolerance, the engine may not be able to pull the rated power out of the water jet, as the engine may not be able to operate at this higher rpm. The 3500C tolerances provide nominal power +/- 3% with a rated speed tolerance of + 0.5% to - 1.0%.

REQUIREMENTS/CONDITIONS:

1. The dynamometer test results at fuel stop power will be used as the criteria for evaluating installed engine power.
2. ISO standard reference conditions apply for power, not site conditions.
3. Minimum power setting (no negative tolerance in the Dyno) will be driven by the quoter including the associated additional cost.
4. The minimum tolerance on engine power in the Dyno will be reduced to 2%.
5. A tolerance of +/- 3.0% applies to engine power in the field based on standard conditions.
6. The standard rated power and speed will not be changed on the new nameplate, only the fuel setting.
7. Maximum power tolerance limits at rated speed.

WATER JET TOLERANCES

Standard water jet tolerances are +/- 1.5% speed at rated power. This speed tolerance is a function of the pump design, hull form, vessel speed and water jet intake design. The engine speed tolerance at rated power is less than the water jet tolerance (+0.5%/-1.0% versus +/- 1.5%). This means there is a possibility for the water jet to be oversized or undersized if the maximum minus or plus speed tolerance on the water jet is obtained at rated power.

An oversized water jet will cause the engine to operate at fuel stop rack (lug) when the engine is set for the rated 2551 bkW at 1800 rpm. The engine speed may be less than the minimum 1782 rpm (-1.0% engine speed tolerance) required to obtain power within the minus tolerance band with factory rack setting. The engine can operate in lug continuously down to 1500 rpm. However, the engine power output will be out of the minus tolerance band.

An undersized water jet will prevent the engine from reaching rated power at the rated 1800 rpm. Engine speed may be increased to a maximum of 1980 rpm but power output may still be below the minimum tolerance.

To minimize the possibility of a significantly oversized water jet, the customer and/or jet manufacturer may choose to use a different nominal jet sizing point than the rated engine operating point (2525 bkW at 1800 rpm). By choosing a lower nominal water jet rating at 1800 rpm, the jet speed tolerance band may be made to fall entirely within the engine limits such that continuous lug operation is not possible.

TECHNICAL DATA

3500C TECHNICAL DATA SHEETS

The following technical data sheets represent the latest available 3500C engine series technical information at the time of publication and are subject to change. Consult with a Cat dealer to obtain the most current data. The data sheets are organized in the order of engine power ratings (lowest to highest) with propulsion ratings listed first showing the technical data sheets, followed directly by the diesel engine technical data sheets (or performance DM# data sheets) which indicate the performance curve data.

TECHNICAL DATA – 3512C RATING A

GENERAL DATA						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Engine Output (IMO Certified)	bkW	(bhp)	1380	(1851)	1230	(1649)
Cylinder Bore	mm	(in)	170	(6.7)	175	(6.9)
Stroke	mm	(in)	215	(8.5)	220	(8.7)
Displacement/Cylinder	L	(in^3)	78.1	(4765)	84.7	(5167)
Configuration	60V-16, 4-Stroke-Cycle-Diesel					
Aspiration	Twin Turbocharged-Aftercooled					
Cooling	Jacket Water & SCAC					
Refill Capacity – Lube Oil System	L	(gal)	625	(165)	625	(165)
Refill Capacity – Cooling System	L	(gal)	157	(41)	157	(41)
Oil Change Interval	1000 hrs					
Rotation (from flywheel end)	Counterclockwise					
Flywheel and Flywheel Housing	SAE No. 00					
Flywheel Teeth	183					
Governor	A4 ECU					
Fuel System Type	MEUI					
Compression Ratio	14.7:1					
High Idle Speed	rpm		1730		1944	
Low Idle Speed (programmable)	rpm		600		600	
Max. Torque at Max. Torque Speed (1100 rpm/1400 rpm)	N•m	(lb-ft)	11971	(1829)	8200.00	(6048)
Length	mm	(in)	3232	(127)	4515	(178)
Width	mm	(in)	2160	(85)	1857	(73)
Height	mm	(in)	2205	(87)	2453	(97)
Weight (approx)	kg	(lb)	7539	(16621)	13041	(28750)
BMEP @ 100% Load	bar	(psi)	17.7	(256)	15.9	(230)
Mean Piston Speed	m/s	(ft/s)	11.4	(37.3)	12.8	(42.1)
Time Before Overall (main)	hrs		22,500			
Firing Order – CCW	1-12-9-4-5-8-11-2-3-0-7-6					

COMBUSTION AIR SYSTEM[1]						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Air Filter Restriction, New/Maximum	kPa	(in H_2O)	3.72/6.22	(14.9/24.9)	3.72/6.22	(14.9/24.9)
Inlet Air Pressure	mm Hg	(in Hg)	775	(31)	775	(31)
Ambient Air Temp. @ Air Cleaner, Maximum	°C	(°F)	50	(122)	50	(122)
Air Flow Rate @ 100% Load (25°C, 101.3 kPa)	m^3/min	(ft^3/min)	132	(4,650)	125	(4,399)

EXHAUST GAS SYSTEM						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Exhaust Temp to Turbo @ 100% Load	°C	(°F)	541	(1007)	504	(940)
Exhaust Gas Flow @ 100% Load, Stack Temp & 101.3 kPa[2]	m^3/min	(ft^3/min)	125	(4,414)	119	(4,187)
Exhaust System Backpressure, Maximum	kPa	(in H_2O)	6.7	(27)	6.7	(27)

HEAT BALANCE @ 100% LOAD AND 25°C AIR[1]						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Jacket Water Overall	kW	(Btu/min)	512	(29,100)	489	(27,821)
Atmosphere	kW	(Btu/min)	110	(6,274)	94	(5,339)
Exhaustion[3]	kW	(Btu/min)	1098	(62,460)	955	(54,332)
Exhaustion Recovery	kW	(Btu/min)	480	(27,277)	379	(21,539)
Oil Cooler	kW	(Btu/min)	174	(9,879)	155	(8,840)
From Aftercooler	kW	(Btu/min)	377	(21,430)	340	(19,339)
Work Energy	kW	(Btu/min)	1379	(78,422)	1230	(69,977)
Low Heat Value Energy	kW	(Btu/min)	3262	(185,481)	2918	(165,964)
High Heat Value Energy	kW	(Btu/min)	3474	(197,584)	3109	(176,793)

FUEL SYSTEM						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Fuel Rail Pressure Nominal @ 100% Load	kPa	(psi)	455	(66)	510	(74)
Max Fuel Flow to Transfer Pump (to engine)	Lpm	(gph)	21	(332)	21	(333)
Max Allow Fuel Supply Line Restriction	kPa	(in Hg)	30	(8.9)	30	(8.9)
Inlet Fuel Temperature	°C	(°F)	30.0	(86.0)	30.0	(86.0)
Max Allow Fuel Temp from Transfer Pump In	°C	(°F)	66.0	(151.0)	66	(151.0)
Max Fuel Flow to Return Line (from engine)	L/hr	(gph)	1220	(322.3)	1220	(322.3)
Max Fuel Flow Return Line Restr.	kPa	(in Hg)	27.0	(8.0)	27.0	(8.0)
Normal Fuel Pressure – Clean System	kPa	(psi)	415	(60.2)	415	(60.2)
BSFC @ 100% Load[4]	g/bkW-hr	(lb/bhp-hr)	198.9	(0.327)	199.5	(0.328)

LUBRICATING OIL SYSTEM						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
Recommended Oil Type	CAT ECF-1					
Oil Filter Type	Full-Flow					
Crankcase Ventilation Type	Closed Crankcase Ventilation					
Nom Oil Pressure w/SAE 10W30 Oil @ 99°C	kPa	(psi)	610	(88.5)	610	(88.5)
Min LI Op w/SAE 10W30 Oil @ 99°C	kPa	(psi)	300	(43.5)	300	(43.5)
Maximum Allowable Oil Temp	°C	(°F)	107	(226.0)	107	(226.0)
Lube Oil Pressure, Nominal	kPa	(psi)	379	(55.0)	406.0	(59.0)
Lube Oil Pressure Low Idle	kPa	(psi)	241	(35.0)	248.0	(36.0)
Sump Capacity	L	(gal)	613.2	(162)	613.2	(162)

COOLING WATER SYSTEM – HTC (ENGINE JACKET WATER)						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
HTC Cooling Water Temperature Engine Out (nominal)	°C	(°F)	99	(210)	99	(210)
HTC Cooling Water Refill Capacity (engine only)	L	(gal)	157	(41)	157	(41)
Engine & Expansion Tank Coolant Capacity	L	(gal)	291.5	(77)	291.5	(77)
Coolant Medium	Caterpillar Extended Life Coolant (ELC) or Equal					
Expansion Tank Pressure Cap	kPa	(psi)	96.5	(14)	96.5	(14)
Regulator Location	Outlet					
Maximun Uninterrupted Fill Rate	L/min	(gal/min)	18.9	(5)	18.5	(5)
Regulator Start-to-Open Temperature	°C	(°F)	90	(195)	88	(190)
Temp Jacket Water Pump Inlet (nominal)	°C	(°F)	89	(192)	89	(192)
Temp Jacket Water Pump Inlet (max)	°C	(°F)	92	(197)	92	(197)
Temp Jacket Water Pump Inlet (min)	°C	(°F)	83	(183)	83	(183)
Delta T Jacket Water (out-in)	°C	(°F)	5.0	(9)	5.0	(9)
Min Allowable Jacket Water Coolant Flow	L/min	(gal/min)	1204.0	(317)	1204.0	(317)
Max Allowable Jacket Water Coolant Flow	L/min	(gal/min)	1808.0	(476)	1808.0	(476)
Jacket Water Coolant Flow (nominal)	L/min	(gal/min)	1400.0	(368)	1400.0	(368)

COOLING WATER SYSTEM – LTC (AFTERCOOLER)						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM8966-00		DM8429-00	
LTC Water Temperature Engine in (max)[5]	°C	(°F)	32	(91)		
Coolant Medium	Caterpillar Extended Life Coolant (ELC) or equal					
Expansion Tank Pressure Cap	kPa	(psi)	96.5	(14)	96.5	(14)
Min Allowable Aftercooler Coolant Flow	L/min	(gal/min)	722	(190)	387	(102)
Max Allowable Aftercooler Coolant Flow	L/min	(gal/min)	965	(254)	437	(115)
Aftercooler Coolant Flow (nominal)	L/min	(gal/min)	580	(153)	435	(115)

STARTING SYSTEM						
	Units Performance DM#		1600 rpm DM8966-00		1800 rpm DM8429-00	
Minimum Cranking Speed Required for Start	rpm		120.0		120.0	
Lowest Ambient Start Temp w/o Aids	°C	°F	0.0	(32)	0.0	(32)

TOLERENCES			
	Units Performance DM#	1600 rpm DM8966-00	1800 rpm DM8429-00
Engine Power	+/- 3%	Specific Fuel Consumption	+/- 3%
Heat Rejection JW (block)	+/- 10%	BSFC ISO 3046/1	+ 5% / - 0%
Heat Rejection SCAC	+/- 5%	Heat Rejection Oil Cooler (OC)	+/- 20%
Heat Rejection Radiant	+/- 50%	Exhaust Stack Temperature	+/- 8%
Charge Air Pressure	+/- 10%	Fuel Rate	+/- 5%
Exhaust Flow	+/- 5%	Inlet Air Flow	+/- 5%

Notes:

[1] Air flows are shown for 25°C air inlet to the turbocharger and 43°C (109°F) cooling water to the charge air cooler. Adjust aftercooler heat load for higher ambients using the Aftercooler Heat Rejection Factors.

[2] 32°F and 29.98 in Hg

[3] Exhaust heat rejection is based on fuel LHV to 25°C and is not normally recoverable in total

[4] At 100% loads with pumps +/- 3% except where specified differently. Performance and fuel consumption are based on 35 API, 16°C fuel having a lower heating value of 42,780 kJ/kg used at 29°C with a density of 838.9 g/liter. Does not include sea water pump parasitic load.

[5] Sizing point with 27ºC sea water

TECHNICAL DATA – 3512C RATING C

GENERAL DATA						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM9255-01		DM9245-02	
Engine Output (IMO Certified)	bkW	(bhp)	1500	(2012)	1764	(2366)
Cylinder Bore	mm	(in)	170	(6.7)	175	(6.9)
Stroke	mm	(in)	215	(8.5)	220	(8.7)
Displacement/Cylinder	liters	(in^3)	78.1	(4765)	84.7	(5167)
Configuration	60V-16, 4-Stroke-Cycle-Diesel					
Aspiration	Twin Turbocharged-Aftercooled					
Cooling	Jacket Water & SCAC					
Refill Capacity – Lube Oil System	L	(gal)	625	(165)	625	(165)
Refill Capacity – Cooling System	L	(gal)	157	(41)	157	(41)
Oil Change Interval	1000 hrs					
Rotation (from flywheel end)	Counterclockwise					
Flywheel and Flywheel Housing	SAE No. 00					
Flywheel Teeth	183					
Governor	A4 ECU					
Fuel System Type	MEUI					
Compression Ratio	14.7:1					
High Idle Speed	rpm		1730		1944	
Low Idle Speed (programmable)	rpm		600			
Max. Torque at Max. Torque Speed (950/1100 rpm)	N•m	(lb-ft)	12099	(8925)	12000	(8851)
Length	mm	(in)	3232	(127)	4515	(178)
Width	mm	(in)	2160	(85)	1857	(73)
Height	mm	(in)	2205	(87)	2453	(97)
Weight (approx)	kg	(lb)	7539	(16621)	13041	(28750)
BMEP @ 100% Load	bar	(psi)	19.2	(279)	20.1	(291)
Mean Piston Speed	m/s	(ft/s)	11.4	(37.3)	12.8	(42.1)
Time Before Overall (main)	hrs		22,500			
Firing Order – CCW	1-12-9-4-5-8-11-2-3-10-7-6					

COMBUSTION AIR SYSTEM[1]						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM9255-01		DM9245-02	
Air Filter Restriction, New/Maximum	kPa	(in H_2O)	3.72/6.22	(14.9/24.9)	3.72/6.22	(14.9/24.9)
Inlet Air Pressure	mm Hg	(in Hg)	775	(31)	775	(31)
Ambient Air Temp. @ Air Cleaner, Maximum	°C	(°F)	50	(122)	50	(122)
Air Flow Rate @ 100% Load (25°C, 101.3 kPa)	m^3/min	(ft^3/min)	136	(4799)	164	(5,802)

EXHAUST GAS SYSTEM						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM9255-01		DM9245-02	
Exhaust Temp to Turbo @ 100% Load	°C	(°F)	565	(1050)	557	(1135)
Exhaust Gas Flow @ 100% Load, Stack Temp & 101.3 kPa[2]	m^3/min	(ft^3/min)	129	(4,570)	155	(5,470)
Exhaust System Backpressure, Maximum	kPa	(in H_2O)	6.7	(27)	6.7	(27)

HEAT BALANCE @ 100% LOAD AND 25°C AIR[1]						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM9255-01		DM9245-02	
Jacket Water Overall	kW	(Btu/min)	537	(30,529)	625	(35,516)
Atmosphere	kW	(Btu/min)	111	(6,288)	118	(6,690)
Exhaustion[3]	kW	(Btu/min)	1200	(68,259)	1610	(91,541)
Exhaustion Recovery	kW	(Btu/min)	546	(31,025)	816	(46,378)
Oil Cooler	kW	(Btu/min)	188	(10,713)	234	(13,315)
From 2nd Stage Aftercooler	kW	(Btu/min)	421	(23,930)	566	(32,195)
Work Energy	kW	(Btu/min)	1500	(85,304)	1763	(100,288)
Low Heat Value Energy	kW	(Btu/min)	3537	(201,141)	4396	(249,983)
High Heat Value Energy	kW	(Btu/min)	3768	(214,265)	4683	(266,295)

FUEL SYSTEM						
	Units		1600 rpm		1800 rpm	
	Performance DM#		DM9255-01		DM9245-02	
Fuel Rail Pressure Nominal @ 100% Load	kPa	(psi)	455	(66)	483	(70)
Max Fuel Flow to Transfer Pump (to engine)	Lpm	(gph)	21	(332)	21	(333)
Max Allow Fuel Supply Line Restriction	kPa	(in Hg)	30	(8.9)	30	(8.9)
Inlet Fuel Temperature	°C	(°F)	30.0	(86.0)	30.0	(86.0)
Max Allow Fuel Temp from Transfer Pump In	°C	(°F)	66.0	(151.0)	66	(151.0)
Max Fuel Flow to Return Line (from engine)	L/hr	(gph)	1220	(322.3)	1220	(322.3)
Max Fuel Flow Return Line Restr.	kPa	(in Hg)	27.0	(8.0)	27.0	(8.0)
Normal Fuel Pressure – Clean System	kPa	(psi)	415	(60.2)	415	(60.2)
BSFC @ 100% Load[4]	g/bkW-hr	(lb/bhp-hr)	198.3	(0.326)	209.8	(0.345)

LUBRICATING OIL SYSTEM						
	Units Performance DM#		1600 rpm DM9255-01		1800 rpm DM9245-02	
Recommended Oil Type	CAT ECF-1					
Oil Filter Type	Full-Flow					
Crankcase Ventilation Type	Closed Crankcase Ventilation					
Nom Oil Pressure w/SAE 10W30 Oil @ 99° C	kPa	(psi)	610	(88.5)	610	(88.5)
Min LI Op w/SAE 10W30 Oil @ 99° C	kPa	(psi)	300	(43.5)	300	(43.5)
Maximum Allowable Oil Temp	°C	(°F)	107	(226.0)	107	(226.0)
Lube Oil Pressure, Nominal	kPa	(psi)	393	(57.0)	468.8	(68.0)
Lube Oil Pressure Low Idle	kPa	(psi)	255	(37.0)	248.0	(37.0)
Sump Capacity	L	(gal)	613.2	(162)	613.2	(162)

COOLING WATER SYSTEM – HTC (ENGINE JACKET WATER)						
	Units Performance DM#		1600 rpm DM9255-01		1800 rpm DM9245-02	
HTC Cooling Water Temperature Engine Out (nominal)	°C	(°F)	99	(210)	99	(210)
HTC Cooling Water Refill Capacity (engine only)	L	(gal)	157	(41)	157	(41)
Engine & Expansion Tank Coolant Capacity	L	(gal)	291.5	(77)	291.5	(77)
Coolant Medium	Caterpillar Extended Life Coolant (ELC) or Equal					
Expansion Tank Pressure Cap	kPa	(psi)	96.5	(14)	96.5	(14)
Regulator Location	Outlet					
Maximun Uninterrupted Fill Rate	L/min	(gal/min)	18.9	(5)	18.5	(5)
Regulator Start-to-Open Temperature	°C	(°F)	90	(195)	88	(190)
Temp Jacket Water Pump Inlet (nominal)	°C	(°F)	89	(192)	89	(192)
Temp Jacket Water Pump Inlet (max)	°C	(°F)	92	(197)	92	(197)
Temp Jacket Water Pump Inlet (min)	°C	(°F)	83	(183)	83	(183)
Delta T Jacket Water (out-in)	°C	(°F)	5.0	(9)	5.0	(9)
Min Allowable Jacket Water Coolant Flow	L/min	(gal/min)	1204	(317)	1204.0	(317)
Max Allowable Jacket Water Coolant Flow	L/min	(gal/min)	1808	(476)	1808.0	(476)
Jacket Water Coolant Flow (nominal)	L/min	(gal/min)	1400	(368)	1400.0	(368)

COOLING WATER SYSTEM – LTC (AFTERCOOLER)						
	Units Performance DM#		1600 rpm DM9255-01		1800 rpm DM9245-02	
LTC Water Temperature Engine in (max)[5]	°C	(°F)	32	(91)	32	(91)
Coolant Medium	Caterpillar Extended Life Coolant (ELC) or equal					
Expansion Tank Pressure Cap	kPa	(psi)	96.5	(14)	96.5	(14)
Min Allowable Aftercooler Coolant Flow	L/min	(gal/min)	345	(91)	387	(102)
Max Allowable Aftercooler Coolant Flow	L/min	(gal/min)	965	(254)	437	(115)
Aftercooler Coolant Flow (nominal)	L/min	(gal/min)	580	(153)	435	(115)

STARTING SYSTEM						
	Units Performance DM#		1600 rpm DM9255-01		1800 rpm DM9245-02	
Minimum Cranking Speed Required for Start	rpm		120.0			
Lowest Ambient Start Temp w/o Aids	°C	°F	0.0	(32)	0.0	(32)

TOLERENCES			
	Units Performance DM#	1600 rpm DM9255-01	1800 rpm DM9245-02
Engine Power	+/- 3%	Specific Fuel Consumption	+/- 3%
Heat Rejection JW (block)	+/- 10%	BSFC ISO 3046/1	+ 5% / - 0%
Heat Rejection SCAC	+/- 5%	Heat Rejection Oil Cooler (OC)	+/- 20%
Heat Rejection Radiant	+/- 50%	Exhaust Stack Temperature	+/- 8%
Charge Air Pressure	+/- 10%	Fuel Rate	+/- 5%
Exhaust Flow	+/- 5%	Inlet Air Flow	+/- 5%

Notes:

[1] Air flows are shown for 25°C air inlet to the turbocharger and 43°C (109°F) cooling water to the charge air cooler. Adjust aftercooler heat load for higher ambients using the Aftercooler Heat Rejection Factors.

[2] 32°F and 29.98 in Hg

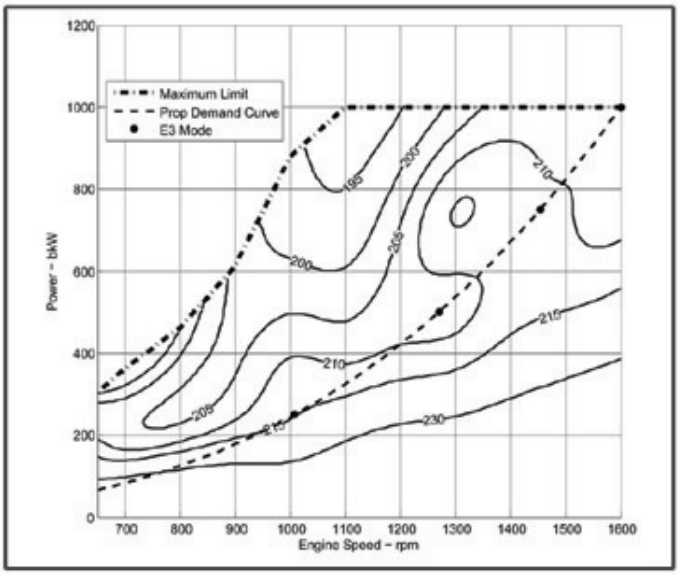
[3] Exhaust heat rejection is based on fuel LHV to 25° C and is not normally recoverable in total

[4] At 100% loads with pumps +/- 3% except where specified differently. Performance and fuel consumption are based on 35 API, 16°C fuel having a lower heating value of 42,780 kJ/kg used at 29°C with a density of 838.9 g/liter. Does not include sea water pump parasitic load.

[5] Sizing point with 27ºC Sea Water

TECHNICAL DATA RATINGS – 3512C HD 1600 RPM

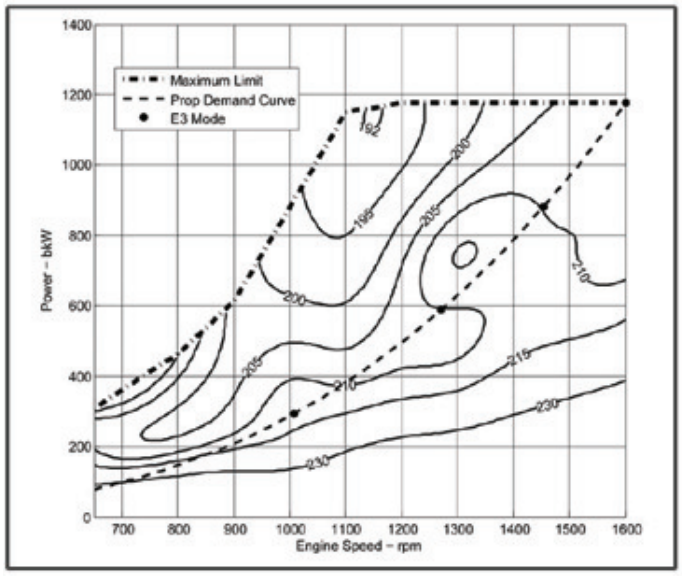
Brake Specific Fuel Consumption
3512C HD @ 1600 rpm 1000 bkW Marine Prop Tier 3 (DM9367)



ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.
Engine rating is with two (2) engine driven water pumps.

DM8906-00-M 09/26/11

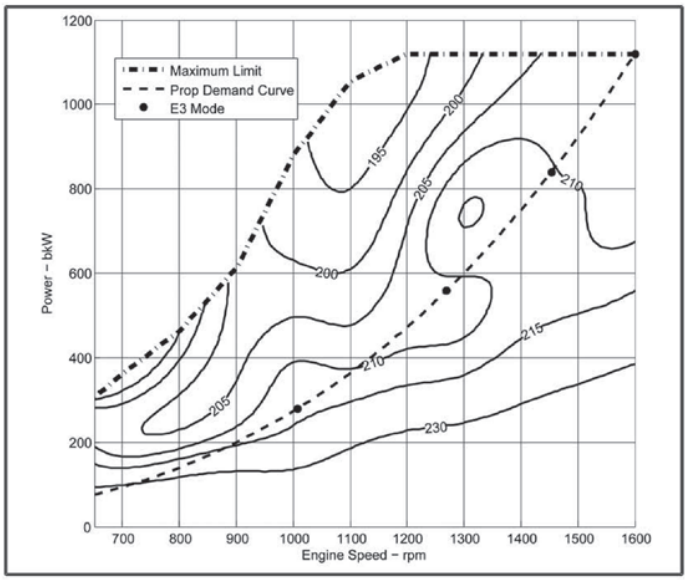
Brake Specific Fuel Consumption
3512C HD @ 1600 rpm 1175 bkW Marine Prop Tier 3 (DM9234)



ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.
Engine rating is with two (2) engine driven water pumps.

DM8904-00-M 09/26/11

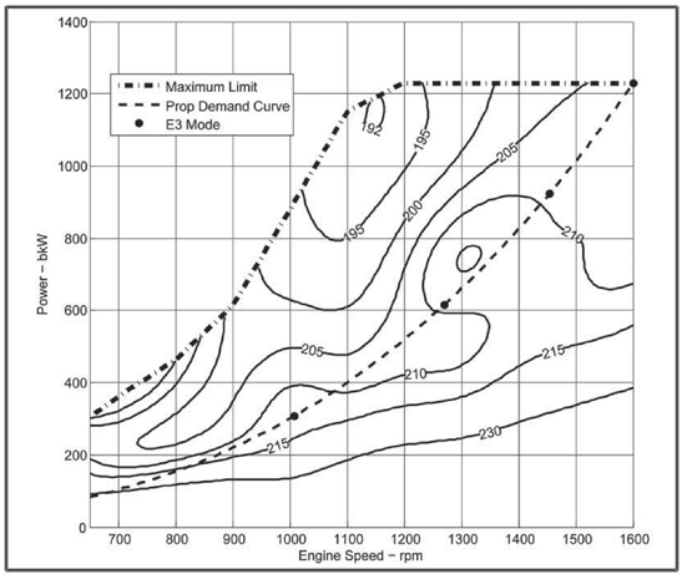
Brake Specific Fuel Consumption
3512C HD @ 1600 rpm 1120 bkW Marine Prop Tier 3 (DM9235)



ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.
Engine rating is with two (2) engine driven water pumps.

DM8905-00-M 09/26/11

Brake Specific Fuel Consumption
3512C HD @ 1600 rpm 1230 bkW Marine Prop Tier 3 (DM9233)



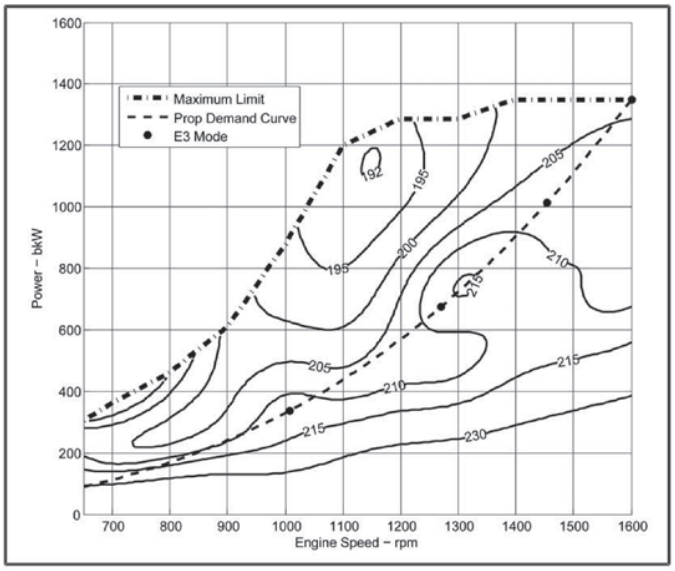
ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.
Engine rating is with two (2) engine driven water pumps.

DM8903-00-M 09/26/11

TECHNICAL DATA RATINGS – 3512C HD 1600 RPM

Brake Specific Fuel Consumption

3512C HD @ 1600 rpm 1350 bkW Marine Prop Tier 3 (DM8979)



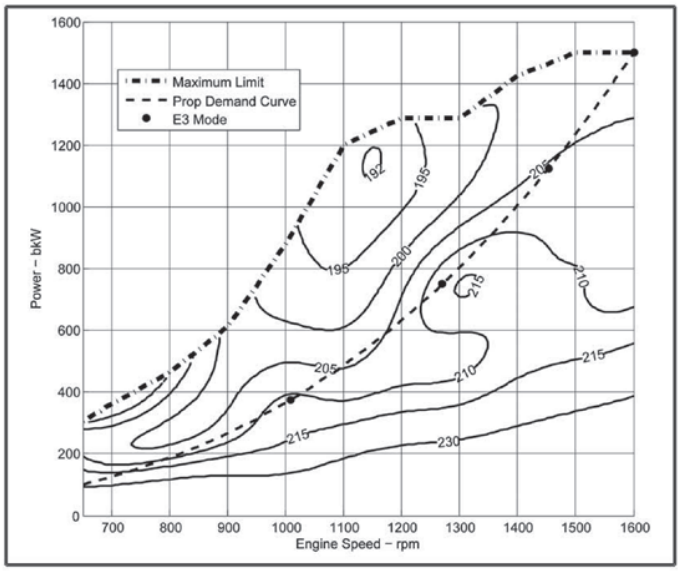
ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

Engine rating is with two (2) engine driven water pumps.

DM8891-00-M 09/26/11

Brake Specific Fuel Consumption

3512C HD @ 1600 rpm 1500 bkW Marine Prop Tier 3 (DM8977)



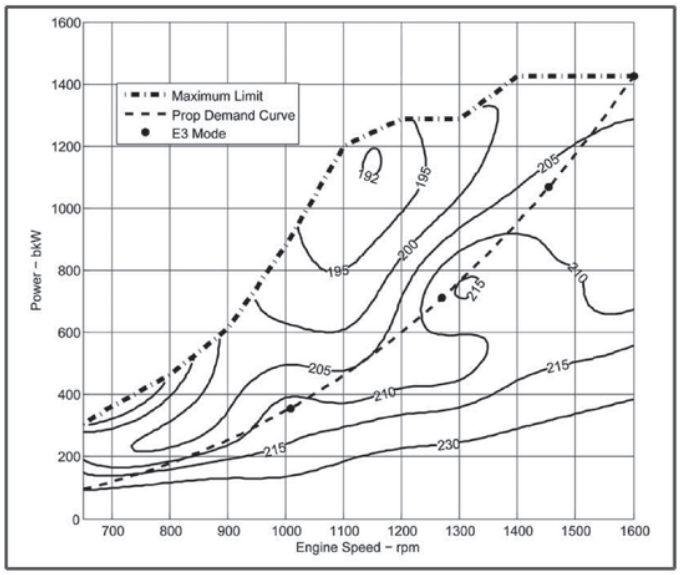
ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

Engine rating is with two (2) engine driven water pumps.

DM8886-00-M 09/26/11

Brake Specific Fuel Consumption

3512C HD @ 1600 rpm 1425 bkW Marine Prop Tier 3 (DM8978)



ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

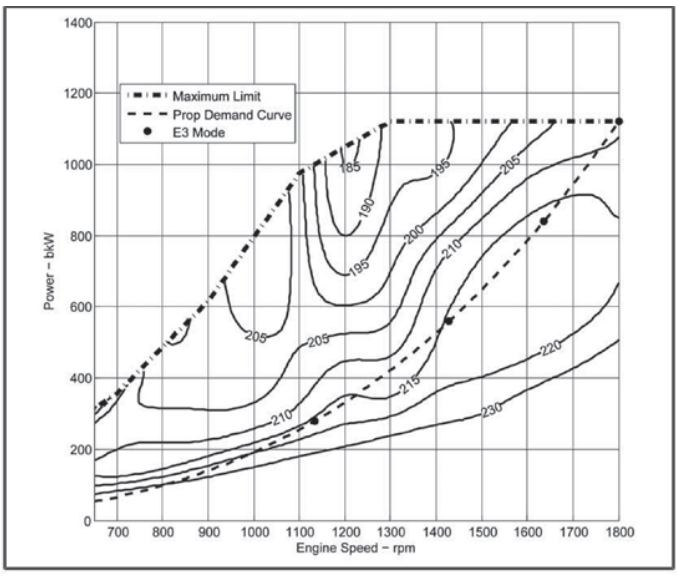
Engine rating is with two (2) engine driven water pumps.

DM8889-00-M 09/26/11

TECHNICAL DATA RATINGS – 3512C HD 1800 RPM

Brake Specific Fuel Consumption

3512C HD @ 1800 rpm 1120 bkW Marine Prop Tier 3 (DM9238)



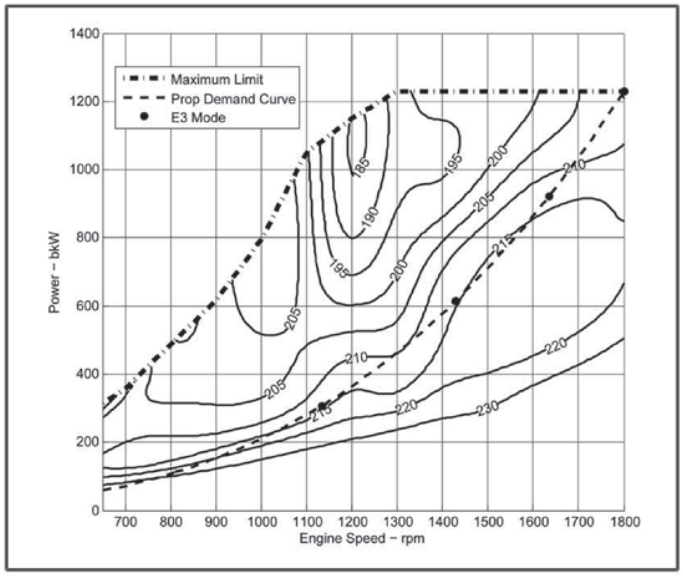
ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

Engine rating is with two (2) engine driven water pumps.

DM9380-00-M 09/26/11

Brake Specific Fuel Consumption

3512C HD @ 1800 rpm 1230 bkW Marine Prop Tier 3 (DM9236)



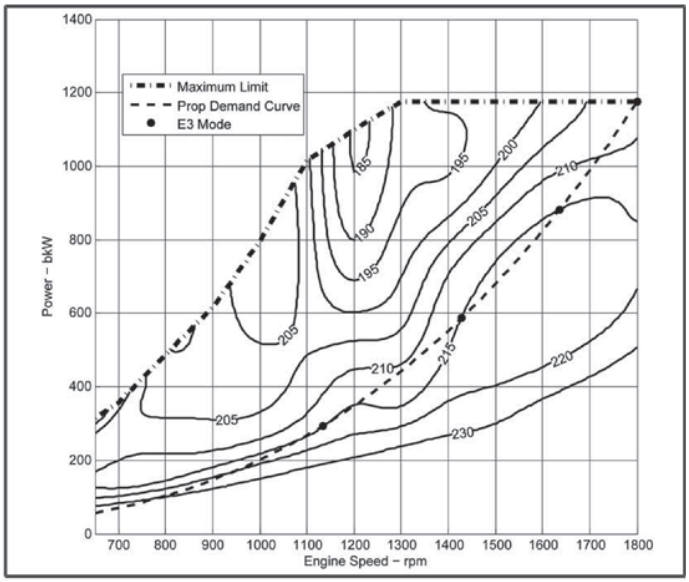
ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

Engine rating is with two (2) engine driven water pumps.

DM9378-00-M 09/26/11

Brake Specific Fuel Consumption

3512C HD @ 1800 rpm 1175 bkW Marine Prop Tier 3 (DM9237)



ISO 3046/1 fuel consumption (g/bkW-hr) tolerance is (+)5, (-)0% of full load data.

Engine rating is with two (2) engine driven water pumps.

DM9379-00-M 09/26/11

EXHAUST NOISE DATA

Performance Number: DM8427 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

EXHAUST Sound Pressure Data (OBCF) **Distance: 1.5 Meters (4.9 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1,118.5	1,500	113	118	114	106	105	106	106	104
1700	942.2	1,264	112	117	113	105	103	105	105	103
1600	785.6	1,053	111	116	111	104	102	104	104	101
1500	647.3	868	109	114	110	102	101	102	103	100
1400	526.3	706	108	113	109	101	100	101	102	99
1300	421.4	565	107	112	107	100	98	102	100	98
1200	331.4	444	106	111	106	99	97	100	99	97
1100	255.3	342	105	110	105	98	96	99	98	96
900	139.8	187	103	107	101	97	96	99	92	87
700	65.8	88	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1,118.5	1,500	100	108	102	93	92	93	92	90
1700	942.2	1,264	99	107	101	92	91	91	91	88
1600	785.6	1,053	97	105	99	90	89	90	91	86
1500	647.3	868	96	103	97	88	88	89	90	85
1400	526.3	706	95	102	96	87	87	88	89	84
1300	421.4	565	94	100	95	88	87	88	88	83
1200	331.4	444	93	99	94	87	86	87	87	82
1100	255.3	342	91	98	92	85	85	86	85	80
900	139.8	187	90	98	89	86	84	84	79	74
700	65.8	88	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1,118.5	1,500	93	101	95	87	85	86	86	83
1700	942.2	1,264	92	100	94	86	84	85	84	82
1600	785.6	1,053	91	98	92	83	83	84	84	80
1500	647.3	868	89	97	91	82	81	82	83	78
1400	526.3	706	88	96	90	81	80	81	82	77
1300	421.4	565	87	94	88	81	81	82	81	76
1200	331.4	444	86	92	87	80	80	80	80	75
1100	255.3	342	85	91	86	79	79	79	79	74
900	139.8	187	83	91	82	79	77	77	72	68
700	65.8	88	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8427 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.118.5	1.500	104	99	100	98	99	100	98	102
1700	942.2	1.264	104	98	99	97	99	100	97	101
1600	785.6	1.053	103	99	98	95	98	98	96	100
1500	647.3	868	102	98	97	94	97	97	95	99
1400	526.3	706	102	97	96	93	96	97	95	98
1300	421.4	565	101	98	95	91	96	96	93	97
1200	331.4	444	101	97	94	90	95	96	93	96
1100	255.3	342	100	96	94	89	94	95	92	95
900	139.8	187	99	95	92	88	93	94	91	94
700	65.8	88	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.118.5	1.500	92	87	88	86	87	88	86	90
1700	942.2	1.264	92	86	87	85	87	88	85	90
1600	785.6	1.053	91	87	86	83	86	86	84	88
1500	647.3	868	90	86	85	82	85	85	83	87
1400	526.3	706	90	85	84	81	84	85	83	87
1300	421.4	565	89	86	83	79	84	85	81	85
1200	331.4	444	89	85	82	78	83	84	81	84
1100	255.3	342	88	84	82	77	82	83	80	83
900	139.8	187	87	83	80	76	81	82	79	82
700	65.8	88	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.118.5	1.500	87	81	82	80	81	83	80	84
1700	942.2	1.264	86	81	81	79	81	82	80	84
1600	785.6	1.053	85	81	80	77	80	80	78	82
1500	647.3	868	85	80	79	76	79	80	78	81
1400	526.3	706	84	80	79	76	79	79	77	81
1300	421.4	565	83	80	77	73	78	79	76	79
1200	331.4	444	83	79	77	72	77	78	75	78
1100	255.3	342	82	79	76	72	77	78	74	78
900	139.8	187	81	77	75	70	75	76	73	76
700	65.8	88	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8428 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,174.5
Rated Power (BHP): 1,575

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	114	119	115	107	105	106	106	104
1700	989.4	1.327	112	117	113	105	104	105	105	103
1600	824.9	1.106	111	116	111	104	102	104	105	101
1500	679.7	911	110	115	110	103	101	103	103	100
1400	552.6	741	108	113	109	101	100	102	102	99
1300	442.5	593	107	112	107	100	99	102	100	98
1200	348.0	467	106	111	106	99	98	101	99	97
1100	268.0	359	105	110	105	98	96	100	98	96
900	146.8	197	103	107	101	97	96	99	92	88
700	69.1	93	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	100	108	102	94	92	93	93	90
1700	989.4	1.327	99	107	101	92	91	92	91	89
1600	824.9	1.106	98	105	99	90	90	91	91	87
1500	679.7	911	96	104	98	89	88	89	90	85
1400	552.6	741	95	103	97	88	87	88	89	84
1300	442.5	593	94	100	95	88	88	88	88	83
1200	348.0	467	93	99	94	87	86	87	87	82
1100	268.0	359	92	98	93	86	85	86	86	81
900	146.8	197	90	98	89	86	84	84	79	75
700	69.1	93	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	94	102	96	87	86	86	86	83
1700	989.4	1.327	92	100	94	86	84	85	85	82
1600	824.9	1.106	91	98	92	83	83	84	85	80
1500	679.7	911	90	97	91	82	82	83	83	79
1400	552.6	741	88	96	90	81	80	82	82	77
1300	442.5	593	87	94	88	81	81	82	81	76
1200	348.0	467	86	93	87	80	80	81	80	75
1100	268.0	359	85	92	86	79	79	80	79	74
900	146.8	197	83	91	82	79	78	77	72	68
700	69.1	93	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8428 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,174.5
Rated Power (BHP): 1,575

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	104	99	100	98	99	100	98	102
1700	989.4	1.327	104	98	99	97	99	100	97	101
1600	824.9	1.106	103	99	98	95	98	98	96	100
1500	679.7	911	102	98	97	94	97	97	95	99
1400	552.6	741	102	97	96	93	96	97	95	98
1300	442.5	593	101	98	95	91	96	96	93	97
1200	348.0	467	101	97	94	90	95	96	93	96
1100	268.0	359	100	96	94	89	94	95	92	95
900	146.8	197	99	95	92	88	93	94	91	94
700	69.1	93	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	92	87	88	86	87	88	86	90
1700	989.4	1.327	92	86	87	85	87	88	85	90
1600	824.9	1.106	91	87	86	83	86	86	84	88
1500	679.7	911	90	86	85	82	85	85	83	87
1400	552.6	741	90	85	84	81	84	85	83	87
1300	442.5	593	89	86	83	79	84	85	81	85
1200	348.0	467	89	85	82	78	83	84	81	84
1100	268.0	359	88	84	82	77	82	83	80	83
900	146.8	197	87	83	80	76	81	82	79	82
700	69.1	93	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.174.5	1.575	87	81	82	80	81	83	80	84
1700	989.4	1.327	86	81	81	79	81	82	80	84
1600	824.9	1.106	85	81	80	77	80	80	78	82
1500	679.7	911	85	80	79	76	79	80	78	81
1400	552.6	741	84	80	79	76	79	79	77	81
1300	442.5	593	83	80	77	73	78	79	76	79
1200	348.0	467	83	79	77	72	77	78	75	78
1100	268.0	359	82	79	76	72	77	78	74	78
900	146.8	197	81	77	75	70	75	76	73	76
700	69.1	93	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8429 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,230.5
Rated Power (BHP): 1,650

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	114	119	115	107	106	107	107	105
1700	1.036.6	1.390	113	118	114	106	104	105	105	103
1600	864.2	1.159	111	116	112	104	103	104	105	102
1500	712.1	955	110	115	110	103	101	103	104	100
1400	579.0	776	109	114	109	102	100	102	102	99
1300	463.5	622	107	112	107	100	99	102	100	98
1200	364.6	489	106	111	106	99	98	101	99	97
1100	280.8	377	105	110	105	98	97	100	98	96
900	153.8	206	103	107	101	97	96	99	92	88
700	72.4	97	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	101	109	103	94	93	93	93	90
1700	1.036.6	1.390	99	107	101	93	91	92	92	89
1600	864.2	1.159	98	105	99	90	90	91	92	87
1500	712.1	955	97	104	98	89	89	90	90	86
1400	579.0	776	95	103	97	88	87	88	89	84
1300	463.5	622	94	101	95	88	88	89	88	83
1200	364.6	489	93	99	94	87	87	87	87	82
1100	280.8	377	92	98	93	86	86	86	86	81
900	153.8	206	90	98	89	86	84	84	79	75
700	72.4	97	88	96	87	84	83	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	94	102	96	88	86	87	87	84
1700	1.036.6	1.390	93	101	95	86	85	85	85	82
1600	864.2	1.159	91	99	93	84	83	84	85	80
1500	712.1	955	90	97	91	82	82	83	84	79
1400	579.0	776	89	96	90	81	81	82	82	78
1300	463.5	622	87	94	88	81	81	82	81	76
1200	364.6	489	86	93	87	80	80	81	80	75
1100	280.8	377	85	92	86	79	79	80	79	74
900	153.8	206	83	91	82	79	78	77	72	68
700	72.4	97	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8429 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,230.5
Rated Power (BHP): 1,650

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	104	99	100	98	99	100	98	102
1700	1.036.6	1.390	104	98	99	97	99	100	97	101
1600	864.2	1.159	103	99	98	95	98	98	96	100
1500	712.1	955	102	98	97	94	97	97	95	99
1400	579.0	776	102	97	96	93	96	97	95	98
1300	463.5	622	101	98	95	91	96	96	93	97
1200	364.6	489	101	97	94	90	95	96	93	96
1100	280.8	377	100	96	94	89	94	95	92	95
900	153.8	206	99	95	92	88	93	94	91	94
700	72.4	97	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	92	87	88	86	87	88	86	90
1700	1.036.6	1.390	92	86	87	85	87	88	85	90
1600	864.2	1.159	91	87	86	83	86	86	84	88
1500	712.1	955	90	86	85	82	85	85	83	87
1400	579.0	776	90	85	84	81	84	85	83	87
1300	463.5	622	89	86	83	79	84	85	81	85
1200	364.6	489	89	85	82	78	83	84	81	84
1100	280.8	377	88	84	82	77	82	83	80	83
900	153.8	206	87	83	80	76	81	82	79	82
700	72.4	97	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.230.5	1.650	87	81	82	80	81	83	80	84
1700	1.036.6	1.390	86	81	81	79	81	82	80	84
1600	864.2	1.159	85	81	80	77	80	80	78	82
1500	712.1	955	85	80	79	76	79	80	78	81
1400	579.0	776	84	80	79	76	79	79	77	81
1300	463.5	622	83	80	77	73	78	79	76	79
1200	364.6	489	83	79	77	72	77	78	75	78
1100	280.8	377	82	79	76	72	77	78	74	78
900	153.8	206	81	77	75	70	75	76	73	76
700	72.4	97	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8466 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,044.0
Rated Power (BHP): 1,400

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	113	118	113	106	104	106	106	103
1500	860.2	1.154	111	116	112	104	103	104	105	102
1400	699.4	938	110	115	110	103	101	103	103	100
1300	560.0	751	109	114	109	102	100	103	102	100
1200	440.4	591	107	112	107	100	99	102	100	98
1100	339.2	455	106	111	106	99	97	101	99	97
1000	254.9	342	105	109	103	99	98	101	94	89
900	185.8	249	104	108	102	98	97	100	93	88
800	130.5	175	103	107	101	97	96	99	92	87
700	87.4	117	102	106	100	96	95	98	91	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	99	107	101	92	91	92	93	88
1500	860.2	1.154	98	105	99	90	90	91	92	87
1400	699.4	938	96	104	98	89	88	90	90	85
1300	560.0	751	95	102	96	89	89	90	89	84
1200	440.4	591	94	100	95	88	88	88	88	83
1100	339.2	455	93	99	94	87	86	87	87	82
1000	254.9	342	91	99	90	87	86	85	80	76
900	185.8	249	90	98	89	86	85	84	79	75
800	130.5	175	89	97	88	85	84	83	78	74
700	87.4	117	88	96	87	84	83	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	93	100	94	85	85	86	86	82
1500	860.2	1.154	91	99	93	84	83	84	85	80
1400	699.4	938	90	97	91	82	82	83	84	79
1300	560.0	751	89	95	90	83	82	83	83	78
1200	440.4	591	87	94	88	81	81	82	81	76
1100	339.2	455	86	93	87	80	80	81	80	75
1000	254.9	342	85	93	84	81	79	79	74	70
900	185.8	249	84	92	83	80	78	78	73	69
800	130.5	175	83	91	82	79	77	77	72	68
700	87.4	117	82	90	81	78	76	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8466 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,044.0
Rated Power (BHP): 1,400

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	103	99	98	95	98	98	96	100
1500	860.2	1.154	102	98	97	94	97	97	95	99
1400	699.4	938	102	97	96	93	96	97	95	98
1300	560.0	751	101	98	95	91	96	96	93	97
1200	440.4	591	101	97	94	90	95	96	93	96
1100	339.2	455	100	96	94	89	94	95	92	95
1000	254.9	342	99	96	93	89	94	95	91	95
900	185.8	249	99	95	92	88	93	94	91	94
800	130.5	175	98	95	92	88	92	93	90	94
700	87.4	117	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	91	87	86	83	86	86	84	88
1500	860.2	1.154	90	86	85	82	85	85	83	87
1400	699.4	938	90	85	84	81	84	85	83	87
1300	560.0	751	89	86	83	79	84	85	81	85
1200	440.4	591	89	85	82	78	83	84	81	84
1100	339.2	455	88	84	82	77	82	83	80	83
1000	254.9	342	87	84	81	77	82	83	80	83
900	185.8	249	87	83	80	76	81	82	79	82
800	130.5	175	86	83	80	76	81	81	78	82
700	87.4	117	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.044.0	1.400	85	81	80	77	80	80	78	82
1500	860.2	1.154	85	80	79	76	79	80	78	81
1400	699.4	938	84	80	79	76	79	79	77	81
1300	560.0	751	83	80	77	73	78	79	76	79
1200	440.4	591	83	79	77	72	77	78	75	78
1100	339.2	455	82	79	76	72	77	78	74	78
1000	254.9	342	82	78	75	71	76	77	74	77
900	185.8	249	81	77	75	70	75	76	73	76
800	130.5	175	80	77	74	70	75	76	72	76
700	87.4	117	80	76	73	69	74	75	72	75

Performance Number: DM8467 **Change Level:** 04

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	113	118	114	106	105	106	107	104
1500	921.6	1.236	112	117	112	105	103	105	105	102
1400	749.3	1.005	110	115	111	103	102	103	104	101
1300	599.9	805	109	114	109	102	100	103	102	100
1200	471.9	633	108	113	108	101	99	102	101	99
1100	363.5	487	106	111	106	99	98	101	99	97
1000	273.1	366	105	109	103	99	98	101	94	90
900	199.1	267	104	108	102	98	97	100	93	88
800	139.8	187	103	107	101	97	96	99	92	87
700	93.7	126	102	106	100	96	95	98	91	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	100	107	101	92	92	93	94	89
1500	921.6	1.236	98	106	100	91	90	91	92	87
1400	749.3	1.005	97	104	98	89	89	90	91	86
1300	599.9	805	96	102	97	90	89	90	90	85
1200	471.9	633	94	101	95	88	88	89	88	83
1100	363.5	487	93	99	94	87	87	87	87	82
1000	273.1	366	92	100	91	88	86	86	81	77
900	199.1	267	91	99	90	87	85	85	80	76
800	139.8	187	90	98	89	86	84	84	79	74
700	93.7	126	89	97	88	85	83	83	78	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	93	101	95	86	85	86	87	82
1500	921.6	1.236	92	99	93	84	84	85	85	81
1400	749.3	1.005	90	98	92	83	82	83	84	79
1300	599.9	805	89	95	90	83	83	83	83	78
1200	471.9	633	88	94	89	82	81	82	82	77
1100	363.5	487	86	93	87	80	80	81	80	75
1000	273.1	366	85	93	84	81	80	79	74	70
900	199.1	267	84	92	83	80	78	78	73	69
800	139.8	187	83	91	82	79	77	77	72	68
700	93.7	126	82	90	81	78	76	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8467 **Change Level:** 04

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	103	99	98	95	98	98	96	100
1500	921.6	1.236	102	98	97	94	97	97	95	99
1400	749.3	1.005	102	97	96	93	96	97	95	98
1300	599.9	805	101	98	95	91	96	96	93	97
1200	471.9	633	101	97	94	90	95	96	93	96
1100	363.5	487	100	96	94	89	94	95	92	95
1000	273.1	366	99	96	93	89	94	95	91	95
900	199.1	267	99	95	92	88	93	94	91	94
800	139.8	187	98	95	92	88	92	93	90	94
700	93.7	126	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	91	87	86	83	86	86	84	88
1500	921.6	1.236	90	86	85	82	85	85	83	87
1400	749.3	1.005	90	85	84	81	84	85	83	87
1300	599.9	805	89	86	83	79	84	85	81	85
1200	471.9	633	89	85	82	78	83	84	81	84
1100	363.5	487	88	84	82	77	82	83	80	83
1000	273.1	366	87	84	81	77	82	83	80	83
900	199.1	267	87	83	80	76	81	82	79	82
800	139.8	187	86	83	80	76	81	81	78	82
700	93.7	126	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.118.5	1.500	85	81	80	77	80	80	78	82
1500	921.6	1.236	85	80	79	76	79	80	78	81
1400	749.3	1.005	84	80	79	76	79	79	77	81
1300	599.9	805	83	80	77	73	78	79	76	79
1200	471.9	633	83	79	77	72	77	78	75	78
1100	363.5	487	82	79	76	72	77	78	74	78
1000	273.1	366	82	78	75	71	76	77	74	77
900	199.1	267	81	77	75	70	75	76	73	76
800	139.8	187	80	77	74	70	75	76	72	76
700	93.7	126	80	76	73	69	74	75	72	75

Performance Number: DM8468 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,193.0
Rated Power (BHP): 1,600

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	114	119	114	107	105	107	107	104
1500	983.0	1.318	112	117	113	105	104	105	106	103
1400	799.2	1.072	111	116	111	104	102	104	104	101
1300	639.9	858	109	114	109	102	101	104	102	100
1200	503.3	675	108	113	108	101	99	102	101	99
1100	387.7	520	107	112	107	100	98	101	100	98
1000	291.3	391	105	109	103	99	98	101	94	90
900	212.3	285	104	108	102	98	97	100	93	89
800	149.1	200	103	107	101	97	96	99	92	88
700	99.9	134	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	100	108	102	93	92	93	94	89
1500	983.0	1.318	99	106	100	91	91	92	93	88
1400	799.2	1.072	97	105	99	90	89	90	91	86
1300	639.9	858	96	102	97	90	90	90	90	85
1200	503.3	675	95	101	96	89	88	89	89	84
1100	387.7	520	93	100	94	87	87	88	87	82
1000	291.3	391	92	100	91	88	86	86	81	77
900	212.3	285	91	99	90	87	85	85	80	76
800	149.1	200	90	98	89	86	84	84	79	75
700	99.9	134	89	97	88	85	83	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	94	101	95	86	86	87	87	83
1500	983.0	1.318	92	100	94	85	84	85	86	81
1400	799.2	1.072	91	98	92	83	83	84	84	80
1300	639.9	858	89	96	90	83	83	84	83	78
1200	503.3	675	88	94	89	82	82	82	82	77
1100	387.7	520	87	93	88	81	80	81	81	76
1000	291.3	391	85	93	84	81	80	79	74	70
900	212.3	285	84	92	83	80	79	78	73	69
800	149.1	200	83	91	82	79	78	77	72	68
700	99.9	134	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8468 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,193.0
Rated Power (BHP): 1,600

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	103	99	98	95	98	98	96	100
1500	983.0	1.318	102	98	97	94	97	97	95	99
1400	799.2	1.072	102	97	96	93	96	97	95	98
1300	639.9	858	101	98	95	91	96	96	93	97
1200	503.3	675	101	97	94	90	95	96	93	96
1100	387.7	520	100	96	94	89	94	95	92	95
1000	291.3	391	99	96	93	89	94	95	91	95
900	212.3	285	99	95	92	88	93	94	91	94
800	149.1	200	98	95	92	88	92	93	90	94
700	99.9	134	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	91	87	86	83	86	86	84	88
1500	983.0	1.318	90	86	85	82	85	85	83	87
1400	799.2	1.072	90	85	84	81	84	85	83	87
1300	639.9	858	89	86	83	79	84	85	81	85
1200	503.3	675	89	85	82	78	83	84	81	84
1100	387.7	520	88	84	82	77	82	83	80	83
1000	291.3	391	87	84	81	77	82	83	80	83
900	212.3	285	87	83	80	76	81	82	79	82
800	149.1	200	86	83	80	76	81	81	78	82
700	99.9	134	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.193.0	1.600	85	81	80	77	80	80	78	82
1500	983.0	1.318	85	80	79	76	79	80	78	81
1400	799.2	1.072	84	80	79	76	79	79	77	81
1300	639.9	858	83	80	77	73	78	79	76	79
1200	503.3	675	83	79	77	72	77	78	75	78
1100	387.7	520	82	79	76	72	77	78	74	78
1000	291.3	391	82	78	75	71	76	77	74	77
900	212.3	285	81	77	75	70	75	76	73	76
800	149.1	200	80	77	74	70	75	76	72	76
700	99.9	134	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8712 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	113	118	113	106	105	108	106	104
1100	861.5	1.155	111	116	111	104	103	106	104	102
1000	647.3	868	109	113	107	103	102	105	98	94
900	471.9	633	108	112	106	102	101	104	97	92
800	331.4	444	106	110	104	100	99	102	95	90
700	222.0	298	104	108	102	98	97	100	93	89
600	139.8	187	103	107	101	97	96	99	92	87
500	80.9	109	102	106	100	96	95	98	91	86
450	59.0	79	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	100	106	101	94	94	94	94	89
1100	861.5	1.155	98	104	99	92	92	92	92	87
1000	647.3	868	96	104	95	92	90	90	85	81
900	471.9	633	94	102	93	90	89	88	83	79
800	331.4	444	93	101	92	89	87	87	82	77
700	222.0	298	91	99	90	87	85	85	80	76
600	139.8	187	90	98	89	86	84	84	79	74
500	80.9	109	88	96	87	84	83	82	77	73
450	59.0	79	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	93	100	94	87	87	88	87	82
1100	861.5	1.155	91	98	92	85	85	86	85	80
1000	647.3	868	89	97	88	85	84	83	78	74
900	471.9	633	88	96	87	84	82	82	77	72
800	331.4	444	86	94	85	82	80	80	75	71
700	222.0	298	84	92	83	80	79	78	73	69
600	139.8	187	83	91	82	79	77	77	72	68
500	80.9	109	82	90	81	78	76	76	71	67
450	59.0	79	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8712 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	101	97	94	90	95	96	93	96
1100	861.5	1.155	100	96	94	89	94	95	92	95
1000	647.3	868	99	96	93	89	94	95	91	95
900	471.9	633	99	95	92	88	93	94	91	94
800	331.4	444	98	95	92	88	92	93	90	94
700	222.0	298	97	94	91	87	92	93	90	93
600	139.8	187	97	93	90	86	91	92	89	92
500	80.9	109	96	93	90	86	91	91	88	92
450	59.0	79	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	89	85	82	78	83	84	81	84
1100	861.5	1.155	88	84	82	77	82	83	80	83
1000	647.3	868	87	84	81	77	82	83	80	83
900	471.9	633	87	83	80	76	81	82	79	82
800	331.4	444	86	83	80	76	81	81	78	82
700	222.0	298	85	82	79	75	80	81	78	81
600	139.8	187	85	81	79	74	79	80	77	80
500	80.9	109	84	81	78	74	79	80	76	80
450	59.0	79	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	83	79	77	72	77	78	75	78
1100	861.5	1.155	82	79	76	72	77	78	74	78
1000	647.3	868	82	78	75	71	76	77	74	77
900	471.9	633	81	77	75	70	75	76	73	76
800	331.4	444	80	77	74	70	75	76	72	76
700	222.0	298	80	76	73	69	74	75	72	75
600	139.8	187	79	76	73	69	73	74	71	75
500	80.9	109	78	75	72	68	73	74	71	74
450	59.0	79	78	75	72	68	73	73	70	74

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8713 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,044.0
Rated Power (BHP): 1,400

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	113	118	113	106	104	107	106	104
1100	804.1	1.078	111	116	111	104	102	105	104	102
1000	604.2	810	109	113	107	103	102	105	98	93
900	440.4	591	107	111	105	101	100	103	96	92
800	309.3	415	106	110	104	100	99	102	95	90
700	207.2	278	104	108	102	98	97	100	93	89
600	130.5	175	103	107	101	97	96	99	92	87
500	75.5	101	102	106	100	96	95	98	91	86
450	55.1	74	101	105	99	95	94	97	90	85

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	99	106	100	93	93	94	93	88
1100	804.1	1.078	97	104	98	91	91	92	91	86
1000	604.2	810	96	104	95	92	90	90	85	80
900	440.4	591	94	102	93	90	88	88	83	79
800	309.3	415	92	100	91	88	87	86	81	77
700	207.2	278	91	99	90	87	85	85	80	76
600	130.5	175	89	97	88	85	84	83	78	74
500	75.5	101	88	96	87	84	83	82	77	73
450	55.1	74	88	96	87	84	82	82	77	72

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	93	99	94	87	86	87	87	82
1100	804.1	1.078	91	97	92	85	84	85	85	80
1000	604.2	810	89	97	88	85	83	83	78	74
900	440.4	591	87	95	86	83	82	81	76	72
800	309.3	415	86	94	85	82	80	80	75	71
700	207.2	278	84	92	83	80	79	78	73	69
600	130.5	175	83	91	82	79	77	77	72	68
500	75.5	101	82	90	81	78	76	76	71	66
450	55.1	74	81	89	80	77	75	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8713 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,044.0
Rated Power (BHP): 1,400

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	101	97	94	90	95	96	93	96
1100	804.1	1.078	100	96	94	89	94	95	92	95
1000	604.2	810	99	96	93	89	94	95	91	95
900	440.4	591	99	95	92	88	93	94	91	94
800	309.3	415	98	95	92	88	92	93	90	94
700	207.2	278	97	94	91	87	92	93	90	93
600	130.5	175	97	93	90	86	91	92	89	92
500	75.5	101	96	93	90	86	91	91	88	92
450	55.1	74	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	89	85	82	78	83	84	81	84
1100	804.1	1.078	88	84	82	77	82	83	80	83
1000	604.2	810	87	84	81	77	82	83	80	83
900	440.4	591	87	83	80	76	81	82	79	82
800	309.3	415	86	83	80	76	81	81	78	82
700	207.2	278	85	82	79	75	80	81	78	81
600	130.5	175	85	81	79	74	79	80	77	80
500	75.5	101	84	81	78	74	79	80	76	80
450	55.1	74	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.044.0	1.400	83	79	77	72	77	78	75	78
1100	804.1	1.078	82	79	76	72	77	78	74	78
1000	604.2	810	82	78	75	71	76	77	74	77
900	440.4	591	81	77	75	70	75	76	73	76
800	309.3	415	80	77	74	70	75	76	72	76
700	207.2	278	80	76	73	69	74	75	72	75
600	130.5	175	79	76	73	69	73	74	71	75
500	75.5	101	78	75	72	68	73	74	71	74
450	55.1	74	78	75	72	68	73	73	70	74

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8714 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 969.5
Rated Power (BHP): 1,300

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	112	117	112	105	104	107	105	103
1100	746.8	1.001	110	115	110	103	102	105	103	101
1000	561.1	752	109	113	107	103	102	105	98	93
900	409.0	548	107	111	105	101	100	103	96	91
800	287.3	385	105	109	103	99	98	101	94	90
700	192.4	258	104	108	102	98	97	100	93	88
600	121.2	163	103	107	101	97	96	99	92	87
500	70.1	94	101	105	99	95	94	97	90	86
450	51.1	69	101	105	99	95	94	97	90	85

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	99	105	100	93	92	93	93	88
1100	746.8	1.001	97	103	98	91	91	91	91	86
1000	561.1	752	95	103	94	91	90	89	84	80
900	409.0	548	93	101	92	89	88	87	82	78
800	287.3	385	92	100	91	88	86	86	81	77
700	192.4	258	90	98	89	86	85	84	79	75
600	121.2	163	89	97	88	85	84	83	78	74
500	70.1	94	88	96	87	84	83	82	77	73
450	51.1	69	87	95	86	83	82	81	76	72

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	92	99	93	86	86	87	86	81
1100	746.8	1.001	90	97	91	84	84	85	84	79
1000	561.1	752	89	97	88	85	83	83	78	73
900	409.0	548	87	95	86	83	81	81	76	72
800	287.3	385	85	93	84	81	80	79	74	70
700	192.4	258	84	92	83	80	78	78	73	69
600	121.2	163	83	91	82	79	77	77	72	67
500	70.1	94	81	89	80	77	76	75	70	66
450	51.1	69	81	89	80	77	75	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8714 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 969.5
Rated Power (BHP): 1,300

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	101	97	94	90	95	96	93	96
1100	746.8	1.001	100	96	94	89	94	95	92	95
1000	561.1	752	99	96	93	89	94	95	91	95
900	409.0	548	99	95	92	88	93	94	91	94
800	287.3	385	98	95	92	88	92	93	90	94
700	192.4	258	97	94	91	87	92	93	90	93
600	121.2	163	97	93	90	86	91	92	89	92
500	70.1	94	96	93	90	86	91	91	88	92
450	51.1	69	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	89	85	82	78	83	84	81	84
1100	746.8	1.001	88	84	82	77	82	83	80	83
1000	561.1	752	87	84	81	77	82	83	80	83
900	409.0	548	87	83	80	76	81	82	79	82
800	287.3	385	86	83	80	76	81	81	78	82
700	192.4	258	85	82	79	75	80	81	78	81
600	121.2	163	85	81	79	74	79	80	77	80
500	70.1	94	84	81	78	74	79	80	76	80
450	51.1	69	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	969.5	1.300	83	79	77	72	77	78	75	78
1100	746.8	1.001	82	79	76	72	77	78	74	78
1000	561.1	752	82	78	75	71	76	77	74	77
900	409.0	548	81	77	75	70	75	76	73	76
800	287.3	385	80	77	74	70	75	76	72	76
700	192.4	258	80	76	73	69	74	75	72	75
600	121.2	163	79	76	73	69	73	74	71	75
500	70.1	94	78	75	72	68	73	74	71	74
450	51.1	69	78	75	72	68	73	73	70	74

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8730 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	113	118	113	106	105	108	106	104
1100	861.5	1.155	111	116	111	104	103	106	104	102
1000	647.3	868	109	113	107	103	102	105	98	94
900	471.9	633	108	112	106	102	101	104	97	92
800	331.4	444	106	110	104	100	99	102	95	90
700	222.0	298	104	108	102	98	97	100	93	89
600	139.8	187	103	107	101	97	96	99	92	87
500	80.9	109	102	106	100	96	95	98	91	86
450	59.0	79	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	100	106	101	94	94	94	94	89
1100	861.5	1.155	98	104	99	92	92	92	92	87
1000	647.3	868	96	104	95	92	90	90	85	81
900	471.9	633	94	102	93	90	89	88	83	79
800	331.4	444	93	101	92	89	87	87	82	77
700	222.0	298	91	99	90	87	85	85	80	76
600	139.8	187	90	98	89	86	84	84	79	74
500	80.9	109	88	96	87	84	83	82	77	73
450	59.0	79	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	93	100	94	87	87	88	87	82
1100	861.5	1.155	91	98	92	85	85	86	85	80
1000	647.3	868	89	97	88	85	84	83	78	74
900	471.9	633	88	96	87	84	82	82	77	72
800	331.4	444	86	94	85	82	80	80	75	71
700	222.0	298	84	92	83	80	79	78	73	69
600	139.8	187	83	91	82	79	77	77	72	68
500	80.9	109	82	90	81	78	76	76	71	67
450	59.0	79	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8730 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,118.5
Rated Power (BHP): 1,500

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	101	97	94	90	95	96	93	96
1100	861.5	1.155	100	96	94	89	94	95	92	95
1000	647.3	868	99	96	93	89	94	95	91	95
900	471.9	633	99	95	92	88	93	94	91	94
800	331.4	444	98	95	92	88	92	93	90	94
700	222.0	298	97	94	91	87	92	93	90	93
600	139.8	187	97	93	90	86	91	92	89	92
500	80.9	109	96	93	90	86	91	91	88	92
450	59.0	79	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	89	85	82	78	83	84	81	84
1100	861.5	1.155	88	84	82	77	82	83	80	83
1000	647.3	868	87	84	81	77	82	83	80	83
900	471.9	633	87	83	80	76	81	82	79	82
800	331.4	444	86	83	80	76	81	81	78	82
700	222.0	298	85	82	79	75	80	81	78	81
600	139.8	187	85	81	79	74	79	80	77	80
500	80.9	109	84	81	78	74	79	80	76	80
450	59.0	79	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.118.5	1.500	83	79	77	72	77	78	75	78
1100	861.5	1.155	82	79	76	72	77	78	74	78
1000	647.3	868	82	78	75	71	76	77	74	77
900	471.9	633	81	77	75	70	75	76	73	76
800	331.4	444	80	77	74	70	75	76	72	76
700	222.0	298	80	76	73	69	74	75	72	75
600	139.8	187	79	76	73	69	73	74	71	75
500	80.9	109	78	75	72	68	73	74	71	74
450	59.0	79	78	75	72	68	73	73	70	74

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8731 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,193.0
Rated Power (BHP): 1,600

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	114	119	114	107	105	108	107	105
1100	918.9	1.232	112	117	112	105	103	106	105	103
1000	690.4	926	110	114	108	104	103	106	99	94
900	503.3	675	108	112	106	102	101	104	97	92
800	353.5	474	106	110	104	100	99	102	95	91
700	236.8	318	105	109	103	99	98	101	94	89
600	149.1	200	103	107	101	97	96	99	92	88
500	86.3	116	102	106	100	96	95	98	91	86
450	62.9	84	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	100	107	101	94	94	95	94	89
1100	918.9	1.232	98	105	99	92	92	93	92	87
1000	690.4	926	96	104	95	92	91	90	85	81
900	503.3	675	95	103	94	91	89	89	84	79
800	353.5	474	93	101	92	89	87	87	82	78
700	236.8	318	91	99	90	87	86	85	80	76
600	149.1	200	90	98	89	86	84	84	79	75
500	86.3	116	88	96	87	84	83	82	77	73
450	62.9	84	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	94	100	95	88	87	88	88	83
1100	918.9	1.232	92	98	93	86	85	86	86	81
1000	690.4	926	90	98	89	86	84	84	79	75
900	503.3	675	88	96	87	84	82	82	77	73
800	353.5	474	86	94	85	82	81	80	75	71
700	236.8	318	85	93	84	81	79	79	74	69
600	149.1	200	83	91	82	79	78	77	72	68
500	86.3	116	82	90	81	78	76	76	71	67
450	62.9	84	81	89	80	77	76	75	70	66

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8731 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,193.0
Rated Power (BHP): 1,600

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	101	97	94	90	95	96	93	96
1100	918.9	1.232	100	96	94	89	94	95	92	95
1000	690.4	926	99	96	93	89	94	95	91	95
900	503.3	675	99	95	92	88	93	94	91	94
800	353.5	474	98	95	92	88	92	93	90	94
700	236.8	318	97	94	91	87	92	93	90	93
600	149.1	200	97	93	90	86	91	92	89	92
500	86.3	116	96	93	90	86	91	91	88	92
450	62.9	84	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	89	85	82	78	83	84	81	84
1100	918.9	1.232	88	84	82	77	82	83	80	83
1000	690.4	926	87	84	81	77	82	83	80	83
900	503.3	675	87	83	80	76	81	82	79	82
800	353.5	474	86	83	80	76	81	81	78	82
700	236.8	318	85	82	79	75	80	81	78	81
600	149.1	200	85	81	79	74	79	80	77	80
500	86.3	116	84	81	78	74	79	80	76	80
450	62.9	84	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.193.0	1.600	83	79	77	72	77	78	75	78
1100	918.9	1.232	82	79	76	72	77	78	74	78
1000	690.4	926	82	78	75	71	76	77	74	77
900	503.3	675	81	77	75	70	75	76	73	76
800	353.5	474	80	77	74	70	75	76	72	76
700	236.8	318	80	76	73	69	74	75	72	75
600	149.1	200	79	76	73	69	73	74	71	75
500	86.3	116	78	75	72	68	73	74	71	74
450	62.9	84	78	75	72	68	73	73	70	74

Performance Number: DM8732 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,268.0
Rated Power (BHP): 1,700

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	114	119	114	107	106	109	107	105
1100	976.7	1.310	112	117	112	105	104	107	105	103
1000	733.8	984	110	114	108	104	103	106	99	95
900	534.9	717	108	112	106	102	101	104	97	93
800	375.7	504	106	110	104	100	99	102	95	91
700	251.7	338	105	109	103	99	98	101	94	89
600	158.5	213	103	107	101	97	96	99	92	88
500	91.7	123	102	106	100	96	95	98	91	86
450	66.9	90	101	105	99	95	94	97	90	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	101	107	102	95	95	95	95	90
1100	976.7	1.310	99	105	100	93	93	93	93	88
1000	733.8	984	97	105	96	93	91	91	86	82
900	534.9	717	95	103	94	91	89	89	84	80
800	375.7	504	93	101	92	89	88	87	82	78
700	251.7	338	91	99	90	87	86	85	80	76
600	158.5	213	90	98	89	86	84	84	79	75
500	91.7	123	89	97	88	85	83	83	78	73
450	66.9	90	88	96	87	84	82	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	94	101	95	88	88	89	88	83
1100	976.7	1.310	92	99	93	86	86	87	86	81
1000	733.8	984	90	98	89	86	85	84	79	75
900	534.9	717	88	96	87	84	83	82	77	73
800	375.7	504	86	94	85	82	81	80	75	71
700	251.7	338	85	93	84	81	79	79	74	70
600	158.5	213	83	91	82	79	78	77	72	68
500	91.7	123	82	90	81	78	76	76	71	67
450	66.9	90	81	89	80	77	76	75	70	66

Performance Number: DM8732 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,200
Rated Power (BKW): 1,268.0
Rated Power (BHP): 1,700

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	101	97	94	90	95	96	93	96
1100	976.7	1.310	100	96	94	89	94	95	92	95
1000	733.8	984	99	96	93	89	94	95	91	95
900	534.9	717	99	95	92	88	93	94	91	94
800	375.7	504	98	95	92	88	92	93	90	94
700	251.7	338	97	94	91	87	92	93	90	93
600	158.5	213	97	93	90	86	91	92	89	92
500	91.7	123	96	93	90	86	91	91	88	92
450	66.9	90	96	92	90	85	90	91	88	91

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	89	85	82	78	83	84	81	84
1100	976.7	1.310	88	84	82	77	82	83	80	83
1000	733.8	984	87	84	81	77	82	83	80	83
900	534.9	717	87	83	80	76	81	82	79	82
800	375.7	504	86	83	80	76	81	81	78	82
700	251.7	338	85	82	79	75	80	81	78	81
600	158.5	213	85	81	79	74	79	80	77	80
500	91.7	123	84	81	78	74	79	80	76	80
450	66.9	90	84	80	78	73	78	79	76	79

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1200	1.268.0	1.700	83	79	77	72	77	78	75	78
1100	976.7	1.310	82	79	76	72	77	78	74	78
1000	733.8	984	82	78	75	71	76	77	74	77
900	534.9	717	81	77	75	70	75	76	73	76
800	375.7	504	80	77	74	70	75	76	72	76
700	251.7	338	80	76	73	69	74	75	72	75
600	158.5	213	79	76	73	69	73	74	71	75
500	91.7	123	78	75	72	68	73	74	71	74
450	66.9	90	78	75	72	68	73	73	70	74

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8964 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,250.0
Rated Power (BHP): 1,676

EXHAUST Sound Pressure Data (OBCF) **Distance: 1.5 Meters (4.9 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	114	119	115	107	106	107	108	105
1500	1.030.0	1.381	113	118	113	106	104	106	106	103
1400	837.4	1.123	111	116	112	104	103	104	105	102
1300	670.5	899	110	115	110	103	101	104	103	101
1200	527.3	707	108	113	108	101	100	103	101	99
1100	406.2	545	107	112	107	100	98	101	100	98
1000	305.2	409	106	110	104	100	99	102	95	90
900	222.5	298	104	108	102	98	97	100	93	89
800	156.3	210	103	107	101	97	96	99	92	88
700	104.7	140	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	101	108	102	93	93	94	95	90
1500	1.030.0	1.381	99	107	101	92	91	92	93	88
1400	837.4	1.123	98	105	99	90	90	91	91	87
1300	670.5	899	96	103	97	90	90	91	90	85
1200	527.3	707	95	101	96	89	89	89	89	84
1100	406.2	545	93	100	94	87	87	88	87	82
1000	305.2	409	92	100	91	88	87	86	81	77
900	222.5	298	91	99	90	87	85	85	80	76
800	156.3	210	90	98	89	86	84	84	79	75
700	104.7	140	89	97	88	85	83	83	78	74

EXHAUST Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	94	102	96	87	86	87	88	83
1500	1.030.0	1.381	93	100	94	85	85	86	86	82
1400	837.4	1.123	91	99	93	84	83	84	85	80
1300	670.5	899	90	96	91	84	83	84	84	79
1200	527.3	707	88	95	89	82	82	83	82	77
1100	406.2	545	87	93	88	81	81	81	81	76
1000	305.2	409	86	94	85	82	80	80	75	70
900	222.5	298	84	92	83	80	79	78	73	69
800	156.3	210	83	91	82	79	78	77	72	68
700	104.7	140	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8964 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,250.0
Rated Power (BHP): 1,676

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	103	99	98	95	98	98	96	100
1500	1.030.0	1.381	102	98	97	94	97	97	95	99
1400	837.4	1.123	102	97	96	93	96	97	95	98
1300	670.5	899	101	98	95	91	96	96	93	97
1200	527.3	707	101	97	94	90	95	96	93	96
1100	406.2	545	100	96	94	89	94	95	92	95
1000	305.2	409	99	96	93	89	94	95	91	95
900	222.5	298	99	95	92	88	93	94	91	94
800	156.3	210	98	95	92	88	92	93	90	94
700	104.7	140	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	91	87	86	83	86	86	84	88
1500	1.030.0	1.381	90	86	85	82	85	85	83	87
1400	837.4	1.123	90	85	84	81	84	85	83	87
1300	670.5	899	89	86	83	79	84	85	81	85
1200	527.3	707	89	85	82	78	83	84	81	84
1100	406.2	545	88	84	82	77	82	83	80	83
1000	305.2	409	87	84	81	77	82	83	80	83
900	222.5	298	87	83	80	76	81	82	79	82
800	156.3	210	86	83	80	76	81	81	78	82
700	104.7	140	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.250.0	1.676	85	81	80	77	80	80	78	82
1500	1.030.0	1.381	85	80	79	76	79	80	78	81
1400	837.4	1.123	84	80	79	76	79	79	77	81
1300	670.5	899	83	80	77	73	78	79	76	79
1200	527.3	707	83	79	77	72	77	78	75	78
1100	406.2	545	82	79	76	72	77	78	74	78
1000	305.2	409	82	78	75	71	76	77	74	77
900	222.5	298	81	77	75	70	75	76	73	76
800	156.3	210	80	77	74	70	75	76	72	76
700	104.7	140	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8965 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,305.0
Rated Power (BHP): 1,750

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	115	120	115	108	106	108	108	105
1500	1.075.3	1.442	113	118	113	106	104	106	107	103
1400	874.2	1.172	111	116	112	104	103	104	105	102
1300	700.0	939	110	115	110	103	101	104	103	101
1200	550.5	738	108	113	108	101	100	103	101	99
1100	424.1	569	107	112	107	100	98	102	100	98
1000	318.6	427	106	110	104	100	99	102	95	90
900	232.3	311	105	109	103	99	98	101	94	89
800	163.1	219	103	107	101	97	96	99	92	88
700	109.3	147	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	101	109	103	94	93	94	95	90
1500	1.075.3	1.442	100	107	101	92	92	93	93	89
1400	874.2	1.172	98	105	99	90	90	91	92	87
1300	700.0	939	96	103	97	90	90	91	90	85
1200	550.5	738	95	102	96	89	89	90	89	84
1100	424.1	569	94	100	95	88	87	88	88	83
1000	318.6	427	92	100	91	88	87	86	81	77
900	232.3	311	91	99	90	87	86	85	80	76
800	163.1	219	90	98	89	86	84	84	79	75
700	109.3	147	89	97	88	85	83	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	95	102	96	87	87	88	88	84
1500	1.075.3	1.442	93	100	94	85	85	86	87	82
1400	874.2	1.172	91	99	93	84	83	84	85	80
1300	700.0	939	90	96	91	84	84	84	84	79
1200	550.5	738	88	95	89	82	82	83	82	77
1100	424.1	569	87	94	88	81	81	82	81	76
1000	318.6	427	86	94	85	82	80	80	75	71
900	232.3	311	85	93	84	81	79	79	74	69
800	163.1	219	83	91	82	79	78	77	72	68
700	109.3	147	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8965 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,305.0
Rated Power (BHP): 1,750

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	103	99	98	95	98	98	96	100
1500	1.075.3	1.442	102	98	97	94	97	97	95	99
1400	874.2	1.172	102	97	96	93	96	97	95	98
1300	700.0	939	101	98	95	91	96	96	93	97
1200	550.5	738	101	97	94	90	95	96	93	96
1100	424.1	569	100	96	94	89	94	95	92	95
1000	318.6	427	99	96	93	89	94	95	91	95
900	232.3	311	99	95	92	88	93	94	91	94
800	163.1	219	98	95	92	88	92	93	90	94
700	109.3	147	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	91	87	86	83	86	86	84	88
1500	1.075.3	1.442	90	86	85	82	85	85	83	87
1400	874.2	1.172	90	85	84	81	84	85	83	87
1300	700.0	939	89	86	83	79	84	85	81	85
1200	550.5	738	89	85	82	78	83	84	81	84
1100	424.1	569	88	84	82	77	82	83	80	83
1000	318.6	427	87	84	81	77	82	83	80	83
900	232.3	311	87	83	80	76	81	82	79	82
800	163.1	219	86	83	80	76	81	81	78	82
700	109.3	147	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.305.0	1.750	85	81	80	77	80	80	78	82
1500	1.075.3	1.442	85	80	79	76	79	80	78	81
1400	874.2	1.172	84	80	79	76	79	79	77	81
1300	700.0	939	83	80	77	73	78	79	76	79
1200	550.5	738	83	79	77	72	77	78	75	78
1100	424.1	569	82	79	76	72	77	78	74	78
1000	318.6	427	82	78	75	71	76	77	74	77
900	232.3	311	81	77	75	70	75	76	73	76
800	163.1	219	80	77	74	70	75	76	72	76
700	109.3	147	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8966 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,380.0
Rated Power (BHP): 1,851

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	115	120	116	108	107	108	109	106
1500	1.137.1	1.525	113	118	114	106	105	106	107	104
1400	924.5	1.240	112	117	112	105	103	105	105	102
1300	740.2	993	110	115	110	103	102	105	103	101
1200	582.2	781	109	114	109	102	100	103	102	100
1100	448.4	601	107	112	107	100	99	102	100	98
1000	336.9	452	106	110	104	100	99	102	95	90
900	245.6	329	105	109	103	99	98	101	94	89
800	172.5	231	104	108	102	98	97	100	93	88
700	115.6	155	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	102	109	103	94	94	95	95	91
1500	1.137.1	1.525	100	107	101	92	92	93	94	89
1400	924.5	1.240	98	106	100	91	90	91	92	87
1300	740.2	993	97	103	98	91	91	91	91	86
1200	582.2	781	95	102	96	89	89	90	89	84
1100	448.4	601	94	100	95	88	88	88	88	83
1000	336.9	452	93	101	92	89	87	87	82	78
900	245.6	329	91	99	90	87	86	85	80	76
800	172.5	231	90	98	89	86	85	84	79	75
700	115.6	155	89	97	88	85	84	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	95	103	97	88	87	88	89	84
1500	1.137.1	1.525	93	101	95	86	85	86	87	82
1400	924.5	1.240	92	99	93	84	84	85	85	81
1300	740.2	993	90	97	91	84	84	85	84	79
1200	582.2	781	89	95	90	83	82	83	83	78
1100	448.4	601	87	94	88	81	81	82	81	76
1000	336.9	452	86	94	85	82	80	80	75	71
900	245.6	329	85	93	84	81	79	79	74	70
800	172.5	231	84	92	83	80	78	78	73	68
700	115.6	155	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM8966 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,380.0
Rated Power (BHP): 1,851

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	103	99	98	95	98	98	96	100
1500	1.137.1	1.525	102	98	97	94	97	97	95	99
1400	924.5	1.240	102	97	96	93	96	97	95	98
1300	740.2	993	101	98	95	91	96	96	93	97
1200	582.2	781	101	97	94	90	95	96	93	96
1100	448.4	601	100	96	94	89	94	95	92	95
1000	336.9	452	99	96	93	89	94	95	91	95
900	245.6	329	99	95	92	88	93	94	91	94
800	172.5	231	98	95	92	88	92	93	90	94
700	115.6	155	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	91	87	86	83	86	86	84	88
1500	1.137.1	1.525	90	86	85	82	85	85	83	87
1400	924.5	1.240	90	85	84	81	84	85	83	87
1300	740.2	993	89	86	83	79	84	85	81	85
1200	582.2	781	89	85	82	78	83	84	81	84
1100	448.4	601	88	84	82	77	82	83	80	83
1000	336.9	452	87	84	81	77	82	83	80	83
900	245.6	329	87	83	80	76	81	82	79	82
800	172.5	231	86	83	80	76	81	81	78	82
700	115.6	155	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.380.0	1.851	85	81	80	77	80	80	78	82
1500	1.137.1	1.525	85	80	79	76	79	80	78	81
1400	924.5	1.240	84	80	79	76	79	79	77	81
1300	740.2	993	83	80	77	73	78	79	76	79
1200	582.2	781	83	79	77	72	77	78	75	78
1100	448.4	601	82	79	76	72	77	78	74	78
1000	336.9	452	82	78	75	71	76	77	74	77
900	245.6	329	81	77	75	70	75	76	73	76
800	172.5	231	80	77	74	70	75	76	72	76
700	115.6	155	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9230 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,051.0
Rated Power (BHP): 1,409

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	113	118	113	106	104	106	106	103
1500	866.0	1.161	111	116	112	104	103	104	105	102
1400	704.1	944	110	115	110	103	101	103	104	100
1300	563.7	756	109	114	109	102	100	103	102	100
1200	443.4	595	107	112	107	100	99	102	100	98
1100	341.5	458	106	111	106	99	97	101	99	97
1000	256.6	344	105	109	103	99	98	101	94	89
900	187.1	251	104	108	102	98	97	100	93	88
800	131.4	176	103	107	101	97	96	99	92	87
700	88.0	118	102	106	100	96	95	98	91	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	99	107	101	92	91	92	93	88
1500	866.0	1.161	98	105	99	90	90	91	92	87
1400	704.1	944	97	104	98	89	89	90	90	86
1300	563.7	756	95	102	96	89	89	90	89	84
1200	443.4	595	94	100	95	88	88	88	88	83
1100	341.5	458	93	99	94	87	86	87	87	82
1000	256.6	344	91	99	90	87	86	85	80	76
900	187.1	251	90	98	89	86	85	84	79	75
800	131.4	176	89	97	88	85	84	83	78	74
700	88.0	118	88	96	87	84	83	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	93	100	94	85	85	86	86	82
1500	866.0	1.161	91	99	93	84	83	84	85	80
1400	704.1	944	90	97	91	82	82	83	84	79
1300	563.7	756	89	95	90	83	82	83	83	78
1200	443.4	595	87	94	88	81	81	82	81	76
1100	341.5	458	86	93	87	80	80	81	80	75
1000	256.6	344	85	93	84	81	79	79	74	70
900	187.1	251	84	92	83	80	78	78	73	69
800	131.4	176	83	91	82	79	77	77	72	68
700	88.0	118	82	90	81	78	76	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9230 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,051.0
Rated Power (BHP): 1,409

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	103	99	98	95	98	98	96	100
1500	866.0	1.161	102	98	97	94	97	97	95	99
1400	704.1	944	102	97	96	93	96	97	95	98
1300	563.7	756	101	98	95	91	96	96	93	97
1200	443.4	595	101	97	94	90	95	96	93	96
1100	341.5	458	100	96	94	89	94	95	92	95
1000	256.6	344	99	96	93	89	94	95	91	95
900	187.1	251	99	95	92	88	93	94	91	94
800	131.4	176	98	95	92	88	92	93	90	94
700	88.0	118	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	91	87	86	83	86	86	84	88
1500	866.0	1.161	90	86	85	82	85	85	83	87
1400	704.1	944	90	85	84	81	84	85	83	87
1300	563.7	756	89	86	83	79	84	85	81	85
1200	443.4	595	89	85	82	78	83	84	81	84
1100	341.5	458	88	84	82	77	82	83	80	83
1000	256.6	344	87	84	81	77	82	83	80	83
900	187.1	251	87	83	80	76	81	82	79	82
800	131.4	176	86	83	80	76	81	81	78	82
700	88.0	118	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.051.0	1.409	85	81	80	77	80	80	78	82
1500	866.0	1.161	85	80	79	76	79	80	78	81
1400	704.1	944	84	80	79	76	79	79	77	81
1300	563.7	756	83	80	77	73	78	79	76	79
1200	443.4	595	83	79	77	72	77	78	75	78
1100	341.5	458	82	79	76	72	77	78	74	78
1000	256.6	344	82	78	75	71	76	77	74	77
900	187.1	251	81	77	75	70	75	76	73	76
800	131.4	176	80	77	74	70	75	76	72	76
700	88.0	118	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9231 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,014.0
Rated Power (BHP): 1,360

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	112	117	113	105	104	106	106	103
1500	835.5	1.120	111	116	112	104	103	104	105	102
1400	679.3	911	110	115	110	103	101	103	103	100
1300	543.9	729	108	113	108	101	100	103	101	99
1200	427.8	574	107	112	107	100	99	102	100	98
1100	329.5	442	106	111	106	99	97	100	99	97
1000	247.6	332	105	109	103	99	98	101	94	89
900	180.5	242	104	108	102	98	97	100	93	88
800	126.8	170	103	107	101	97	96	99	92	87
700	84.9	114	102	106	100	96	95	98	91	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	99	107	101	92	91	92	93	88
1500	835.5	1.120	98	105	99	90	90	91	91	87
1400	679.3	911	96	104	98	89	88	89	90	85
1300	543.9	729	95	101	96	89	89	89	89	84
1200	427.8	574	94	100	95	88	87	88	88	83
1100	329.5	442	93	99	94	87	86	87	87	82
1000	247.6	332	91	99	90	87	86	85	80	76
900	180.5	242	90	98	89	86	85	84	79	75
800	126.8	170	89	97	88	85	84	83	78	74
700	84.9	114	88	96	87	84	83	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	92	100	94	85	84	86	86	81
1500	835.5	1.120	91	99	93	84	83	84	85	80
1400	679.3	911	90	97	91	82	82	83	83	79
1300	543.9	729	88	95	89	82	82	83	82	77
1200	427.8	574	87	94	88	81	81	82	81	76
1100	329.5	442	86	92	87	80	80	80	80	75
1000	247.6	332	85	93	84	81	79	79	74	70
900	180.5	242	84	92	83	80	78	78	73	69
800	126.8	170	83	91	82	79	77	77	72	68
700	84.9	114	82	90	81	78	76	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9231 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,014.0
Rated Power (BHP): 1,360

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	103	99	98	95	98	98	96	100
1500	835.5	1.120	102	98	97	94	97	97	95	99
1400	679.3	911	102	97	96	93	96	97	95	98
1300	543.9	729	101	98	95	91	96	96	93	97
1200	427.8	574	101	97	94	90	95	96	93	96
1100	329.5	442	100	96	94	89	94	95	92	95
1000	247.6	332	99	96	93	89	94	95	91	95
900	180.5	242	99	95	92	88	93	94	91	94
800	126.8	170	98	95	92	88	92	93	90	94
700	84.9	114	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	91	87	86	83	86	86	84	88
1500	835.5	1.120	90	86	85	82	85	85	83	87
1400	679.3	911	90	85	84	81	84	85	83	87
1300	543.9	729	89	86	83	79	84	85	81	85
1200	427.8	574	89	85	82	78	83	84	81	84
1100	329.5	442	88	84	82	77	82	83	80	83
1000	247.6	332	87	84	81	77	82	83	80	83
900	180.5	242	87	83	80	76	81	82	79	82
800	126.8	170	86	83	80	76	81	81	78	82
700	84.9	114	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.014.0	1.360	85	81	80	77	80	80	78	82
1500	835.5	1.120	85	80	79	76	79	80	78	81
1400	679.3	911	84	80	79	76	79	79	77	81
1300	543.9	729	83	80	77	73	78	79	76	79
1200	427.8	574	83	79	77	72	77	78	75	78
1100	329.5	442	82	79	76	72	77	78	74	78
1000	247.6	332	82	78	75	71	76	77	74	77
900	180.5	242	81	77	75	70	75	76	73	76
800	126.8	170	80	77	74	70	75	76	72	76
700	84.9	114	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9232 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 955.0
Rated Power (BHP): 1,281

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	112	117	113	105	104	105	106	103
1500	786.9	1.055	111	116	111	104	102	104	104	101
1400	639.8	858	109	114	110	102	101	102	103	100
1300	512.2	687	108	113	108	101	99	103	101	99
1200	402.9	540	107	112	107	100	98	101	100	98
1100	310.3	416	106	111	106	99	97	100	99	97
1000	233.2	313	105	109	103	99	98	101	94	89
900	170.0	228	103	107	101	97	96	99	92	88
800	119.4	160	103	107	101	97	96	99	92	87
700	80.0	107	102	106	100	96	95	98	91	86

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	99	106	100	91	91	92	92	88
1500	786.9	1.055	97	105	99	90	89	90	91	86
1400	639.8	858	96	103	97	88	88	89	90	85
1300	512.2	687	95	101	96	89	88	89	89	84
1200	402.9	540	93	100	94	87	87	88	87	82
1100	310.3	416	92	99	93	86	86	87	86	81
1000	233.2	313	91	99	90	87	86	85	80	76
900	170.0	228	90	98	89	86	85	84	79	75
800	119.4	160	89	97	88	85	84	83	78	74
700	80.0	107	88	96	87	84	83	82	77	73

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	92	100	94	85	84	85	86	81
1500	786.9	1.055	91	98	92	83	83	84	84	80
1400	639.8	858	89	97	91	82	81	82	83	78
1300	512.2	687	88	95	89	82	82	83	82	77
1200	402.9	540	87	93	88	81	81	81	81	76
1100	310.3	416	86	92	87	80	79	80	80	75
1000	233.2	313	85	93	84	81	79	79	74	69
900	170.0	228	83	91	82	79	78	77	72	68
800	119.4	160	83	91	82	79	77	77	72	67
700	80.0	107	82	90	81	78	76	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9232 **Change Level:** 00

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 955.0
Rated Power (BHP): 1,281

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	103	99	98	95	98	98	96	100
1500	786.9	1.055	102	98	97	94	97	97	95	99
1400	639.8	858	102	97	96	93	96	97	95	98
1300	512.2	687	101	98	95	91	96	96	93	97
1200	402.9	540	101	97	94	90	95	96	93	96
1100	310.3	416	100	96	94	89	94	95	92	95
1000	233.2	313	99	96	93	89	94	95	91	95
900	170.0	228	99	95	92	88	93	94	91	94
800	119.4	160	98	95	92	88	92	93	90	94
700	80.0	107	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	91	87	86	83	86	86	84	88
1500	786.9	1.055	90	86	85	82	85	85	83	87
1400	639.8	858	90	85	84	81	84	85	83	87
1300	512.2	687	89	86	83	79	84	85	81	85
1200	402.9	540	89	85	82	78	83	84	81	84
1100	310.3	416	88	84	82	77	82	83	80	83
1000	233.2	313	87	84	81	77	82	83	80	83
900	170.0	228	87	83	80	76	81	82	79	82
800	119.4	160	86	83	80	76	81	81	78	82
700	80.0	107	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	955.0	1.281	85	81	80	77	80	80	78	82
1500	786.9	1.055	85	80	79	76	79	80	78	81
1400	639.8	858	84	80	79	76	79	79	77	81
1300	512.2	687	83	80	77	73	78	79	76	79
1200	402.9	540	83	79	77	72	77	78	75	78
1100	310.3	416	82	79	76	72	77	78	74	78
1000	233.2	313	82	78	75	71	76	77	74	77
900	170.0	228	81	77	75	70	75	76	73	76
800	119.4	160	80	77	74	70	75	76	72	76
700	80.0	107	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9244 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,678.0
Rated Power (BHP): 2,250

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	117	122	118	110	108	110	110	108
1700	1.413.6	1.896	115	120	116	108	107	108	108	106
1600	1.178.5	1.580	114	119	114	107	105	107	107	104
1500	971.1	1.302	112	117	113	105	104	105	106	103
1400	789.5	1.059	111	116	111	104	102	104	104	101
1300	632.1	848	109	114	109	102	101	104	102	100
1200	497.2	667	108	113	108	101	99	102	101	99
1100	383.0	514	107	112	107	100	98	101	100	98
1000	287.7	386	105	109	103	99	98	101	94	90
900	209.8	281	104	108	102	98	97	100	93	89
800	147.3	198	103	107	101	97	96	99	92	88
700	98.7	132	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	104	112	106	97	96	96	96	93
1700	1.413.6	1.896	102	110	104	95	94	95	94	92
1600	1.178.5	1.580	100	108	102	93	92	93	94	89
1500	971.1	1.302	99	106	100	91	91	92	92	88
1400	789.5	1.059	97	105	99	90	89	90	91	86
1300	632.1	848	96	102	97	90	90	90	90	85
1200	497.2	667	94	101	95	88	88	89	88	83
1100	383.0	514	93	100	94	87	87	88	87	82
1000	287.7	386	92	100	91	88	86	86	81	77
900	209.8	281	91	99	90	87	85	85	80	76
800	147.3	198	90	98	89	86	84	84	79	75
700	98.7	132	89	97	88	85	83	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	97	105	99	90	89	90	89	87
1700	1.413.6	1.896	95	103	97	89	87	88	88	85
1600	1.178.5	1.580	94	101	95	86	86	87	87	83
1500	971.1	1.302	92	100	94	85	84	85	86	81
1400	789.5	1.059	91	98	92	83	83	84	84	80
1300	632.1	848	89	96	90	83	83	84	83	78
1200	497.2	667	88	94	89	82	82	82	82	77
1100	383.0	514	87	93	88	81	80	81	81	76
1000	287.7	386	85	93	84	81	80	79	74	70
900	209.8	281	84	92	83	80	79	78	73	69
800	147.3	198	83	91	82	79	78	77	72	68
700	98.7	132	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9244 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,678.0
Rated Power (BHP): 2,250

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	104	99	100	98	99	100	98	102
1700	1.413.6	1.896	104	98	99	97	99	100	97	101
1600	1.178.5	1.580	103	99	98	95	98	98	96	100
1500	971.1	1.302	102	98	97	94	97	97	95	99
1400	789.5	1.059	102	97	96	93	96	97	95	98
1300	632.1	848	101	98	95	91	96	96	93	97
1200	497.2	667	101	97	94	90	95	96	93	96
1100	383.0	514	100	96	94	89	94	95	92	95
1000	287.7	386	99	96	93	89	94	95	91	95
900	209.8	281	99	95	92	88	93	94	91	94
800	147.3	198	98	95	92	88	92	93	90	94
700	98.7	132	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	92	87	88	86	87	88	86	90
1700	1.413.6	1.896	92	86	87	85	87	88	85	90
1600	1.178.5	1.580	91	87	86	83	86	86	84	88
1500	971.1	1.302	90	86	85	82	85	85	83	87
1400	789.5	1.059	90	85	84	81	84	85	83	87
1300	632.1	848	89	86	83	79	84	85	81	85
1200	497.2	667	89	85	82	78	83	84	81	84
1100	383.0	514	88	84	82	77	82	83	80	83
1000	287.7	386	87	84	81	77	82	83	80	83
900	209.8	281	87	83	80	76	81	82	79	82
800	147.3	198	86	83	80	76	81	81	78	82
700	98.7	132	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.678.0	2.250	87	81	82	80	81	83	80	84
1700	1.413.6	1.896	86	81	81	79	81	82	80	84
1600	1.178.5	1.580	85	81	80	77	80	80	78	82
1500	971.1	1.302	85	80	79	76	79	80	78	81
1400	789.5	1.059	84	80	79	76	79	79	77	81
1300	632.1	848	83	80	77	73	78	79	76	79
1200	497.2	667	83	79	77	72	77	78	75	78
1100	383.0	514	82	79	76	72	77	78	74	78
1000	287.7	386	82	78	75	71	76	77	74	77
900	209.8	281	81	77	75	70	75	76	73	76
800	147.3	198	80	77	74	70	75	76	72	76
700	98.7	132	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9245 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,763.5
Rated Power (BHP): 2,365

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	117	122	118	110	109	110	110	108
1700	1.485.6	1.992	116	121	117	109	107	109	108	106
1600	1.238.6	1.661	114	119	115	107	106	107	108	105
1500	1.020.5	1.369	113	118	113	106	104	106	106	103
1400	829.7	1.113	111	116	111	104	102	104	105	101
1300	664.3	891	110	115	110	103	101	104	103	101
1200	522.5	701	108	113	108	101	100	103	101	99
1100	402.5	540	107	112	107	100	98	101	100	98
1000	302.4	406	106	110	104	100	99	102	95	90
900	220.4	296	104	108	102	98	97	100	93	89
800	154.8	208	103	107	101	97	96	99	92	88

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	104	112	106	98	96	97	97	94
1700	1.485.6	1.992	102	110	105	96	94	95	95	92
1600	1.238.6	1.661	101	108	102	93	93	94	94	90
1500	1.020.5	1.369	99	107	101	92	91	92	93	88
1400	829.7	1.113	98	105	99	90	90	91	91	87
1300	664.3	891	96	103	97	90	90	91	90	85
1200	522.5	701	95	101	96	89	88	89	89	84
1100	402.5	540	93	100	94	87	87	88	87	82
1000	302.4	406	92	100	91	88	87	86	81	77
900	220.4	296	91	99	90	87	85	85	80	76
800	154.8	208	90	98	89	86	84	84	79	75

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	97	105	100	91	89	90	90	87
1700	1.485.6	1.992	96	104	98	89	88	88	88	86
1600	1.238.6	1.661	94	102	96	87	86	87	88	83
1500	1.020.5	1.369	93	100	94	85	85	86	86	82
1400	829.7	1.113	91	98	92	83	83	84	85	80
1300	664.3	891	90	96	91	84	83	84	84	79
1200	522.5	701	88	95	89	82	82	83	82	77
1100	402.5	540	87	93	88	81	81	81	81	76
1000	302.4	406	86	94	85	82	80	80	75	70
900	220.4	296	84	92	83	80	79	78	73	69
800	154.8	208	83	91	82	79	78	77	72	68

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9245 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,763.5
Rated Power (BHP): 2,365

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	104	99	100	98	99	100	98	102
1700	1.485.6	1.992	104	98	99	97	99	100	97	101
1600	1.238.6	1.661	103	99	98	95	98	98	96	100
1500	1.020.5	1.369	102	98	97	94	97	97	95	99
1400	829.7	1.113	102	97	96	93	96	97	95	98
1300	664.3	891	101	98	95	91	96	96	93	97
1200	522.5	701	101	97	94	90	95	96	93	96
1100	402.5	540	100	96	94	89	94	95	92	95
1000	302.4	406	99	96	93	89	94	95	91	95
900	220.4	296	99	95	92	88	93	94	91	94
800	154.8	208	98	95	92	88	92	93	90	94

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	92	87	88	86	87	88	86	90
1700	1.485.6	1.992	92	86	87	85	87	88	85	90
1600	1.238.6	1.661	91	87	86	83	86	86	84	88
1500	1.020.5	1.369	90	86	85	82	85	85	83	87
1400	829.7	1.113	90	85	84	81	84	85	83	87
1300	664.3	891	89	86	83	79	84	85	81	85
1200	522.5	701	89	85	82	78	83	84	81	84
1100	402.5	540	88	84	82	77	82	83	80	83
1000	302.4	406	87	84	81	77	82	83	80	83
900	220.4	296	87	83	80	76	81	82	79	82
800	154.8	208	86	83	80	76	81	81	78	82

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.763.5	2.365	87	81	82	80	81	83	80	84
1700	1.485.6	1.992	86	81	81	79	81	82	80	84
1600	1.238.6	1.661	85	81	80	77	80	80	78	82
1500	1.020.5	1.369	85	80	79	76	79	80	78	81
1400	829.7	1.113	84	80	79	76	79	79	77	81
1300	664.3	891	83	80	77	73	78	79	76	79
1200	522.5	701	83	79	77	72	77	78	75	78
1100	402.5	540	82	79	76	72	77	78	74	78
1000	302.4	406	82	78	75	71	76	77	74	77
900	220.4	296	81	77	75	70	75	76	73	76
800	154.8	208	80	77	74	70	75	76	72	76

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9246 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: D-RATING (INTERMITTENT DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,901.5
Rated Power (BHP): 2,550

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.901.5	2.550	118	123	119	111	110	111	111	109
1700	1.601.9	2.148	116	121	117	109	108	109	109	107
1600	1.335.5	1.791	115	120	115	108	106	108	108	105
1500	1.100.4	1.476	113	118	114	106	105	106	107	104
1400	894.7	1.200	112	117	112	105	103	105	105	102
1300	716.3	961	110	115	110	103	101	105	103	101
1200	563.4	756	109	114	109	102	100	103	102	100
1100	434.0	582	107	112	107	100	99	102	100	98
1000	326.0	437	106	110	104	100	99	102	95	90
900	237.7	319	105	109	103	99	98	101	94	89
800	166.9	224	103	107	101	97	96	99	92	88
700	111.8	150	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.901.5	2.550	105	113	107	98	97	97	97	95
1700	1.601.9	2.148	103	111	105	97	95	96	96	93
1600	1.335.5	1.791	101	109	103	94	93	94	95	90
1500	1.100.4	1.476	100	107	101	92	92	93	93	89
1400	894.7	1.200	98	106	100	91	90	91	92	87
1300	716.3	961	97	103	98	91	90	91	91	86
1200	563.4	756	95	102	96	89	89	90	89	84
1100	434.0	582	94	100	95	88	88	88	88	83
1000	326.0	437	92	100	91	88	87	86	81	77
900	237.7	319	91	99	90	87	86	85	80	76
800	166.9	224	90	98	89	86	85	84	79	75
700	111.8	150	89	97	88	85	83	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1800	1.901.5	2.550	98	106	100	92	90	91	91	88
1700	1.601.9	2.148	96	104	99	90	88	89	89	86
1600	1.335.5	1.791	95	102	96	87	87	88	88	84
1500	1.100.4	1.476	93	101	95	86	85	86	87	82
1400	894.7	1.200	92	99	93	84	84	85	85	81
1300	716.3	961	90	97	91	84	84	85	84	79
1200	563.4	756	89	95	90	83	82	83	83	78
1100	434.0	582	87	94	88	81	81	82	81	76
1000	326.0	437	86	94	85	82	80	80	75	71
900	237.7	319	85	93	84	81	79	79	74	69
800	166.9	224	83	91	82	79	78	77	72	68
700	111.8	150	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9246 **Change Level:** 02

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: D-RATING (INTERMITTENT DUTY)

Rated Speed (RPM): 1,800
Rated Power (BKW): 1,901.5
Rated Power (BHP): 2,550

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1800	1.901.5	2.550	104	99	100	98	99	100	98	102
1700	1.601.9	2.148	104	98	99	97	99	100	97	101
1600	1.335.5	1.791	103	99	98	95	98	98	96	100
1500	1.100.4	1.476	102	98	97	94	97	97	95	99
1400	894.7	1.200	102	97	96	93	96	97	95	98
1300	716.3	961	101	98	95	91	96	96	93	97
1200	563.4	756	101	97	94	90	95	96	93	96
1100	434.0	582	100	96	94	89	94	95	92	95
1000	326.0	437	99	96	93	89	94	95	91	95
900	237.7	319	99	95	92	88	93	94	91	94
800	166.9	224	98	95	92	88	92	93	90	94
700	111.8	150	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1800	1.901.5	2.550	92	87	88	86	87	88	86	90
1700	1.601.9	2.148	92	86	87	85	87	88	85	90
1600	1.335.5	1.791	91	87	86	83	86	86	84	88
1500	1.100.4	1.476	90	86	85	82	85	85	83	87
1400	894.7	1.200	90	85	84	81	84	85	83	87
1300	716.3	961	89	86	83	79	84	85	81	85
1200	563.4	756	89	85	82	78	83	84	81	84
1100	434.0	582	88	84	82	77	82	83	80	83
1000	326.0	437	87	84	81	77	82	83	80	83
900	237.7	319	87	83	80	76	81	82	79	82
800	166.9	224	86	83	80	76	81	81	78	82
700	111.8	150	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1800	1.901.5	2.550	87	81	82	80	81	83	80	84
1700	1.601.9	2.148	86	81	81	79	81	82	80	84
1600	1.335.5	1.791	85	81	80	77	80	80	78	82
1500	1.100.4	1.476	85	80	79	76	79	80	78	81
1400	894.7	1.200	84	80	79	76	79	79	77	81
1300	716.3	961	83	80	77	73	78	79	76	79
1200	563.4	756	83	79	77	72	77	78	75	78
1100	434.0	582	82	79	76	72	77	78	74	78
1000	326.0	437	82	78	75	71	76	77	74	77
900	237.7	319	81	77	75	70	75	76	73	76
800	166.9	224	80	77	74	70	75	76	72	76
700	111.8	150	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9253 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,350.0
Rated Power (BHP): 1,810

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	115	120	115	108	106	108	108	105
1500	1.112.4	1.492	113	118	114	106	105	106	107	104
1400	904.4	1.213	112	117	112	105	103	105	105	102
1300	724.1	971	110	115	110	103	101	105	103	101
1200	569.5	764	109	114	109	102	100	103	102	100
1100	438.7	588	107	112	107	100	99	102	100	98
1000	329.6	442	106	110	104	100	99	102	95	90
900	240.3	322	105	109	103	99	98	101	94	89
800	168.8	226	103	107	101	97	96	99	92	88
700	113.0	152	102	106	100	96	95	98	91	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	101	109	103	94	93	95	95	90
1500	1.112.4	1.492	100	107	101	92	92	93	94	89
1400	904.4	1.213	98	106	100	91	90	91	92	87
1300	724.1	971	97	103	98	91	90	91	91	86
1200	569.5	764	95	102	96	89	89	90	89	84
1100	438.7	588	94	100	95	88	88	88	88	83
1000	329.6	442	93	101	92	89	87	87	82	77
900	240.3	322	91	99	90	87	86	85	80	76
800	168.8	226	90	98	89	86	85	84	79	75
700	113.0	152	89	97	88	85	84	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	95	102	96	87	87	88	89	84
1500	1.112.4	1.492	93	101	95	86	85	86	87	82
1400	904.4	1.213	92	99	93	84	84	85	85	81
1300	724.1	971	90	97	91	84	84	85	84	79
1200	569.5	764	89	95	90	83	82	83	83	78
1100	438.7	588	87	94	88	81	81	82	81	76
1000	329.6	442	86	94	85	82	80	80	75	71
900	240.3	322	85	93	84	81	79	79	74	70
800	168.8	226	83	91	82	79	78	77	72	68
700	113.0	152	82	90	81	78	77	76	71	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9253 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: A RATING (UNRESTRICTED CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,350.0
Rated Power (BHP): 1,810

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	103	99	98	95	98	98	96	100
1500	1.112.4	1.492	102	98	97	94	97	97	95	99
1400	904.4	1.213	102	97	96	93	96	97	95	98
1300	724.1	971	101	98	95	91	96	96	93	97
1200	569.5	764	101	97	94	90	95	96	93	96
1100	438.7	588	100	96	94	89	94	95	92	95
1000	329.6	442	99	96	93	89	94	95	91	95
900	240.3	322	99	95	92	88	93	94	91	94
800	168.8	226	98	95	92	88	92	93	90	94
700	113.0	152	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	91	87	86	83	86	86	84	88
1500	1.112.4	1.492	90	86	85	82	85	85	83	87
1400	904.4	1.213	90	85	84	81	84	85	83	87
1300	724.1	971	89	86	83	79	84	85	81	85
1200	569.5	764	89	85	82	78	83	84	81	84
1100	438.7	588	88	84	82	77	82	83	80	83
1000	329.6	442	87	84	81	77	82	83	80	83
900	240.3	322	87	83	80	76	81	82	79	82
800	168.8	226	86	83	80	76	81	81	78	82
700	113.0	152	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.350.0	1.810	85	81	80	77	80	80	78	82
1500	1.112.4	1.492	85	80	79	76	79	80	78	81
1400	904.4	1.213	84	80	79	76	79	79	77	81
1300	724.1	971	83	80	77	73	78	79	76	79
1200	569.5	764	83	79	77	72	77	78	75	78
1100	438.7	588	82	79	76	72	77	78	74	78
1000	329.6	442	82	78	75	71	76	77	74	77
900	240.3	322	81	77	75	70	75	76	73	76
800	168.8	226	80	77	74	70	75	76	72	76
700	113.0	152	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9254 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,425.0
Rated Power (BHP): 1,911

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	115	120	116	108	107	108	109	106
1500	1.174.2	1.575	114	119	114	107	105	107	107	104
1400	954.6	1.280	112	117	113	105	104	105	106	103
1300	764.3	1.025	110	115	110	103	102	105	103	101
1200	601.2	806	109	114	109	102	100	103	102	100
1100	463.1	621	107	112	107	100	99	102	100	98
1000	347.9	467	106	110	104	100	99	102	95	91
900	253.6	340	105	109	103	99	98	101	94	89
800	178.1	239	104	108	102	98	97	100	93	88
700	119.3	160	103	107	101	97	96	99	92	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	102	109	103	94	94	95	96	91
1500	1.174.2	1.575	100	108	102	93	92	93	94	89
1400	954.6	1.280	99	106	100	91	91	92	92	88
1300	764.3	1.025	97	104	98	91	91	92	91	86
1200	601.2	806	96	102	97	90	89	90	90	85
1100	463.1	621	94	101	95	88	88	89	88	83
1000	347.9	467	93	101	92	89	87	87	82	78
900	253.6	340	91	99	90	87	86	85	80	76
800	178.1	239	90	98	89	86	85	84	79	75
700	119.3	160	89	97	88	85	84	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	95	103	97	88	87	88	89	84
1500	1.174.2	1.575	94	101	95	86	86	87	87	83
1400	954.6	1.280	92	100	94	85	84	85	86	81
1300	764.3	1.025	90	97	91	84	84	85	84	79
1200	601.2	806	89	95	90	83	83	83	83	78
1100	463.1	621	87	94	88	81	81	82	81	76
1000	347.9	467	86	94	85	82	81	80	75	71
900	253.6	340	85	93	84	81	79	79	74	70
800	178.1	239	84	92	83	80	78	78	73	69
700	119.3	160	83	91	82	79	77	77	72	67

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9254 **Change Level:** 03

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: B-RATING (HEAVY DUTY)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,425.0
Rated Power (BHP): 1,911

MECHANICAL Sound Pressure Data (OBCF) **Distance: 1 Meters (3.3 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	103	99	98	95	98	98	96	100
1500	1.174.2	1.575	102	98	97	94	97	97	95	99
1400	954.6	1.280	102	97	96	93	96	97	95	98
1300	764.3	1.025	101	98	95	91	96	96	93	97
1200	601.2	806	101	97	94	90	95	96	93	96
1100	463.1	621	100	96	94	89	94	95	92	95
1000	347.9	467	99	96	93	89	94	95	91	95
900	253.6	340	99	95	92	88	93	94	91	94
800	178.1	239	98	95	92	88	92	93	90	94
700	119.3	160	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) **Distance: 7 Meters (23.0 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	91	87	86	83	86	86	84	88
1500	1.174.2	1.575	90	86	85	82	85	85	83	87
1400	954.6	1.280	90	85	84	81	84	85	83	87
1300	764.3	1.025	89	86	83	79	84	85	81	85
1200	601.2	806	89	85	82	78	83	84	81	84
1100	463.1	621	88	84	82	77	82	83	80	83
1000	347.9	467	87	84	81	77	82	83	80	83
900	253.6	340	87	83	80	76	81	82	79	82
800	178.1	239	86	83	80	76	81	81	78	82
700	119.3	160	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) **Distance: 15 Meters (49.2 Feet)**

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.425.0	1.911	85	81	80	77	80	80	78	82
1500	1.174.2	1.575	85	80	79	76	79	80	78	81
1400	954.6	1.280	84	80	79	76	79	79	77	81
1300	764.3	1.025	83	80	77	73	78	79	76	79
1200	601.2	806	83	79	77	72	77	78	75	78
1100	463.1	621	82	79	76	72	77	78	74	78
1000	347.9	467	82	78	75	71	76	77	74	77
900	253.6	340	81	77	75	70	75	76	73	76
800	178.1	239	80	77	74	70	75	76	72	76
700	119.3	160	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9255 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,500.0
Rated Power (BHP): 2,012

EXHAUST Sound Pressure Data (OBCF) Distance: 1.5 Meters (4.9 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.500.0	2.012	116	121	116	109	107	109	109	106
1500	1.236.0	1.657	114	119	115	107	106	107	108	105
1400	1.004.9	1.348	112	117	113	105	104	105	106	103
1300	804.6	1.079	111	116	111	104	102	105	104	102
1200	632.8	849	109	114	109	102	101	104	102	100
1100	487.4	654	108	113	108	101	99	102	101	99
1000	366.2	491	106	110	104	100	99	102	95	91
900	267.0	358	105	109	103	99	98	101	94	90
800	187.5	251	104	108	102	98	97	100	93	88
700	125.6	168	103	107	101	97	96	99	92	87

EXHAUST Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.500.0	2.012	102	110	104	95	94	96	96	91
1500	1.236.0	1.657	101	108	102	93	93	94	94	90
1400	1.004.9	1.348	99	107	101	92	91	92	93	88
1300	804.6	1.079	97	104	98	91	91	92	91	86
1200	632.8	849	96	102	97	90	90	90	90	85
1100	487.4	654	94	101	95	88	88	89	88	83
1000	366.2	491	93	101	92	89	87	87	82	78
900	267.0	358	92	100	91	88	86	86	81	77
800	187.5	251	90	98	89	86	85	84	79	75
700	125.6	168	89	97	88	85	84	83	78	74

EXHAUST Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED	ENGINE POWER	ENGINE POWER	OVERALL	125 HZ	250 HZ	500 HZ	1000 HZ	2000 HZ	4000 HZ	8000 HZ
RPM	BKW	BHP	DB(A)	DB	DB	DB	DB	DB	DB	DB
1600	1.500.0	2.012	96	103	97	88	88	89	90	85
1500	1.236.0	1.657	94	102	96	87	86	87	88	83
1400	1.004.9	1.348	92	100	94	85	84	85	86	81
1300	804.6	1.079	91	97	92	85	85	85	85	80
1200	632.8	849	89	96	90	83	83	84	83	78
1100	487.4	654	88	94	89	82	81	82	82	77
1000	366.2	491	86	94	85	82	81	80	75	71
900	267.0	358	85	93	84	81	80	79	74	70
800	187.5	251	84	92	83	80	78	78	73	69
700	125.6	168	83	91	82	79	77	77	72	68

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

Performance Number: DM9255 **Change Level:** 01

Sales Model: 3512C
Application: MARINE PROPULSION
Rating Level: C-RATING (MAXIMUM CONTINUOUS)

Rated Speed (RPM): 1,600
Rated Power (BKW): 1,500.0
Rated Power (BHP): 2,012

MECHANICAL Sound Pressure Data (OBCF) Distance: 1 Meters (3.3 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1600	1.500.0	2.012	103	99	98	95	98	98	96	100
1500	1.236.0	1.657	102	98	97	94	97	97	95	99
1400	1.004.9	1.348	102	97	96	93	96	97	95	98
1300	804.6	1.079	101	98	95	91	96	96	93	97
1200	632.8	849	101	97	94	90	95	96	93	96
1100	487.4	654	100	96	94	89	94	95	92	95
1000	366.2	491	99	96	93	89	94	95	91	95
900	267.0	358	99	95	92	88	93	94	91	94
800	187.5	251	98	95	92	88	92	93	90	94
700	125.6	168	97	94	91	87	92	93	90	93

MECHANICAL Sound Pressure Data (OBCF) Distance: 7 Meters (23.0 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1600	1.500.0	2.012	91	87	86	83	86	86	84	88
1500	1.236.0	1.657	90	86	85	82	85	85	83	87
1400	1.004.9	1.348	90	85	84	81	84	85	83	87
1300	804.6	1.079	89	86	83	79	84	85	81	85
1200	632.8	849	89	85	82	78	83	84	81	84
1100	487.4	654	88	84	82	77	82	83	80	83
1000	366.2	491	87	84	81	77	82	83	80	83
900	267.0	358	87	83	80	76	81	82	79	82
800	187.5	251	86	83	80	76	81	81	78	82
700	125.6	168	85	82	79	75	80	81	78	81

MECHANICAL Sound Pressure Data (OBCF) Distance: 15 Meters (49.2 Feet)

ENGINE SPEED RPM	ENGINE POWER BKW	ENGINE POWER BHP	OVERALL DB(A)	125 HZ DB	250 HZ DB	500 HZ DB	1000 HZ DB	2000 HZ DB	4000 HZ DB	8000 HZ DB
1600	1.500.0	2.012	85	81	80	77	80	80	78	82
1500	1.236.0	1.657	85	80	79	76	79	80	78	81
1400	1.004.9	1.348	84	80	79	76	79	79	77	81
1300	804.6	1.079	83	80	77	73	78	79	76	79
1200	632.8	849	83	79	77	72	77	78	75	78
1100	487.4	654	82	79	76	72	77	78	74	78
1000	366.2	491	82	78	75	71	76	77	74	77
900	267.0	358	81	77	75	70	75	76	73	76
800	187.5	251	80	77	74	70	75	76	72	76
700	125.6	168	80	76	73	69	74	75	72	75

Data Date: 3/29/2011 Sound Performance Number: DM8779-06

TORSIONAL VIBRATION DATA

3500 DAMPER SELECTION MATRIX FOR MARINE APPLICATIONS									
Damper Group	Damper Part No.	Damper Adapter	Adapter Inertia (kgm^2)	Damper hsg. Inertia (kgm^2)	Damper Ring Inertia (kgm^2)	Engine	Stiffness (MNm/rad)	Damping (Nmsec/rad)	Surface Area (m^2)
8N-7182 (21")	193-3288	7W-3409	0.555	1.15	1.639	D3508	0.367	508	0.314
						D3512	0.169	565	
						3516	0.328	650	
8N-0339 (23")	146-3740	1N-3482	0.216	3.327	5.616	3508	0.75	1300	0.553
						3512	0.4	1000	
						3516	0.429	1130	
125-9749 (23")	171-4571	1N-3482	0.216	3.327	5.616	3508	0.75	1300	0.562
						3512	0.4	1000	
						3516	0.429	1130	
240-7762 (23" HCF)	244-4508	1N-3482	0.216	3.27	5.81	3512	See HCF Damper Table	See HCF Damper Table	0.562
						3516			
248-0197 (23" HCF)	247-0845	1N-3482	0.216	3.27	5.81	3512	See HCF Damper Table	See HCF Damper Table	0.562
						3516			

Permissible Damper Loading:

Thermal breakdown of silicone fluid can occur at temperatures above 100°C. Therefore, the permissible damper load values are estimated based on this limit. The permissible damper loading values (kW/m^2) depend on the damper surface area, ambient temperature, and engine speed. For estimating the permissible damper loads, we assumed ambient temperatures of 50°C and 65°C with reasonably good ventilation around the damper.

Allowable damper thermal load for 21" damper @ 50°C and @ 65°C:

The allowable heat load varies somewhat linearly with engine speed.

- 50°C → 800 rpm - 2.8 kW/m^2, 2100 rpm - 6.1 kW/m^2
- 65°C → 800 rpm - 2.2 kW/m^2, 2100 rpm - 4.8 kW/m^2

Allowable damper thermal load for 23" damper @ 50°C and @ 65°C:

The allowable heat load varies somewhat linearly with engine speed.

- 50°C → 800 rpm - 3.4 kW/m^2, 2100 rpm - 7.3 kW/m^2
- 65°C → 800 rpm - 2.6 kW/m^2, 2100 rpm - 5.8 kW/m^2

HCF DAMPER TABLE GROUP 240-7762, DAMPER 244-4508 STIFFNESS (MNm/rad)													
Temp. (°C)	Frequency (hz)												
	5	10	20	30	40	50	60	70	80	120	140	160	180
32	.145	.207	.297	.366	.425	.477	.524	.568	.608	.750	.813	.871	.926
40	.122	.178	.261	.326	.382	.431	.477	.519	.559	.698	.760	.818	.873
50	.099	.149	.224	.284	.336	.383	.427	.467	.505	.642	.702	.760	.814
63	.077	.120	.186	.240	.288	.332	.373	.411	.448	.579	.638	.695	.749
80	.057	.092	.149	.197	.240	.280	.318	.353	.387	.512	.569	.624	.677
100	.042	.070	.118	.159	.198	.234	.268	.300	.332	.450	.505	.557	.609
125	.029	.052	.091	.126	.159	.191	.222	.251	.280	.389	.441	.492	.541

HCF DAMPER TABLE GROUP 240-7762, DAMPER 244-4508 DAMPING (Nmsec/rad)													
Temp. (°C)	Frequency (hz)												
	5	10	20	30	40	50	60	70	80	120	140	160	180
32	14349	8791	5385	4043	3299	2818	2477	2221	2021	1518	1361	1238	1139
40	12874	7998	4969	3761	3087	2648	2337	2102	1918	1452	1306	1191	1099
50	11328	7154	4518	3453	2853	2461	2181	1969	1802	1377	1243	1138	1053
63	9702	6250	4027	3114	2594	2252	2006	1819	1671	1292	1172	1077	999
80	8060	5318	3509	2751	2315	2025	1815	1655	1528	1198	1092	1008	939
100	6622	4481	3032	2413	2052	1809	1633	1497	1388	1105	1013	940	879
125	5325	3706	2579	2086	1795	1597	1452	1339	1279	1010	932	869	817

HCF DAMPER TABLE GROUP 248-0197, DAMPER 247-0845 STIFFNESS (MNm/rad)										
Temp. (°C)	Frequency (hz)									
	30	40	50	60	70	80	120	140	160	180
32	.366	.425	.477	.524	.568	.608	.750	.813	.871	.926
40	.326	.382	.431	.477	.519	.559	.698	.760	.818	.873
50	.284	.336	.383	.427	.467	.505	.642	.702	.760	.814
63	.240	.288	.332	.373	.411	.448	.579	.638	.695	.749
80	.197	.240	.280	.318	.353	.387	.512	.596	.624	.677
100	.159	.198	.234	.268	.300	.332	.450	.505	.557	.609
125	.126	.159	.191	.222	.251	.280	.389	.441	.492	.541

HCF DAMPER TABLE GROUP 248-0197, DAMPER 247-0845 DAMPING (Nmsec/rad)										
Temp. (°C)	Frequency (hz)									
	30	40	50	60	70	80	120	140	160	180
32	4043	3299	2818	2477	2221	2021	1518	1361	1238	1139
40	3761	3087	2648	2337	2102	1918	1452	1306	1191	1099
50	3453	2853	2461	2181	1969	1802	1377	1243	1138	1053
63	3114	2594	2252	2006	1819	1671	1292	1172	1077	999
80	2751	2315	2025	1815	1655	1528	1198	1092	1008	939
100	2413	2052	1809	1633	1497	1388	1105	1013	940	879
125	2086	1795	1597	1452	1339	1279	1010	932	869	817

3500 ATTACHMENT SELECTION MATRIX FOR MARINE APPLICATIONS		
Name/Feature Code	Part Number	Inertia (kgm^2)
Flywheel	243-3216	14.61
Flywheel	243-3221	14.61
Flywheel	1N-3770	5.875
Flywheel	7N-7732	5.875
CRKPL01 (crankshaft pulley 197 mm)	7N-4106	0.060
CRKPL02 (crankshaft pulley 248 mm)	8N-6564	0.119
SHAFT01 (low hp stub shaft)	7N-7057	0.0598
SHAFT02 (high hp stub shaft)	7W-3579	0.158
HPDRHF0 (hydraulic pump mounting)	Adapter 7W-0287	0.112
	Coupling 2W-8014	0.536
HPDRHF2 (hydraulic pump mounting)	Adapter 7W-3415	0.524
	Coupling 2W-8014	0.536
FRENCL6 (front enclosed clutch w/21" damper)	Clutch 3N-4130	0.123 (2 drive plates)
		0.867 (total)
	Coupling 2W-8014	0.536
	Adapter 7W-3415	0.524
FRENCL7 (front enclosed clutch w/23" damper)	Clutch 3N-4130	0.123 (2 drive plates)
		0.867 (total)
	Coupling 2W-8014	0.536
	Adapter 7W-0287	0.112

3500 HARMONIC COMPONENTS[1]/TANGENTIAL PRESSURES/CYLINDER				
Harmonic Order	Real Component Cosine Term (kPa)		Imaginary Component Sine term (kPa)[2]	
	0.0 kPa (BMEP)	2068.5 kPa (BMEP)	0.0 kPa (BMEP)	2068.5 kPa (BMEP)
0.5	54.34	579.05	-87.62	-577.74
1	30.56	305.24	-145.48	-1061.48
1.5	10.13	54.76	-171.59	-921.34
2	-1.09	-87.08	-149.26	-790.93
2.5	-8.99	-107.22	-151.22	-626.96
3	-10.36	-110.25	-127.89	-512.18
3.5	-12.51	-118.58	-112.43	-415.31
4	-13.44	-120.67	-93.35	-319.32
4.5	-13.67	-111.17	-73.66	-242.57
5	-10.92	-94.38	-61.55	-193.66
5.5	-9.89	-85.87	-51.41	-153.76
6	-8.04	-79.28	-44.10	-115.29
6.5	-6.67	-64.78	-37.80	-85.72
7	-5.27	-54.05	-32.00	-67.68
7.5	-4.56	-48.26	-26.59	-53.93
8	-3.71	-44.17	-21.97	-38.72
8.5	-2.98	-35.89	-18.09	-27.37
9	-2.22	-29.86	-14.91	-21.88
9.5	-2.09	-26.77	-12.55	-17.63
10	-2.22	-24.77	-10.52	-12.01
10.5	-1.86	-18.99	-8.53	-7.86
11	-1.52	-16.71	-7.54	-6.61
11.5	-1.24	-15.28	-6.55	-5.87

[1]Table includes gas only harmonics; inertial harmonics are not included. The Harmonic Components are determined by calculating the engine's BMEP for the load case being analyzed, then interpolating from the above table.

[2]See notes on Caterpillar sign convention for TVA on pages 133-134.

Engine Front End Amplitude Limits

+/- 1.00 degree for 0.5 and 1st orders

+/- 0.25 degree for 1.5 order

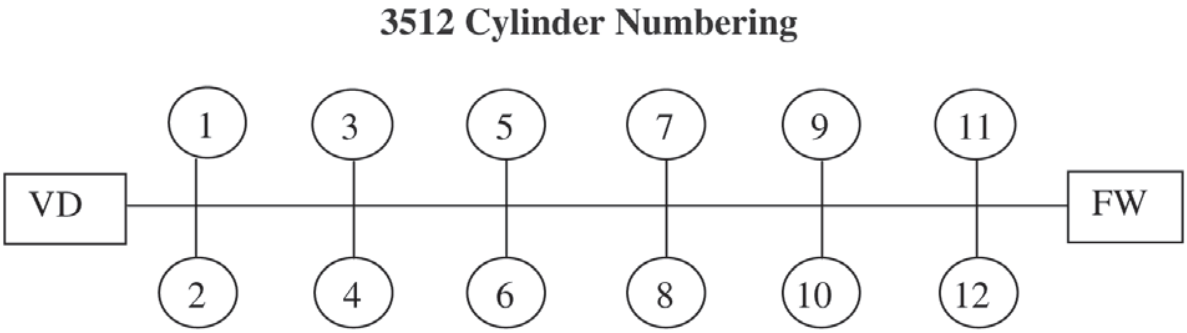
+/- 0.15 degree for all other orders above 1.5

Crankshaft Stress Limits

+/- 21 Mpa for single order

In the event that the above limits are exceeded, the customer must contact Caterpillar!

3512 Torsional Vibration Data Marine Applications

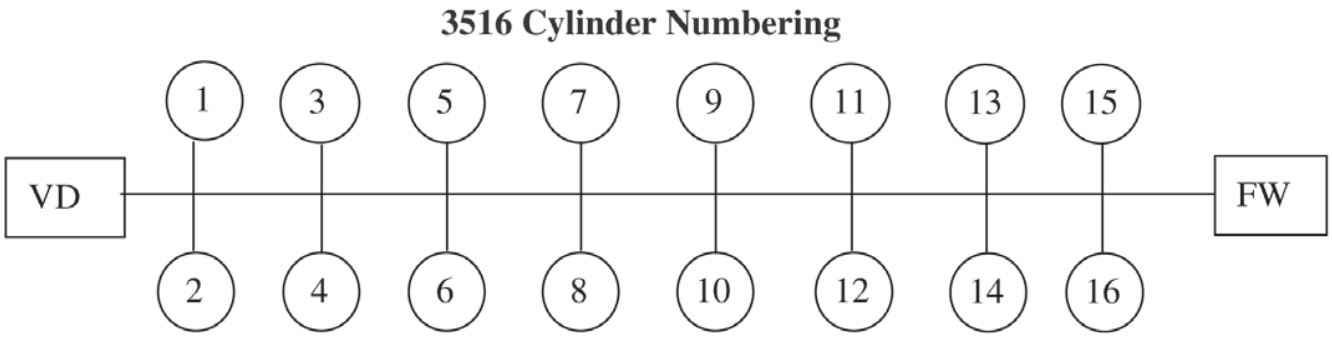


3512 CYLINDER PHASE ANGLES (FIRING ORDER)		
Cylinder Number	Phase Angle (degrees)	
	Std. Rotation CCW	Rev. Rotation CW
1	0	0
2	420	300
3	480	480
4	180	60
5	240	240
6	660	540
7	600	600
8	300	180
9	120	120
10	540	420
11	360	360
12	60	660

Caterpillar TVA Sign Convention

Engines are usually viewed from the rear, at which point the crankshaft is rotating counterclockwise (CCW). This view creates **leading sign convention**, whereas most mathematical systems work with a **lagging sign convention**. Therefore the signs (+ve or -ve) for imaginary components of tangential pressures based on the sign convention of the Caterpillar TVA will be different from most of the commercial FFT programs. Analysts performing torsional analysis using torsional codes other than Caterpillar TVA code need to consult Caterpillar regarding the sign convention before using the values given in this table.

3516 Torsional Vibration Data Marine Applications



3512 CYLINDER PHASE ANGLES (FIRING ORDER)		
Cylinder Number	Phase Angle (degrees)	
	Std. Rotation CCW	Rev. Rotation CW
1	0	0
2	60	660
3	180	180
4	240	120
5	90	90
6	150	30
7	630	630
8	690	570
9	270	270
10	330	210
11	450	450
12	510	390
13	540	540
14	600	480
15	360	360
16	420	300

Caterpillar TVA Sign Convention

Engines are usually viewed from the rear, at which point the crankshaft is rotating counterclockwise (CCW). This view creates **leading sign convention**, whereas most mathematical systems work with a **lagging sign convention**. Therefore the signs (+ve or -ve) for imaginary components of tangential pressures based on the sign convention of the Caterpillar TVA will be different from most of the commercial FFT programs. Analysts performing torsional analysis using torsional codes other than Caterpillar TVA code need to consult Caterpillar regarding the sign convention before using the values given in this table.

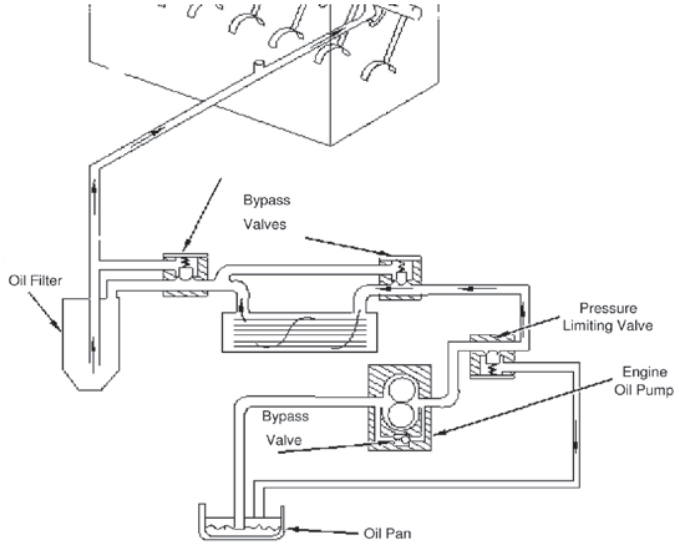
LUBRICATION OIL SYSTEM

GENERAL

The lube system is designed to provide a constant supply of filtered oil from 570 to 630 kPa (83 to 91 psi) pressure under all engine operating conditions. The lube system contains an oil cooler, oil filter, gear-driven oil pump, pre-lube pump and an oil pan that meets marine tilt requirements.

INTERNAL LUBRICATION SYSTEM

This system uses an engine oil pump with three pump gears. The pump gears are driven by the front gear train. Oil is pulled from the pan through suction bell and through the elbow by the engine oil pump. The suction bell has a screen in order to clean the engine oil.



There is an engine oil relief valve in the engine oil pump. The engine oil relief valve controls the pressure of the engine oil from the engine oil pump. The engine oil pump can put too much engine oil into the system. When there is too much engine oil, the engine oil pressure goes up and the relief valve opens. This allows the engine oil that is not needed to go back to the inlet oil passage of the engine oil pump.

The engine oil pump pushes engine oil through the engine oil cooler and through the engine oil filters to the main oil gallery and through the camshaft oil gallery. The engine oil cooler lowers the temperature of the engine oil before it is sent to the filters.

The engine oil cooler bypass valve allows engine oil to flow directly to the filters if the engine oil cooler becomes plugged. The engine oil cooler bypass valve also allows engine oil to flow directly to the filters if the engine oil becomes thick. The engine oil cooler bypass valve will bypass the engine oil to the filters above 180 ± 20 kPa (26 ± 3 psi) of oil pressure differential.

Cartridge type filters are used. The filters are located in an engine oil filter housing. Cartridge type filters use a single bypass valve that is located in the engine oil filter housing.

Clean engine oil from the filters flows through the engine oil line and into the block through the elbow. Part of the engine oil flows to the left camshaft oil gallery. The remainder of the engine oil flows to the main oil gallery.

The main oil gallery and left camshaft oil gallery are connected to each camshaft bearing by a drilled hole. The engine oil flows around each camshaft journal. The engine oil then travels through the cylinder head and through the rocker arm housing to the rocker arm shaft. A drilled hole connects the bores for the valve lifters to the oil hole for the rocker arm shaft. The valve lifters are lubricated at the top of each stroke.

The main oil gallery is connected to the main bearings by drilled holes. Drilled holes in the crankshaft connect the main bearing oil supply to the rod bearings. Engine oil from the rear of the main oil gallery goes to the rear of right camshaft oil gallery.

Sequence valves allow engine oil from the main oil gallery to flow to the piston cooling jet galleries. The sequence valves begin to open at approximately 130 kPa (19 psi). The sequence valves will not allow engine oil into the piston cooling jet galleries until there is pressure in the main oil gallery. This decreases the amount of time that is necessary for pressure buildup when the engine is started. This also helps hold pressure at idle speed.

Oil Pump

The oil pump provides high-pressure oil flow to the engine. Oil is drawn up from the sump by the oil pump. There is a pressure relief valve on the outlet of the of oil pump that will open and feed the oil back to the inlet side of the pump. The oil pump is designed to deliver more oil to the engine than what is required. This way the engine still receives the correct amount of oil even if the pump is slightly worn. The ECU is programmed to first give a warning of low lube oil pressure then shut the engine down. A map of engine oil pressure versus engine rpm gives the pressure at which the engine is shut down.

Prelubrication (Optional Caterpillar Supply)

A prelubrication electric pump is available from Caterpillar if the operator requires one. It is highly advisable to fit a prelubrication sump pump to the engine. This electric prelube system uses a package-mounted pump that is engaged immediately prior to engine start-up.

The prelubrication pump will fill the engine galleries from the engine oil sump until the presence of oil is sensed at the upper portion of the lubrication system. A prelubrication pump will minimize the sometimes severe engine wear associated with starting the engine after periods of idleness.

3500 series engines do not require prelubrication before starting. Not having prelubrication pumps installed will not affect engine maintenance or warranty.

Lubricating Oil Cooler

The lubricating oil cooler controls the temperature of the oil that's delivered to the engine. This cooler is cooled via the jacket water. The flow of oil through the cooler is controller by an oil temperature regulator control valve. To reduce the risks of contamination the lube oil is supplied to the cooler at a higher pressure then that of the jacket water.

Oil Filter

From the lube oil cooler the engine oil passes through the primary engine oil filters before passing through the engine oil ways and returning to the engine's sump. Caterpillar supplies the primary lubricating oil filter as standard. The ECU will automatically warn the operator of high fuel filter differential pressure. The default setting is 105 kPa but this can be programmed to other values if required.

Centrifugal Lube Oil Filter (Optional Caterpillar Supply)

If required, Caterpillar can supply a centrifugal oil filter which is designed to remove soot and other fine particles. This would be used in addition to the engine lube oil filter/lube oil duplex oil filters. This would be highly recommended to increase oil life on high-hour commercial applications where a separator is not present.

Duplex Filters – Class Requirement (Optional Caterpillar Supply)

Many Cat engines can be equipped with duplex oil filters, which can be serviced without shutting off the engine. There are two types: the symmetrical type, which has two identical filter sets, and the main auxiliary type, which has a main filter set and a smaller capacity auxiliary set.

It is possible to run both filter sets simultaneously to extend running time in an emergency. One set of filters is required to satisfy the requirements of classification societies.

Note: If duplex lube oil filters are fitted, they will replace the standard lube oil filters that are fitted on the engine.

Emergency Oil Standby Pump

3500 series engines are available with optional connections for emergency oil pumps. These options are available in the pricelist and can be selected at the time of order.

Emergency oil pumps are connected in parallel with the engine oil pump. The oil is pulled directly from the oil pan and must re-enter the lubrication system before the oil cooler and oil filters.

Use caution when deciding to install and use emergency oil pumps as further damage may occur, depending on the cause of the original oil pump failure and the resultant damage.

Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the emergency connections required for emergency lube oil operation.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

The Cat dealer is able to supply the emergency pump required to maintain lube oil pressure and circulation, should the engine-driven pump fail.

Oil Mist Detector (Optional Caterpillar Supply)

It is not a classification requirement for an oil mist detector to be fitted to all 3500C series engines. Classification societies require an oil mist detector on any engines that produce more than 2250 bkW. An oil mist detector is required to give early indication of a potential hot spot with the engine's crankcase. Activation of the alarm will enable the operator to take action to prevent damage being caused to the engine.

If an owner specifically requires an oil mist detector (OMD) alarm for a lower powered engine, it should be possible for Caterpillar to fit an OMD at the factory when the engine is manufactured. Consultation with Caterpillar would be required to establish additional costs to the engine build.

Please Note: An OMD will be required for the 3516C series engine as these engines are above the 2250 bkW power threshhold set by classification societies. It can be selected as an option when the order is placed for the engine.

Caterpillar will supply the engine with a fitted OMD if a 3516C series engine is to be prepared to classification society standards.

External Lube Oil Piping

When installing auxiliary elements to the 3500 lube oil on-engine system, external piping will be fitted by the shipyard. These auxiliary elements can be:

- External lube oil storage tanks
- Lube oil purifier
- Emergency oil standby pump

For a good engine performance when fitting external lube oil pipes please follow the following recommendations:

- Keep pressure drops to a minimum by using short, low restriction lines.
- Use a line size at least as large as the engine connection point.
- Install a low restriction strainer in front of the auxiliary element.
- Install a low restriction check valve between the auxiliary element discharge and the engine inlet connection.
- Use a pressure limiting valve in the external equipment set at the maximum oil pressure limit of the engine.
- Follow flushing procedures according to this project guide.

It is a SOLAS requirement that all low-pressure oil lines going to and from the filters are screened to prevent lube oil spraying near hot surfaces that will cause ignition. It is the responsibility of the shipyard that any lube oil connections made on board the ship meet the SOLAS minimum requirements.

Sump Pump (Optional Cat Dealer Supply)

If required, Caterpillar can supply a hand-operated sump pump to assist in changing the engine's lube oil. The Cat dealer is able to supply a 24 volt electrically driven sump pump to assist in changing the engine lube oil.

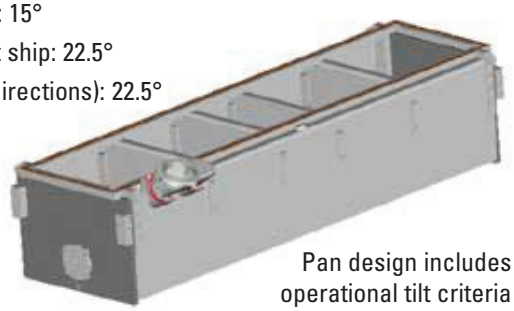
Deep Sump Oil Pan (Optional Caterpillar Supply)

Caterpillar can supply the engine with a deep sump oil pan to double oil change times. In some case where the engines are fitted in an inclined installation such as fishing vessels it is necessary to add a deep sump to ensure the engine is capable of drawing the required amount of lube oil.

Inclination Capability

For marine applications with tilt requirements, the Cat 3500C marine engine uses a deep wet sump and provides:

- Static fore/aft: 15°
- Static athwart ship: 22.5°
- Dynamic (all directions): 22.5°



Pan design includes operational tilt criteria

Customer Piping Connections

Engine Connections

- Oil fill and drain: 38 mm (1-1/2 in. 12 TAP)

Oil Requirements

Due to significant variations in the quality and performance of commercially available lubrication oils, Caterpillar recommends the oils listed in the following table for the 3500C engine. Additional information can be found in publication PEHJ0059.

CAT® DEO (DIESEL ENGINE OIL) FOR 3500C DIESEL ENGINE

SAE Viscosity Grade	TBN	Ambient Temperature	
		Minimum	Maximum
SAE 15W-40	11.3	-9.50°C (15°F)	50°C (122°F)
SAE 10W-30	11.3	-18°C (0°F)	40°C (140°F)

Use of Commercial Oil

Caterpillar does not recommend the names of other commercial brands of lube oils, but has established guidelines for their use. Commercially available lubrication oils may be used in Cat 3500 engines, but they must have proof of performance in Caterpillar field performance evaluation, included in Cat document SEBU6251.

Oil Change Interval

To achieve maximum life from the engine oil and provide optimum protection for the internal engine components, a Scheduled Oil Sampling analysis (S•O•S℠) should be used. This program is available through the Cat dealer network. If an S•O•S analysis program is not available, the oil change interval is recommended in accordance with the following table.

OIL CHANGE INTERVALS FOR 3500C DIESEL ENGINES

Engine Model	Lube Oil Capacity	Oil Change Interval
3512C	625 L (165 gal)	1000 Service Hours
3516C	807 L (213 gal)	1000 Service Hours

Scheduled Oil Sampling

TBN, viscosity and oil consumption trends must be analyzed every 250 hours. The S•O•S analysis involves a two-part test program:

- **Wear Analysis.** The wear analysis identifies engine wear elements present in the oil. These elements indicate the condition of the engine.
- **Oil Condition Analysis.** The oil condition analysis identifies the wear status of the oil. The program will determine oil change intervals based on trend analysis and condemning limits established for the engine.

Change Interval without Oil Analysis Results

- If S•O•S analysis results are not available, the initial oil change interval should be used to determine oil change intervals. Even though oil sampling results may not be available on the recommended 250-hour intervals, oil samples should be analyzed at every oil change period, even if the turnaround time for the data is long.

CRANKCASE EMISSIONS

CLOSED CRANKCASE VENTILATION (CCV)

Crankcase emissions result from combustion byproducts and/or exhaust fumes escaping around the piston rings and into the crankcase, commonly called blow-by. If not controlled, this blow-by can contaminate the lube oil and pressurize the crankcase, possibly leading to an oil leak.

Venting the emissions to the atmosphere is a simple solution to release the pressure and trapped fumes. Managing the emissions, however, adds complexity to crankcase ventilation systems.

Current 3500C diesel engines are provided with a closed-loop, on-engine crankcase filtration system.

In combination with Caterpillar 3500C high efficiency on fuel delivery, air management, electronics, and combustion design, the closed crankcase filtration system improves the exhaust emissions reductions by eliminating crankcase emissions.

The Closed Crankcase Ventilation (CCV) fumes disposal is equipped with a service indicator. If the fumes disposal filter becomes plugged prior to the normal service interval, increased restriction of the filter will cause the vacuum to become positive. When the pressure continues to rise, the service indicator will show through the cap. The service indicator indicates the need for the fumes disposal filter to be changed.

For the current data on the lube system please reference LEBW4958 in Electronic Media Center.

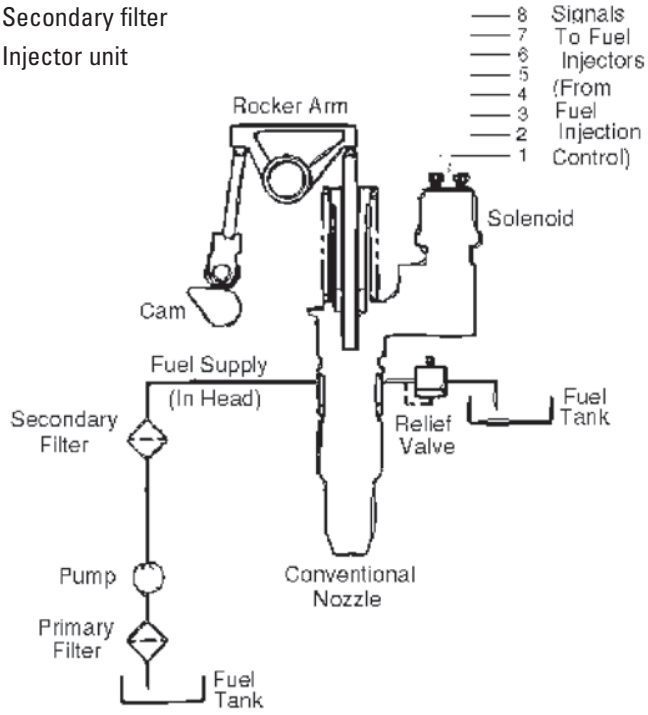
For safety, crankcase relief valves are installed on CCV engines.

FUEL SYSTEM

GENERAL

The 3500C engine uses a direct injection fuel system, electronically controlled. The major components of the fuel system are:

- Fuel tank
- Primary filter
- Fuel pump
- Secondary filter
- Injector unit



Fuel Tank

The supply system must assure a continuous, clean supply of fuel. The tanks should not exceed the height of the engine fuel injectors in order to prevent possible leakage of fuel into the cylinders. If a higher position is required, check valves with backpressures set to the fuel column height must be installed.

Cat fuel transfer pumps lifting capability is equivalent to 40 kPa (5.8 psi) inlet restriction.

Fuel Transfer Pump

The fuel supply circuit uses a fuel transfer pump to deliver fuel from the fuel tank to the electronic fuel injectors. The transfer pump is a fixed displacement gear pump with a 21 L/min capacity at 415 kPa and 2400 rpm. The minimum bypass cracking pressure is 620 kPa and the maximum bypass full-open pressure is 965 kPa.

The fuel pump delivers more fuel to the engine then what's required at maximum load, with the excess fuel being returned to the day tank. The excess fuel removes heat from the injectors and cools the engine's pipe work.

Fuel Filters

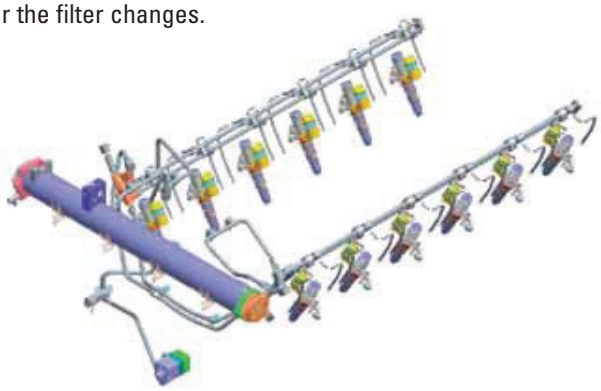
The fuel passes through a primary set of engine fuel filters that are on the engine before entering the fuel manifold. The ECU will automatically warn the operator of high fuel filter differential pressure. The default setting is 105 kPa but this can be programmed to other values if required.

Unless otherwise specified the engine will be supplied from Caterpillar with standard spin oil fuel filters. It is highly recommended that operators fit Duplex filters to the engine.

Please Note: Duplex filters are a class requirement.

Secondary Filter

The fuel flows through a 4-micron fuel filter before entering the fuel supply manifold. A fuel priming pump is located on the fuel filter base in order to fill the system. The system must be primed after the filter changes.



Fuel Pressure Regulating Valve

A pressure-regulating valve maintains a fuel pressure in the manifold of 415 to 450 kPA (60 to 65 psi). This is the pressure that is required to ensure proper filling of the injectors.

Electric Fuel Injector Units

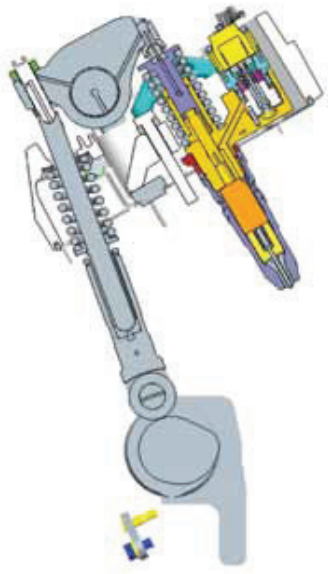
The fuel injector units are controlled by the ECU for precise timing and delivery of the fuel.

The fuel flows continuously from the fuel supply manifold through the fuel injectors. The fuel flows when either the supply or the fill port in the injector is not closed by the injector body assembly plunger. The fuel that is not injected into the cylinder is returned to the tank through the fuel return manifold.

A pressure-regulating valve is at the end of the fuel return manifold. The pressure-regulating valve controls the entire fuel system pressure. This provides proper filling of the fuel injectors.

The MEUI system provides total electronic control of injection timing. The injection timing is varied to optimize the engine's performance.

The timing ring is part of the rear gear group. The engine speed/timing sensor monitors the timing ring for detection of crankshaft position and for engine speed. Other information and this data allow the ECU to correctly send a signal to the injector solenoids. The fuel injector's solenoid is energized in order to begin fuel injection. The fuel injector's solenoid is de-energized to end fuel injection.



EXTERNAL FUEL SYSTEM DESIGN CONSIDERATIONS

Diesel fuel supply systems must ensure a continuous and clean supply of fuel to the engine's fuel system. The fuel system is designed for distillate fuel, requiring viscosity ranging from 1.4 cSt to 20 cSt at 38°C (100°F). The external fuel system typically has three major components: a fuel storage system, a fuel transfer system and fuel filtration system; and each of these systems demand careful attention to ensure the success of each installation.

Fuel Storage System

The minimum pressure at the transfer pump is:

- -40 kPa(g) with dirty primary filters
- -20 kPa(g) with clean primary filters

The maximum pressure is 30 kPa(g).

Cat fuel transfer pumps' lifting capability is equivalent to 40 kPa inlet restriction.

Fuel Transfer System

Line Restriction – The piping carrying fuel to the fuel transfer pump and the return line carrying excess fuel to the tank should be no smaller than the engine connections. The maximum inlet flow restriction is 20 kPa at rated speed. Air in the system causes hard starting and erratic engine operation and will erode injectors.

Return Line – The return line should enter the top of the tank without shutoff valves. Bypass (return) fuel leaving the engine pressure regulator should be returned to the engine day tank. The maximum allowable fuel return line restriction is 60 kPa.

Fuel Filtration System

Primary Fuel Filter – Caterpillar requires the use of a primary filter/separator prior to the fuel booster pump. On-engine filtration consists of a secondary 4-micron fuel filter.

Miscellaneous Fuel System Considerations

Flexible Connections – Connections to the engine must be flexible hose and must be located directly at the engine inlet and outlet to accommodate engine motion.

Fuel Temperature – Engines are power set at the factory with 66°C (151°F) fuel to the engine transfer pump. Higher fuel temperatures will reduce fuel stop power capability. The "fuel stop" power reduction is 1% for each 5.6°C (10°F) fuel supply temperature increase above 30°C (86°F). If the engine is operating below the "fuel stop" limit, the governor will add fuel as required to maintain the required engine speed. The classification societies have a maximum return to tank fuel temperature. This temperature is related to the fuel flash point. The minimum allowable viscosity of the fuel entering the engine is 1.4 cSt.

Fuel Coolers – The 3500C has minimal fuel heat rejection therefore the need for fuel coolers is project-specific and depends greatly on day-tank size and location. Calculations for determining the need for a fuel cooler are contained in publication LEBW4976 (Diesel – Fuels and Fuel Systems) and publication REHS4726. Refer to the following table for fuel heat rejection data. If a heat exchanger is used, it must not contain copper. When copper comes in contact with the fuel it has been found to cause issues with the 3500C engines. The max fuel inlet temp is 70°C.

FUEL COOLER FUEL FLOW AND HEAT REJECTION

Engine	Rated Speed	Max Fuel Flow to Return Line	Fuel Heat Rejection
3500C	1600-1800 rpm	20.41 L/min (5.37 U.S. gal/min)	0.123 kW (40 Btu/min)

Fuel Coolers (Optional Cat Dealer Supply)

The need for fuel coolers is project-specific and depends greatly on day-tank size and location.

The excess fuel returned to the fuel tank picks up heat from the injectors and cylinder heads and over a period of time can raise the temperature of the fuel with in the tanks.

To avoid decreased injector life, fuel temperature to the engine must not exceed 150°F (66°C). Caterpillar has started to deliver on-engine plate-type heat exchangers that can cool the engine's jacket water as well as the fuel. In installations where off-engine heat exchangers are used, the Cat dealer is able to supply fuel coolers.

Only if the periods of operation are short will the heat returned to the tank have time to dissipate. If this is the case a fuel cooler may not be required.

Flexibles (Optional Caterpillar Supply)

Flexibles are the fixed pipe work on board the ship that are connected to the engine via flexible fuel lines. The flexible fuel lines can be supplied by Caterpillar. These can be supplied with classification society type approval certificates if required.

Check Valves (Optional Cat Dealer Supply)

If the fuel tank is positioned above the height of the fuel injectors, it will be necessary to install a check valve on both the supply and return lines. If these are not fitted, there is chance that if the engine had a leaky injector and fuel could leak in to the cylinder space when the engine was stopped. Starting the engine in a case like this would lead to a complete failure of the engine.

Duplex Filters – Class Requirement (Optional Caterpillar and Dealer Supply)

3500 series engines can be equipped with duplex fuel filters. These filters may be serviced without shutting off the engine. There are two types: the symmetrical type, which has two identical filter sets, and the main-auxiliary type, which has a main filter set and a smaller capacity auxiliary set.

It is possible to run both filter sets simultaneously to extend running time in an emergency. Typically, two set filters are supplied in the fuel system to satisfy the requirements of classification societies.

Generally, Caterpillar supplies the duplex filters on the engine, replacing the primary fuel filters that are supplied with the engines as standard. The duplex filters off the engine are supplied by the Cat dealer.

Emergency Operation

Some marine applications require the capability to connect an emergency fuel pump to the engine's fuel system. This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure fuel oil pressure and supply if the engine-driven fuel oil pump fails.

Emergency Connections (Optional Cat Dealer Supply)

The Cat dealer would be able to supply emergency connections should the operator require a standby fuel oil pump in the system.

Emergency Pump (Optional Cat Dealer Supply)

The Cat dealer is able to supply the emergency pump required to maintain the fuel oil pressure and supply, should the engine-driven pump fail.

SOLAS Requirements

SOLAS (Safety Of Life At Sea) is a regulation designed to maintain safety of life at sea. A new regulation was introduced in July, 2003 regarding the mandatory use of double-wall, high-pressure fuel lines, hot surface insulation, and improved joint screening. This was introduced to reduce the risk of fire in engine rooms caused by marine engines. (Please refer to SOLAS Ch. II-2 Part A Regulation 15.2.9-11, 15.3 and 15.4).

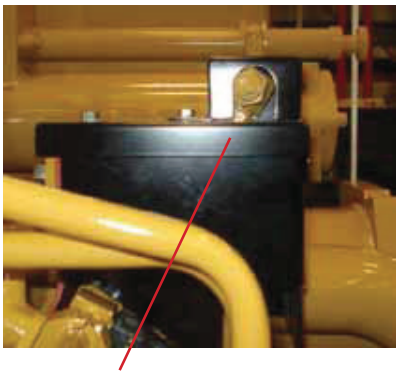
3500C series engines use a low-pressure fuel system, so it is not a requirement for them to have double-walled fuel lines. The fuel line connections before and after the filters mounted on the engine are to be adequately shielded to prevent pressurized fuel being sprayed onto hot surfaces.

The SOLAS tape can be applied in the factory if required, offered as an option on the quoting systems. If this is not done at the factory, the Cat dealer can fit the tape; however, this is quite a labor-intensive process.

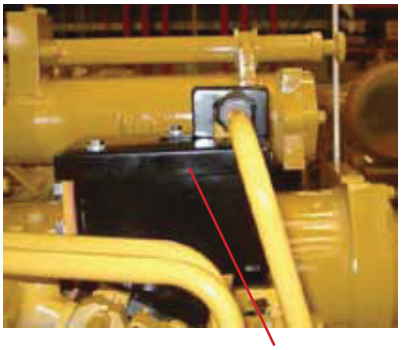
Please Note: This has also been a requirement of certain classification societies for a number of years.

Fuel Shield for Fire Hazard at Sea Prevention

To increase safety regarding fire hazard at sea according to SOLAS rules, a fuel shield is fitted on 3500C TIER 3 engines to guarantee a good protection at the connecting point on the engine for fuel lines, both supply and return. Caterpillar fuel shield design guarantees a perfect alignment between the shield itself and the fuel lines in order to avoid possible wear points because of rubbing of the shield.



246-0457 Shield Group



246-0456 Shield Group

Fuel Recommendations

The fuels recommended for use in Caterpillar 3500C series diesel engines are No. 2-D diesel fuel and No. 2 fuel oil. Refer to publication SEBU6251 for additional explanation of acceptable fuels.

Customer Piping Connections

Engine Fuel Line Connections

- Fuel Supply: 3/4 – 14 NPSM THD
- Excess Fuel Return: 1/2 – 14 NPSM THD

Fuel Recommendations

The fuels recommended for use in Caterpillar 3500C series diesel engines are normally No. 2-D diesel fuel and No. 2 fuel oil, although No. 1 grades are also acceptable. Table 4 lists worldwide fuel standards which meet Caterpillar requirements.

Fuel with CIMAC designation DB, commonly referred to as Marine Diesel Oil (MDO), is an acceptable fuel, provided the fuel complies with Caterpillar fuel recommendations.

WORLDWIDE FUEL STANDARDS[1]

Standard	Name	Description
American	ASTM D975	No. 1-D and No. 2-D Diesel Fuel Oils
	ASTM D396	No. 1-D and No. 2 Fuel Oils
	ASTM D2880	No. 1-GT & No. 2-GT Gas Turbine Fuels
British	BS 2869	Classes A1, A2 and B2 Engine Fuels
	BS 2869	Classes C2 and D Burner Fuels
West German	DIN 51601	Diesel Fuel
	DIN 51603	Heating Oil EL
Australian	AS 3570	Automotive Diesel Fuel
Japanese	JIS K2204	Types 1 (spl), 1, 2, 3, and 3 (spl) Gas Oil
U.S. Government	W-F-800C	DF-1, DF-2 Conus and DF-20 Conus Diesel Fuel
	W-F-815C	FS-1 and FS-2 Burner Fuel Oil
U.S. Military	MIL-L-16884G	Marine Oil

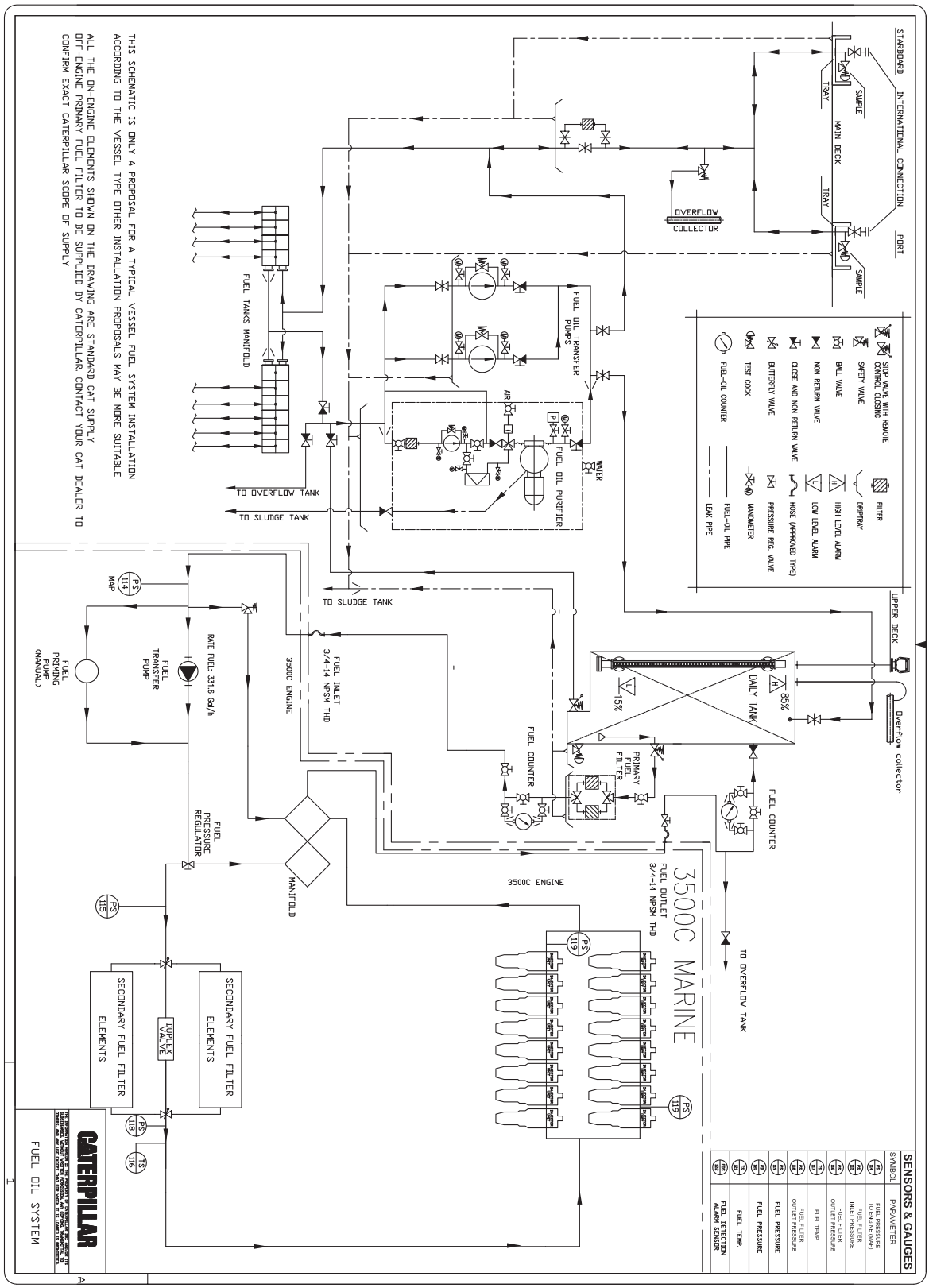
[1]These fuel standards are usually acceptable, but are subject to change. The distillate fuel chart for acceptable limits should be used as the guide for any fuel whether it's listed in this chart or not (consult Caterpillar A&I for acceptability of any other fuels).

Customer Piping Connections

ENGINE FUEL LINE CONNECTIONS

Fuel Supply	Excess Fuel Return
3/4"-14 NPSM THD Flange	1/2"-14 NPSM THD Flange

FUEL OIL SCHEMATIC



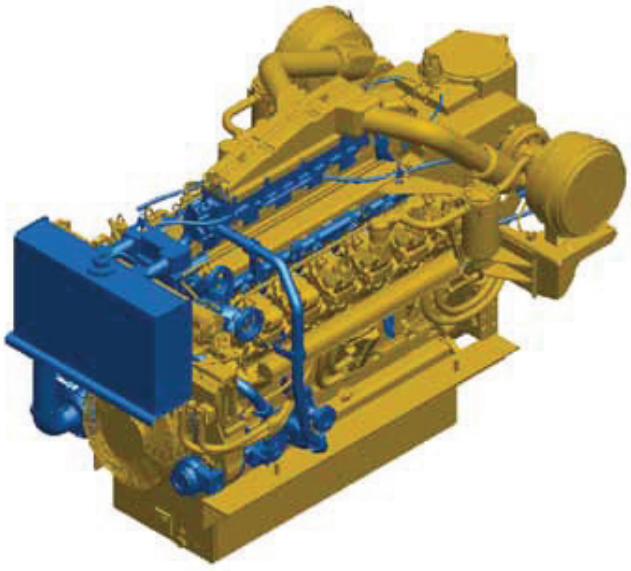
.COOLING SYSTEM

GENERAL

The cooling system configuration for the marine 3500C consists of a jacket water aftercooled system (JWAC) for engine and oil cooling and a separate circuit for turbocharged (charged air) cooling, also known as a SCAC system. So for the 3500C Tier 3 engine the aftercooling system is cooled by mean of two stages – one from the JW pump circuit and another from the SCAC pump circuit – with two passes. This design maintains engine coolant, oil, and intake air at optimum temperatures at all operating conditions.

A titanium-plate heat exchanger is offered as optional, providing a compact, high-efficiency design with low maintenance.

The engine comes from the factory with preservation. The system must be drained and refilled with coolant prior to operation.



INTERNAL COOLING SYSTEM

Fresh Water Pumps

The marine 3500C engine has two gear-driven centrifugal water pumps mounted on-engine. On the front of the engine, the jacket water pump supplies coolant to the oil cooler, block, and heads. The SCAC pump located at the left side of the engine supplies coolant to aftercooler circuit.

A sea water pump is also available as an option at the engine front.

Coolant Temperature Control

The 3500C engine uses fluid inlet sensed, outlet controlled, electronic temperature regulators for uniform coolant temperature to the aftercooler, oil cooler, and cylinder block.

Jacket Water Aftercooled System (JWAC)

Coolant goes into water pump through an elbow. The elbow connects to the radiator or to the heat exchanger. The coolant flow is divided at the outlet of the water pump. Part of the coolant flow is sent to aftercooler and the remainder goes through the engine oil cooler. Coolant that is sent to the aftercooler goes through the aftercooler core. The coolant is sent by an elbow into a passage in cylinder block. The passage is near the center of the vee at the rear of the cylinder block.

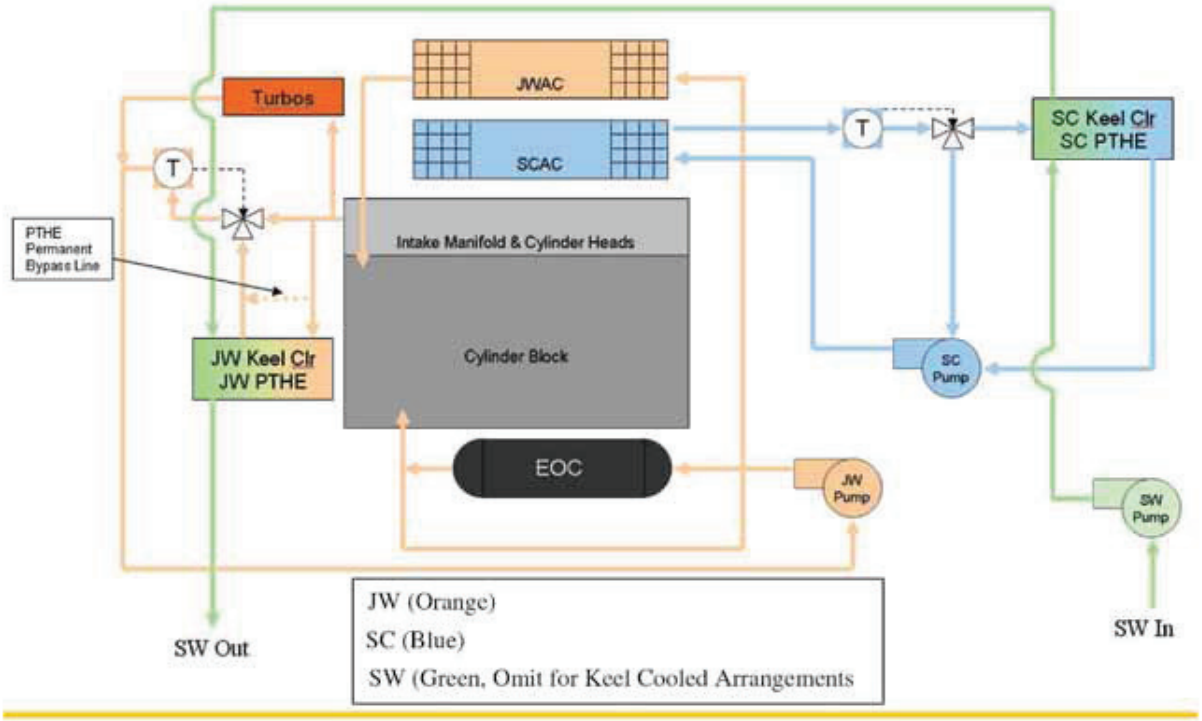
The coolant flows through the engine oil cooler into the water jacket of the cylinder block at the right rear cylinder. The cooler coolant and the hotter coolant are then mixed. The coolant goes to both sides of the cylinder block through distribution manifolds. The distribution manifolds are connected to the water jacket of all the cylinders. The main distribution manifold is located just above the main bearing oil gallery.

The coolant flows upward through the water jackets. The coolant flows around the cylinder liners from the bottom to the top. The hottest temperature is near the top of the cylinder liners. The water jacket is smaller near the top of the cylinder liners. This shelf causes the coolant to flow faster for better liner cooling.

Coolant from the top of the liners goes into the cylinder head. The cylinder head sends the coolant around the hottest parts, then to the top of the cylinder head. The coolant goes out through an elbow at each cylinder head and into the water manifold at each bank of cylinders. Coolant goes through the water manifold to temperature regulator housing.

The water temperature regulator housing has an upper flow section and a lower flow section. The housing uses four temperature regulators. The sensing bulbs of the four temperature regulators are in the lower section of the housing. Before the regulators open, cold coolant is sent through bypass tube back to the inlet of the water pump. As the temperature of the coolant increases and the regulators start to open, the coolant flow in the bypass tube is restricted. Some coolant is sent through the outlets to the radiator or to the heat exchanger.

The total system capacity will depend on the amount of coolant in the following components: cylinder block, radiator, or the heat exchanger and the coolant lines. See the following drawing.



EXTERNAL COOLING SYSTEM

Cooling Methods

The marine 3500C engine can be cooled with off-package-mounted radiators or plate-type heat exchangers. The selected cooling method must provide the required coolant temperature and flow at the SCAC pump inlet to meet the applicable emission requirements. Following is a list of considerations for sizing radiators and heat exchangers.

- Maximum ambient temp
- Maximum cooling water temp
- External cooling water (fresh or sea water)
- Internal cooling water composition (i.e. 50% ethylene glycol)
- Engine performance data (for up-to-date numbers see TMI)

Expansion Tanks

The jacket water circuit and the aftercooler circuit both require an expansion tank. Its primary function is to contain the expansion volume of the coolant as it heats up. The expansion tank size should be at least 15% of the total system volume. This provides for expansion plus reserve. To find out what type of expansion tank your system needs (full flow or partial flow) please see the expansion tank section in the Cooling Systems A&I guide (LEBW4978).

As an option for 3500C marine engines, a shipped loose expansion tank can be included in Caterpillar scope of supply. Specifically the expansion tank supplied by Caterpillar has a maximum capacity of 635 L (167 gal) so it is suitable for use in cooling systems with total volume of 635 liters or less. This expansion tank has already fitted a 14 psi pressure cap to ensure better performance on the cooling system.

CATERPILLAR OFF-ENGINE EXPANSION TANK CAPACITY			
Engine	**Rated Speed**	**Liters**	**U.S. Gal**
3500C	1600-1800 rpm	635	167

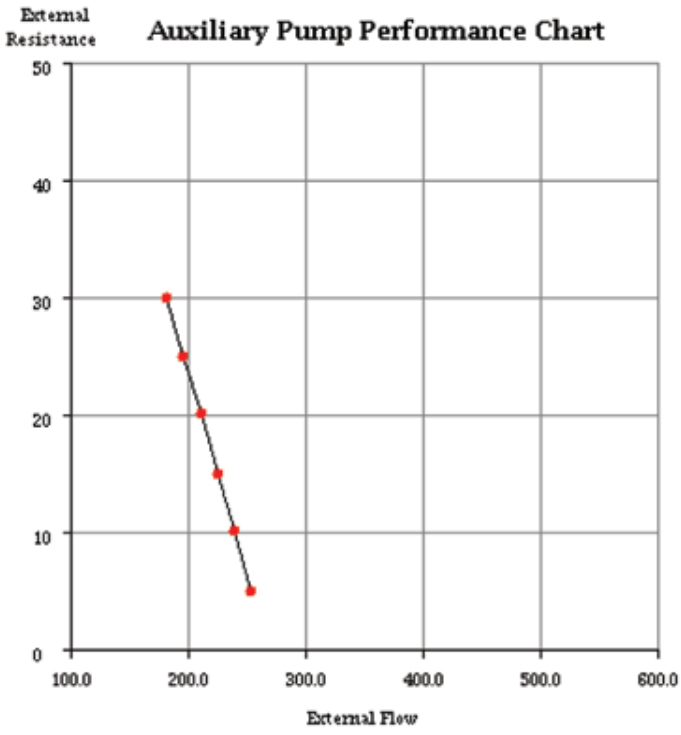
EXTERNAL COOLING SYSTEM DESIGN CONSIDERATIONS

Coolant Flow Control

The external circuit resistance setting establishes the total circuit flow by balancing total circuit losses with the characteristic pump performance curves. Correct external resistance is very important. Excessive high restriction results in reduced coolant flow and system effectiveness. Excessive low restriction may cause high fluid velocity resulting in cavitation/ early component erosion. Following are the pump performance curves at the time of publication. For current data please refer to TMI.

SCAC Pump Performance

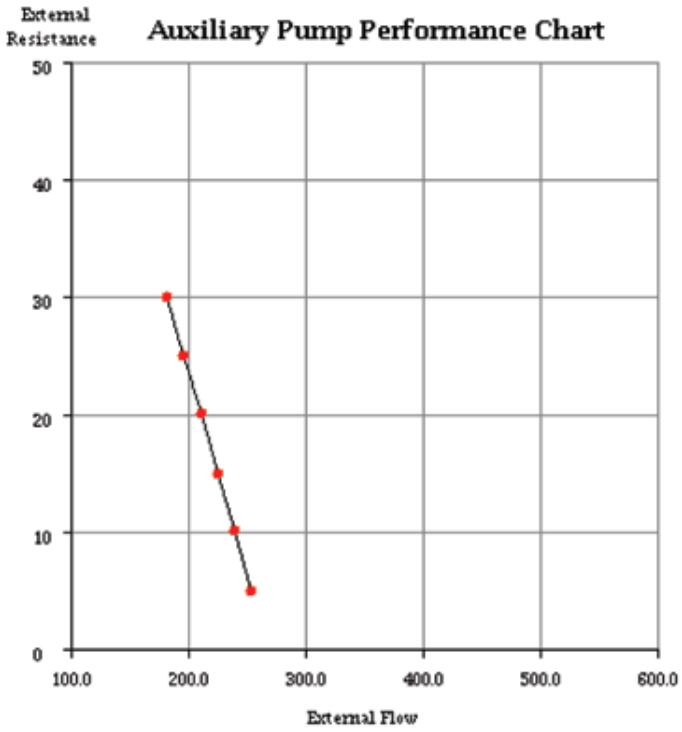
Engine Speed — 1600 rpm (DM8623)



Engine Speed RPM: 1,600
Pump Speed RPM: 2,128

EXT RESIST FT H2O	EXT FLOW GPM
4.99	254.4
10.01	239.87
14.99	225.6
20.01	211.07
25	196.81
29.99	182.28

Engine Speed — 1800 rpm (DM8624)

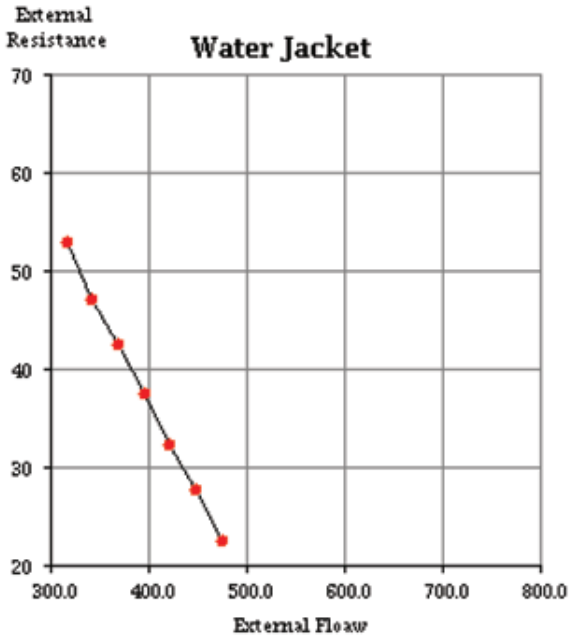


Engine Speed RPM: 1,800
Pump Speed RPM: 2,400

EXT RESIST FT H2O	EXT FLOW GPM
4.99	251.76
10.01	240.92
14.99	229.83
20.01	219
25	207.9
29.99	197.07

Jacket Water Pump Performance

Engine Speed — 1200 rpm (DM1299)



Engine Speed RPM: 1,200
Pump Speed RPM: 2,400

EXT RESIST FT H2O	EXT FLOW GPM
22.31	476.04
27.56	449.09
32.15	422.68
37.4	396.26
42.32	369.84
46.92	343.42
52.82	317.01

Jacket Water Heaters

Jacket water heaters may be required to meet cold starting and load acceptance criteria. To provide for the optimum use of the heater, Caterpillar routes the heater water into the top of the cylinder block and to exit at the bottom to maintain block temperature. Caterpillar offers an optional heater for installations.

System Pressures

Correct cooling system pressure minimizes pump cavitation and increases pump efficiency. The combination of static and dynamic pressure heads must meet the pressure criteria listed in the technical data.

Venting

Proper venting is required for all applications. Vent lines should be routed to an expansion tank at a constant upward slope. On the marine 3500C there are two venting locations (3/4 – 16 THD connection); one JW and one AC. The AC only needs venting when filling the system. Please see the installation drawings in this project guide for location.

System Monitoring

During the design and installation phase it is important that provisions are made to measure pressure and temperature differentials across major system components. This allows accurate documentation of the cooling system during the commissioning procedure. Future system problems or component deterioration (such as fouling) are easier to identify if basic data is available.

Serviceability

Suitable access should be provided for cleaning, removal, or replacement of all system components. Isolation valves should be installed as deemed necessary to facilitate such work.

System Pressures and Velocities

The following pressure and velocity limits apply to 3500C series engines:

3500C SERIES ENGINES	
Water Pump Pressures	
Maximum Allowable Static Head	170 kPa(g)
Minimum SCAC Inlet Pressure (dynamic)	-6 kPa(g)
Minimum Jacket Water Heater Sizing with Inlet Pressure (dynamic)	-6 kPa(g)
Maximum Operating Pressures	
Engine Cooling Circuits	300 kPa(g)
Water Velocities	
Pressurized Lines	4.5 m/s
Suction Lines (Pump Inlet)	1.5 m/s
Low Velocity De-aeration Line	0.6 m/s

Coolant Flow Control

The correct coolant flows are obtained by factory installed orifices on the engine, combined with proper external circuit resistance set at each site during commissioning, either with customer installed orifices or balancing valves, although a lockable plug valve is recommended. The external circuit resistance setting establishes the total circuit flow by balancing total circuit losses with the characteristic pump performance curves. Correct external resistance is very important. Too high a resistance will result in reduced flows to the aftercooler and oil cooler, and their effectiveness will decrease. If there is too low a resistance, the fluid velocity limits may be exceeded, and cavitation/early wear could be the result.

Note: Factory-packaged cooling systems eliminate the need for the customer to set external resistance for engine cooling circuits at site. Proper flow rates for the engine cooling circuits of a factory packaged cooling system are designed by Caterpillar and tested during the factory acceptance test.

COOLING WATER REQUIREMENTS

Water Quality, Rust Inhibitors, and Antifreeze

Maintaining water quality is very important in closed cooling systems. Excessive hardness will cause deposits, fouling, and reduced effectiveness of cooling system components. Caterpillar coolant inhibitor is available to properly condition the cooling water. When using it, the cooling water piping must not be galvanized and aluminum should not be used. If the piping is galvanized, the zinc will react with the coolant inhibitor and form clogs, which will interfere with the system operation.

3500C EPA Tier 3 Glycol Percentage

All new 3500C Marine EPA Tier 3 capable engines will be required to use a maximum concentration of 20% glycol mixture in the aftercooler circuit. This restriction applies equally to both heat exchanger cooled and keel cooled configurations (box coolers). In the event that specific project needs require higher levels of freeze protection, (lower freeze temperature), please contact ASC to review the specific engine rating and glycol concentration desired.

The jacket water circuit will continue to be capable of operation up to 50%.

CUSTOMER PIPING CONNECTIONS

Engine Connections	
Engine Cooling Water Inlet/Outlet	See GA schematics within this guide
AC Cooling Water Inlet	
AC Cooling Water Outlet	

Types of Coolers

Caterpillar marine engines use one or two cooling water circuits depending on the cooling systems configuration. A separate circuit engine operates with two independent cooling circuits. One is used to cool the lube oil and engine jackets and the other is used to cool the aftercooler water. A combined cooling system links the engine's pipe work so that there is only one inlet and outlet on the engine. A combined cooling system offers less pipe work and is more economical, as it requires only one heat exchanger.

Cooling of transmission oil can be achieved by using the jacket water, aftercooler water, or a separate cooling circuit depending on the transmission model and/or the engine cooling arrangements.

Three different coolers are available to be used with the engines depending on the vessel/system requirements.

Heat Exchanger (Caterpillar Supply)

Heat exchanger cooling for jacket water can be mounted either on the engine or remote from the engine. Engine-mounted heat exchangers require the least amount of off-engine pipe work fitting since the factory provides the jacket water connections to the heat exchanger.

Remote-mounted heat exchangers require connections between the jacket water inlet and outlet of the engine to the shell side of the exchanger. An engine-driven sea water pump is used to circulate the sea water through the heat exchanger/s.

Caterpillar supplies engine-mounted heat exchangers and Cat dealers are able to supply any heat exchangers that are to be positioned off the engine.

Keel Cooler (Yard Supply)

In most cases the yard will supply the keel cooler. As the keel cooler sizing and arrangement will be different for every build, once the engine order has been placed the Cat dealer will inform the yard of the pump flows and heat rejection data so the yard is able to size the keel cooler correctly.

The keel cooler is an outboard heat exchanger that is either attached to the submerged part of a vessel's hull or built as a part of it. Jacket water/aftercooler water is circulated through the coolers by the engine-driven pumps.

Note: If a keel cooler is to be used, the sea water pump can be removed from the main price.

Keel Conversion (Caterpillar Supply)

If the customer intends to use a keel cooler with the engine, Caterpillar is able to supply the engine to the customer with the connections required for a keel conversion.

Radiators (Optional Cat Dealer Supply)

Radiator cooling is available for these engines. Caterpillar will supply the engine with all the required fittings except the radiator. The radiators can be purchased via Caterpillar or Cat dealer. In most cases the radiators are specified from Caterpillar with the engine build; however, if required, the Cat dealer is able to supply a radiator to suit an engine installation.

It is possible to mount the radiators remote to the engine; however, if this is the case, the cooling system layout would need to be reviewed to ensure the engine is still going to be cooled sufficiently in the way it was designed to be cooled.

Please Note: It is important to discuss with customer/yard if they wish to cool other circuits with the supplied heat exchanger. The engines are often coupled to gearboxes and it is possible in some cases to provide cooling for the gearboxes via the engine. This can usually be done where the heat exchanger is mounted off the engine. The heat rejection figures would need to be obtained from the gearbox suppliers to correctly size the heat exchanger.

SEA WATER SYSTEM

COMBINED CIRCUIT SYSTEM (SEPARATE CIRCUIT OFF-ENGINE HEAT EXCHANGERS)

On a separate system the sea water is used to cool the fuel returning from the engine, aftercooler water and the jacket water.

Engine-Driven Sea Water Pump

The sea water pump draws water from the vessel's existing sea chest to the engine-driven sea water pump. After the pump, the water goes through the fuel cooler, then to the aftercooler heat exchanger, and then through the jacket water heat exchanger.

Fuel Cooler (See Fuel System)

The fuel returning from the engine is cooled prior to entering the day tank. This is done to maintain a fuel temperature to the engine of below 66°C to prevent damage being done to the injectors.

Aftercooler Heat Exchanger (Optional Caterpillar Supply)

The cooling sea water passes from the fuel cooler to the aftercooler heat exchanger. The aftercooler heat exchanger cools the combustion air after it leaves the turbocharger and before it enter the combustion spaces.

Jacket Water Heat Exchanger (Optional Caterpillar Supply)

The sea water then passes through to the jacket water heat exchanger, before it is sent overboard.

Emergency Operation – Class Requirement

There is a specific requirement of some classification societies relating to seagoing propulsion engine applications. The purpose is to ensure sea water pressure and circulation if the engine-driven sea water pump fails.

Emergency Connections – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the connections required for emergency operation of the sea water systems. In some cases the shipyard might want to carry out these modifications.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply an emergency electric pump required to maintain the sea water pressure and circulation should the engine-driven pump fail.

COMBINED CIRCUIT SYSTEM (SINGLE OFF- OR ON-ENGINE HEAT EXCHANGERS)

Where a combined cooling water system is used, the sea water passes through one heat exchanger. This is known as a jacket water aftercooled system. The heat exchanger cools the jacket water that in turn cools the rest of the engine systems.

Please Note: If the engine is supplied to class, coolers need to be sized for 32ºC sea water inlet temperature.

Engine-driven Sea Water Pump

The sea water pump draws water from the vessel's existing sea chest to the engine-driven sea water pump. After the pump the water goes through the jacket/aftercooler water heat exchanger.

Heat Exchanger (Optional Caterpiller Supply)

On a combined circuit the sea water/raw water heat exchanger is used to cool the water that is flowing through both the heat exchanger and aftercooler heat exchanger. As previously stated, this can be supplied on or off the engine.

Emergency Operation – Class Requirement

There is a specific requirement of some classification societies for emergency operation of sea water pumps for single propulsion engine applications. The purpose is to ensure sea water pressure and circulation if the engine-driven sea water pump fails.

Emergency Connections – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency connections required for emergency operation of the sea water system. In some cases the shipyard might want to carry out these modifications.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply an emergency electric pump required to maintain the sea water pressure and circulation should the engine-driven pump fail.

COOLING SYSTEM

COMBINED COOLING WATER SYSTEM

Remote Off-engine Heat Exchanger

This system is referred to a Jacket Water Aftercooled (JWAC) system in Caterpillar literature and publications.

The combined system provides cooling for both the jacket water circuits and the aftercooler circuits. This system is derived from converting a engine that has been built by Caterpillar as a separate circuit system to a combined system.

The advantage of using a system such as this is that it only requires one raw/sea water heat exchanger and there are fewer system connections.

Engine-driven Jacket Water Pump

The jacket water pump is engine-mounted and delivers the coolant through the lubricating oil cooler and then to the engine block. From the engine it enters a temperature regulator. From the temperature regulator the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Lubricating Oil Cooler

The jacket water coolant flows through the oil cooler. The jacket water coolant is supplied to a cooler at a pressure that is lower than that of the lubricating oil.

Engine-driven Aftercooler Water Pump

The aftercooler water pump passes the coolant through the aftercooler to cool the air before it enters a thermostatic valve. From the thermostatic valve the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Aftercooler

Some of the jacket water coolant flows through the aftercooler to cool the air before it enters the cylinders. It is desirable to maintain an inlet manifold temperature between 30°C and 52°C.

Thermostatic Temperature Regulating Valves

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature the regulator opens and allows more coolant to pass through the cooler.

Heat Exchanger (Caterpillar Supply)

The coolant passes through the sea water-cooled heat exchanger when it gets up to temperature.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by Cat dealers. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven lube jacket water or aftercooler pump fails.

Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the emergency connections required for the jacket water system. Cat dealers can provide the emergency connections for the aftercooler and sea water circuits.

Emergency Pumps – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the jacket water, aftercooler water, and sea water pressure and circulation should any of the engine-driven pumps fail.

SEPARATE COOLING WATER SYSTEM

This system uses two separate circuits that operate independently to provide cooling to the engine.

JACKET WATER CIRCUIT – OFF-ENGINE HEAT EXCHANGER

Engine-mounted Jacket Water Pump

The jacket water pump is engine-mounted and delivers the coolant to the lubricating oil cooler and to then to the engine block, cylinder heads, etc.

Lubricating Oil Cooler

The jacket water coolant flows through the oil cooler. The jacket water coolant is supplied to the cooler at a pressure that is lower than that of the lubricating oil.

Temperature Regulator

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature the regulator opens to allow more coolant to pass through the cooler.

Heat Exchanger (Optional Cat Dealer Supply)

The aftercooler circuit water passes through the heat exchanger when it gets up to temperature. The size of the additional aftercooler heat exchanger will depend on the engine size and rated horsepower.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven lube jacket water pump fails.

This is subject to change and will depend on the engine application and installation arrangements onboard the vessel.

Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the connections required for emergency operation of the emergency jacket water pump.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the jacket water pressure and circulation should the engine-driven pump fail.

AFTERCOOLER WATER CIRCUIT (SCAC – SEPARATE CIRCUIT AFTERCOOLED WITH OFF-ENGINE HEAT EXCHANGER)

Aftercooler Water Pump

The aftercooler water pump passes the coolant through a separate cooler that cools the air before it enters the cylinder liners. Caterpillar supplies the engine-driven pump.

Aftercooler

The aftercooler cools the air that exits from the turbochargers before it enters the air inlet manifold so the engine can achieve complete and efficient combustion.

Thermostatic Housing

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature, the regulator opens and allows more coolant to pass through the cooler.

Heat Exchanger (Caterpillar Supply)

The aftercooler circuit water passes through the heat exchanger when it gets up to temperature. The size of the aftercooler heat exchanger will depend on the engine size and rated horsepower. This is mounted off the engine. This system requires an additional Cat dealer or customer-supplied expansion tank.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by Cat dealers. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven lube aftercooler water pump fails.

Emergency Connections – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the connections required for emergency operation of an emergency aftercooler pump.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the aftercooler water pressure and circulation should the engine-driven pump fail.

AFTERCOOLER WATER CIRCUIT (SWAC – SEA WATER AFTERCOOLED)

Aftercooler Water Pump

The aftercooler water pump passes sea water through a separate cooler that cools the air before it enters the cylinder liners. Caterpillar supplies the engine-driven pump.

Aftercooler

The aftercooler cools the air that exits from the turbochargers before it enters the air inlet manifold so the engine can achieve complete and efficient combustion.

Thermostatic Housing

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature the regulator opens and allows more coolant to pass through the cooler.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by Cat dealers. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven lube aftercooler water pump fails.

Emergency Connections – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the connections required for emergency operation of an emergency aftercooler pump.

Emergency Pump – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the aftercooler water pressure and circulation should the engine-driven pump fail.

COMBINED COOLING WATER SYSTEM – ON-ENGINE HEAT EXCHANGER

Important Note: This combined cooling system with engine-mounted heat exchanger is available for 3500 series engines up to 2682 bhp. This heat exchanger incorporates a diesel fuel oil cooler as well. Above this engine power the heat load of the engine becomes too excessive for the heat exchanger. This system can be purchased direct off the current price lists.

This system is referred to a JWAC – jacket water aftercooled system in Caterpillar literature and publications.

The combined system provides cooling for both the jacket water circuits and the aftercooler circuits. The advantage of this system is that there are only two cooling water connections to be made with the engine: sea water in and sea water out. This compact installation is ideal where space is at a premium.

Engine-driven Jacket Water Pump

The jacket water pump is engine-mounted and delivers the coolant through the lubricating oil cooler and then to the engine block. From the engine it enters a temperature regulator. From the temperature regulator the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Lubricating Oil Cooler

The jacket water coolant flows through the oil cooler. The jacket water coolant is supplied to a cooler at a pressure that is lower than that of the lubricating oil.

Engine-driven Aftercooler Water Pump

The aftercooler water pump passes the coolant through the aftercooler to cool the air before it enters a thermostatic valve. From the thermostatic valve the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Aftercooler

Some of the jacket water coolant flows through the aftercooler to cool the air before it enters the cylinders. It is desirable to maintain an inlet manifold temperature between 30°C and 52°C.

Thermostatic Temperature Regulating Valves

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature, the regulator opens and allows more coolant to pass through the engine-mounted heat exchanger.

Heat Exchanger (Caterpillar Supplied)

The coolant passes through the engine-mounted sea water-cooled heat exchanger when it gets up to temperature. This cooler also incorporates a diesel fuel oil cooler that is used to monitor the temperature of the fuel.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by your Cat dealer. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven jacket water or aftercooler pump fails.

Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the emergency connections required for the jacket water system. Cat dealers can provide the emergency connections for the aftercooler and sea water circuits.

Emergency Pumps – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the jacket water, aftercooler water, and sea water pressure and circulation should any of the engine-driven pumps fail.

DUAL COOLING WATER CIRCUIT – ON ENGINE HEAT EXCHANGER

Important Note: This separate cooling system with engine-mounted heat exchanger is available for 3500 series engines with powers up to 2682 bhp. This heat exchanger does not incorporate a diesel fuel oil cooler so a separate cooler will be required. Above this engine power the heat load of the engine becomes too excessive for the heat exchanger. This system can be purchased from Caterpillar; however, as this is not currently available off the standard price list, a design will need to be requested from the factory at an additional cost. This might increase the lead time of the engine.

This system is referred to as a Separate Circuit Aftercooled (SCAC) system in Caterpillar literature and publications.

The dual circuit system provides cooling for both the jacket water circuits and the aftercooler circuits. The advantage of this system is that there are only two cooling water connections to be made with the engine: sea water in and sea water out. This compact arrangement is ideal where space is at a premium.

Engine-driven Jacket Water Pump

The jacket water pump is engine-mounted and delivers the coolant through the lubricating oil cooler and then to the engine block. From the engine it enters a temperature regulator. From the temperature regulator the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Lubricating Oil Cooler

The jacket water coolant flows through the oil cooler. The jacket water coolant is supplied to a cooler at a pressure that is lower than that of the lubricating oil.

Engine-driven Aftercooler Water Pump

The aftercooler water pump passes the coolant through the aftercooler to cool the air before it enters a thermostatic valve. From the thermostatic valve the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Aftercooler

Some of the jacket water coolant flows through the aftercooler to cool the air before it enters the cylinders. It is desirable to maintain an inlet manifold temperature between 30°C and 52°C.

Please Note: This system requires an additional Cat dealer or customer supplied expansion tank.

Thermostatic Temperature Regulating Valves

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature, the regulator opens and allows more coolant to pass through the engine-mounted heat exchanger.

Heat Exchanger (Caterpillar Supplied)

The coolant passes through the engine-mounted sea water-cooled heat exchanger when it gets up to temperature.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by Cat dealers. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven jacket water or aftercooler pump fails.

Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the emergency connections required for the jacket water system. Cat dealers can provide the emergency connections for the aftercooler and sea water circuits.

Emergency Pumps – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the jacket water, aftercooler water, and sea water pressure and circulation should any of the engine-driven pumps fail.

SINGLE COOLING WATER SYSTEM – ON-ENGINE HEAT EXCHANGER

Important Note: This single cooling system with engine-mounted heat exchanger is available for 3500 series engines with power up to 3386 bhp. This heat exchanger is used to cool the jacket water only. The aftercooler can be cooled by a separate heat exchanger or sea water and a separate heat exchanger is required for the fuel oil. Above this engine power the heat load of the engine becomes too excessive for the heat exchanger. This system can be purchased from Caterpillar; however, as this is not currently available off the standard price list, a design will need to be requested from the factory at an additional cost. This might increase the lead time of the engine.

This system is referred to as a Jacket Water Aftercooled (JWAC) system in Caterpillar literature and publications.

The single system provides cooling for the jacket water circuits only. This compact arrangement is ideal where space is at a premium.

Engine-driven Jacket Water Pump

The jacket water pump is engine-mounted and delivers the coolant through the lubricating oil cooler and then to the engine block. From the engine it enters a temperature regulator. From the temperature regulator the coolant is either diverted back through the system to the pump suction or through the heat exchanger.

Lubricating Oil Cooler

The jacket water coolant flows through the oil cooler. The jacket water coolant is supplied to a cooler at a pressure that is lower than that of the lubricating oil.

Thermostatic Temperature Regulating Valves

When the coolant is cold, the regulator bypasses the heat exchanger until it gets up to temperature. When the coolant starts to get up to temperature the regulator opens and allows more coolant to pass through the engine-mounted heat exchanger.

Heat Exchanger (Caterpillar Supplied)

The coolant passes through the engine-mounted sea water-cooled heat exchanger when it gets up to temperature. This cooler also incorporates a diesel fuel oil cooler that is used to monitor the temperature of the fuel.

Flexible Connectors (Optional Cat Dealer Supply)

The customer-supplied coolant piping must be attached to the engine via flexible hoses, which can be supplied by your Cat dealer. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

Emergency Operation – Class Requirement

This is a specific requirement of some classification societies for seagoing single propulsion engine applications. The purpose is to ensure jacket water pressure and circulation if the engine-driven jacket water pump fails.

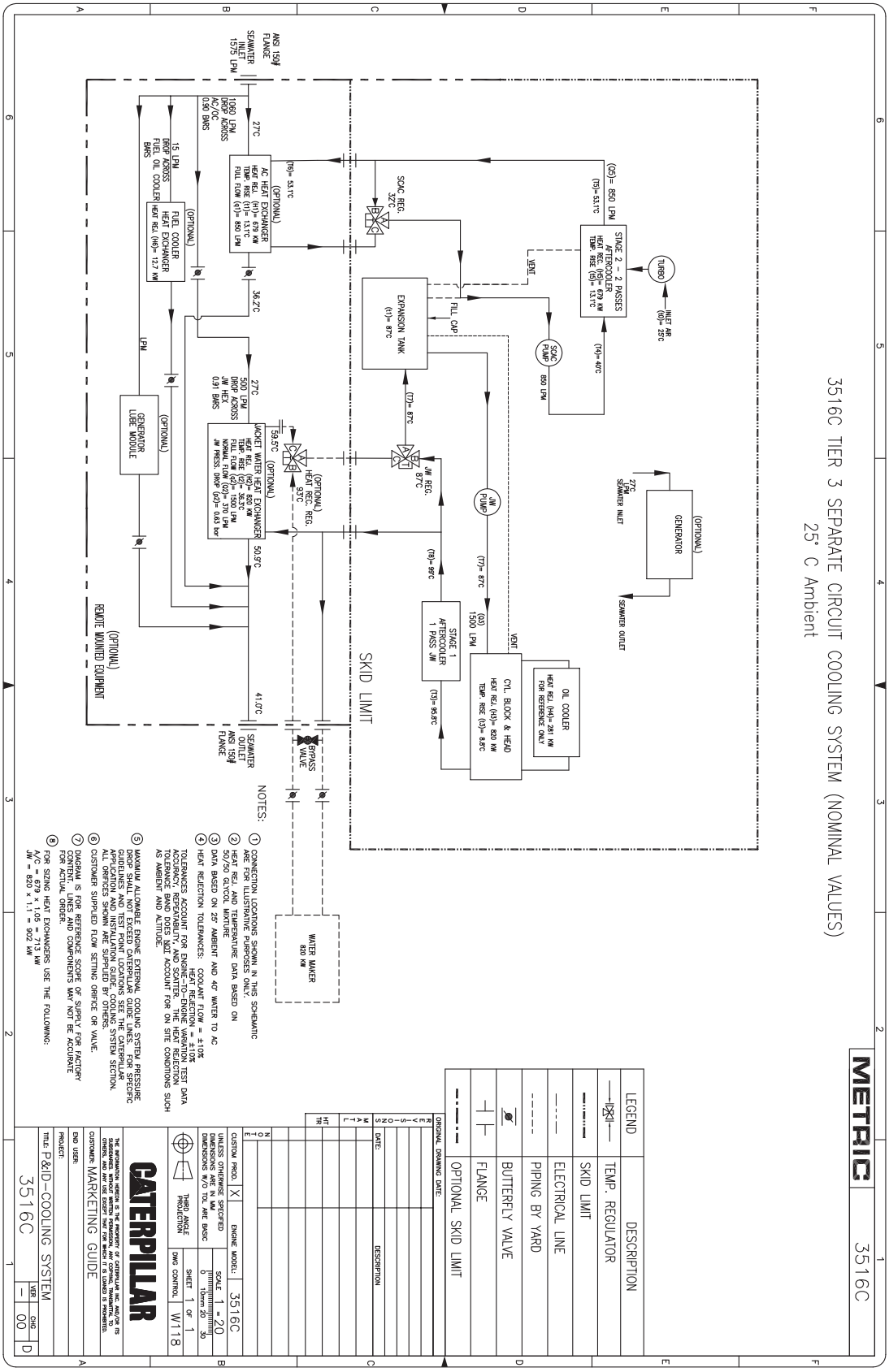
Emergency Connections – Class Requirement (Optional Caterpillar Supply)

Caterpillar can supply the emergency connections required for the jacket water system. Cat dealers can provide the emergency connections for the sea water circuits.

Emergency Pumps – Class Requirement (Optional Cat Dealer Supply)

Cat dealers can supply the emergency pump required to maintain the jacket water and sea water pressure and circulation should any of the engine-driven pumps fail.

COOLING SYSTEM SCHEMATIC



STARTING AIR SYSTEM

GENERAL

The 3500C marine engine starting system consists of dual electric starters or a turbine air starter, according to required specifications.

The starting requirements of the engine can be altered to suit the customer's requirements and what the customer has available to them. It is also important that if the engine is being built to class that the classification society's requirements are taken into account.

Electrical Starting Systems

Use chemical energy stored in batteries, automatically recharged by an engine-driven alternator or by an external source.

Air or Pneumatic Starting

Uses compressed air in pressure vessels, automatically recharged by an electric motor-driven air compressor.

Hydraulic Starting System

An additional starting system that uses hydraulic oil stored in steel pressure vessels under high pressure, automatically recharged by a small engine-driven hydraulic pump with integral pressure relief valve.

ELECTRICAL STARTING SYSTEM

Battery powered, electric motors use low voltage direct current and provide fast, convenient, pushbutton starting with lightweight compact engine components.

Electrical Starting Motor

Unless otherwise specified, the engine will be supplied from Caterpillar with an electric start motor.

Batteries

Where the main engine is arranged for electric starting, two or four separate batteries are to be fitted. The batteries cannot be connected in parallel. Each battery must be capable of starting the main engine when the engine is cold and in ready-to-start condition.

The starting batteries are to be used for starting and the engine's own monitoring purposes only. Stored energy must be continuously maintained. The batteries should be located as close as possible to the starter and the battery cables should be suitably supported at intervals along their length.

It is a class requirement that the batteries combined capacity is able to provide, without recharge, a number of starts as specified by the classification societies. Further information relating to the requirements of classification societies will follow.

The size of the batteries will depend on the ambient air temperature where the engine is going to operate and the type of starter fitted.

Battery Charger (Optional Caterpillar Supply)

If the engine is going to be left idle for periods, it will be necessary to keep the batteries are kept fully charged and in the ready-to-use state. Caterpillar is able to supply a 10-amp battery charger that has automatic switching from equalize to float.

Sizing

The ambient air temperatures in the engine's working environment must be taken into account, as this will affect the number of batteries required to start the engine.

Note: If lead acid batteries are used, give special consideration to where the batteries are located, as hydrogen gas is given off the batteries when they are charged. The hydrogen gas is very flammable and compartments containing lead acid batteries must be suitably vented.

Lower ambient temperatures drastically affect battery performance and charging efficiencies.

When operating in cold climates, heaters should be used to maintain a battery temperature of between 32°C and 52°C (90°F to 125°F).

Five different sizes of starters are available from Caterpillar depending on the engine arrangement and layout. These draw up to a maximum of 140 amps @ 23 volts. Your Cat dealer will advise regarding the required starting current once the engine build has been specified.

Class Requirement

Where the engine has been built to class with an electric start motor, it will be important that they are sized correctly to meet the requirements of class. It is a requirement of classification societies that the total combined capacity of the batteries is sufficient to provide, without being recharged, a minimum of six consecutive starts of each main non-reversing engine connected to a controllable pitch propeller or other device enabling the start, without opposite torque, within a half-hour period.

Regardless of above, for multi-engine installations the number of starts required for each engine may be reduced upon agreement with the classification society depending upon the arrangement of the engines and transmission of the output propellers.

AIR START MOTOR (OPTIONAL CATERPILLAR SUPPLY)

Cat engines can be supplied with an air start motor if required. Air starting of the engines is highly reliable. The torque available from air start motors is able to accelerate the engine to twice the cranking speed in about half the time required by electric starters.

Pipe Work (Yard Supply)

The air starter supply pipe work should be as short and direct as and at least equal to the pipe air start motor intake. Black iron piping is preferred.

Compressors (Yard Supply)

Where the main engine is arranged for starting by compressed air, two or more compressors are to be fitted. At least one of the compressors is to be driven independent of the main propulsion unit and is to have the capacity of not less than 50 percent of the total required.

The total capacity of the air receivers is to be sufficient to supply, within one hour, the quantity of air needed to satisfy the minimum number of starts as specified by classification societies.

Sizing of Air Storage Tanks (Optional Cat Dealer Supply)

Many applications require the sizing of air storage tanks to provide a specified number of starts without recharging. In certain cases other consumers with high air consumption will need to be taken in to account when sizing the air receiver, especially if the engine is being built to class.

Where the main engines are arranged for starting by compressed air, at least two starting air receivers of about equal capacity are to be fitted and may be used independently. The total capacity of the air receiver is to be sufficient to provide, without being replenished, not less than six consecutive starts.

Cat dealers are also able to supply air receivers to be used in multiple engine installations. The size of the air receivers will depend of the engine type and installation arrangement.

Class Requirements

Where the engine has been built to class with an air start motor, the air receiver must be sized correctly to meet the requirements of class. It is a requirement of classification societies that the total capacity of the air receivers is sufficient to provide, without being replenished, a minimum of six consecutive starts of each main non-reversing engine connected to a controllable pitch propeller or other device enabling the start without opposite torque, within one hour.

Regardless of above, for multi-engine installations the number of starts required for each engine may be reduced upon agreement with the classification society depending upon the arrangement of the engines and transmission of the output propellers.

Moisture Traps (Caterpillar Supply)

It is important that either a manual or automatic fluid trap is positioned between the airline and the engine in the lowest part of the pipe work to ensure that water or oil is able to reach the starter motor. It is important that oil and water are removed from the air prior to the air reaching the starter motor to prevent damage being done to the starter. Caterpillar supplies a moisture trap when the an air starter is to be fitted to the engine.

Flexible Connection (Optional Caterpillar Supply)

The customer-supplied air piping must be attached to the engine via flexible hoses, which can be supplied by your Cat dealer. The positions of the flexible connections and shutoff valves are important so that if there is a broken flexible connection it can be isolated without shutting down the whole system.

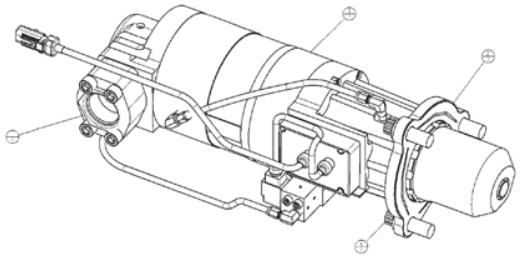
Turbine Starter (Optional Caterpillar Supply)

The standard turbine starter operates on air inlet pressures from 275 to 1034 kPa (40 to 150 psi). These pressures are required at the starter inlet port. An air tank pressure below 415 kPa will not start the engine because of pressure drop associated with the air supply lines. For initial system evaluation, assume a 200 kPa (29 psi) pressure drop between the tank and the air starter inlet.

A pressure regulator is necessary when the supply pressure at the starter exceeds 1034 kPa (150 psi). The quantity of air required for each start and the size of the air receiver depend upon cranking time and air-starter consumption.

The 3500C air starter consumption is:

- 15.8 m^3/min @ 414 kPa (559 scfm @ 60 psi)
- 22.3 m^3/min @ 620 kPa (787 scfm @ 90 psi)
- 28.7 m^3/min @ 414 kPa (1014 scfm @ 120 psi)
- 35.2 m^3/min @ 620 kPa (1242 scfm @ 150 psi)



Turbine Air Starter for 3500C Marine Engine

External Starting Air System Design Considerations

The starting air receiver size is normally determined by the requirements of the classification society for the number of starts or start attempts. The size of the air receivers should be increased if the starting air receiver also supplies air for purposes other than the main engine starting (e.g. engine air prelube, work air, auxiliary generator sets).

Engine Piping Connections

The 3500C turbine type starters must be supplied with clean air. Deposits of oil-water mixture must be removed by traps installed in the lines. Lines should slope toward the traps and away from the engine. The air supply pipes should be short with the number of elbows kept to a minimum and at least equal in size to the engine inlet connection, which is 1-1/2" NPTF. A strainer can be provided under request. Although this turbine air staring system normally does not require an air strainer, it is recommended to use #40 mesh Y-strainer in a dirty environment.

Turbine air starters are sensitive to air flow restrictions. The performance of the turbine air starting system will be significantly degraded if air supply lines are not sized properly.

STARTING AIR SYSTEM DESIGN CONSIDERATIONS

Pneumatic Starting (Air)

Air starting, either manual or automatic, is highly reliable. Torque available from air motors accelerates the engine to twice the cranking speed in about half the time required by electric starters.

The air system can be quickly recharged; but air storage tanks are prone to condensation problems and must be protected against internal corrosion and freezing.

For the marine 3500C, the air starting motor is designed at max power with 1034 kPa of pressure (150 psi), consuming $0.59 \frac{m^3}{s}$ $(20.8 \frac{ft^3}{s})$ of air.

Air Tank Sizing

Air tanks are required to meet specific characteristics, such as the specifications of the American Society of Mechanical Engineers (ASME). Compressed air storage tanks must be equipped with a maximum pressure valve and a pressure gauge. Check the maximum pressure valve and pressure gauge often to confirm proper operation.

A drain cock must be provided in the lowest part of the air receiver tank for draining condensation.

Marine applications require sizing air storage tanks to provide a specified number of starts without recharging.

This is accomplished using the following formula:

$$V_T = \frac{V_S \times T \times P_A}{P1 - P_{MIN}}$$

Where:

V_T = Air storage tank capacity (cubic feet or cubic meters)

V_S = Air consumption of the starter motor ($\frac{ft^3}{s}$ or $\frac{m^3}{s}$)

If any other air supply is used for other than main engine starting (e.g., work air, auxiliary generator sets starting, etc.) its consumption must be added to V_S also.

T = Total cranking time required (seconds); If six consecutive starts are required, use seven seconds for first start (while engine is cold), and two seconds each for remaining five starts, or a total cranking time of seventeen seconds.

This cranking time is for bare engine only. If there is any additional load, the cranking time should be adjusted accordingly.

P_A = Atmospheric pressure (psi or kPa): Normally, atmospheric pressure is 101 kPa (14.7 psi)

P_T = Air storage tank pressure (psi or kPa): This is the storage tank pressure at the start of cranking

P_{MIN} = Minimum air storage tank pressure required to sustain cranking at 120 rpm (psi or kPa)

Example:

Maximum air tank pressure = 1379 kPag (200 psig)

Minimum air-to-starter pressure = 1034 kPag (150 psig)

Expected air line pressure drop = 207 kPag (30 psig)

Six consecutive starts. First start = 7 seconds; the other 5 starts = 2 seconds

Average barometric pressure = 100 kPa (14.5 psi)

(cfm x 0.02832 = m^3/min)

Solution:

$V_S = 0.59 \frac{m^3}{s} (20.8 \frac{ft^3}{s})$

T = 7 + (5 x 2) = 17 sec

P_A = 100 kPa (14.5 psi)

P_T = 1379 – 207 = 1172 kPag

(200 – 30 = 170 psig)

P_{MIN} = 1034 kPag (150 psig)

Therefore:

$V_T = \frac{0.59 \times 17 \times 100}{1172 - 1034} = 7.26\ m^3$

$V_T = \frac{20.8 \times 17 \times 14.5}{170 - 150} = 256\ ft^3$

Cranking Time Required

The cranking time for a 3500C depends on ambient air temperature, oil viscosity, and fuel type. Five to seven seconds is typical for a 3500C at 26.7°C (80°F). Restarting hot engines usually requires less than two seconds. Most marine societies require a minimum of six consecutive starts for propulsion engines. Refer to the applicable marine society rules for current requirements for propulsion and other applications on marine vessels.

AIR SUPPLY LINE SIZING

TDI turbine starters must be supplied with clean, dry air. Deposits of oil-water mixture must be removed by traps installed in the lines. Lines should slope toward the traps and away from the engine. Air supply lines should be routed and sized to ensure adequate pressure and flow at the starter(s). As a general rule of thumb, the air supply pipes should be short with number of elbows kept to a minimum to reduce pressure loss to the starter.

For simple starting motor systems the customer connection is either 1-1/2 inch or 2-inch NPT. 2-inch supply line size is minimum required and a customer-provided 3-inch supply air line is recommended for installations with more than 50 ft (15 m) of equivalent straight length of pipe from receiver or regulator to air starter.

A flexible connection between engine starting line and supply line should always be used to prevent vibration-induced fatigue. If a pressure reducing valve is required, a valve with Cv40 should be used to provide sufficient air flow. Locate the pressure reducing valve as close to the engine as possible to minimize the air pressure reduction valve supply pipe diameter. Water and oil must be removed frequently to prevent possible damage to the motor and pipes.

HYDRAULIC STARTING

Hydraulic starting provides high cranking speeds and fast starts. It is relatively compact and recharging time using a small engine-driven recharging pump is fast. A hand pump is provided for this purpose; although hand recharging is very laborious, it can be used to recharge this system.

The high pressure of the system requires special pipes and fittings to be used throughout. Because of the high pressures involved (typically 3000 psi [20,700 kPa] when fully charged) recharging the accumulator requires special equipment.

Hydraulic starting is sometimes selected when the engine is being used as an emergency generator or when the use of electrical connections could pose a safety hazard.

Note: The hydraulic actuators, if used, will contain large amounts of stored energy; therefore, the accumulator must be adequately protected from perforation or breakage.

Hydraulic Start Motor (Optional Cat Dealer Supplied)

Cat dealers may be able to supply a hydraulic starter for the engine should the customer require it. They are often chosen for emergency generators when a independent method of starting is required.

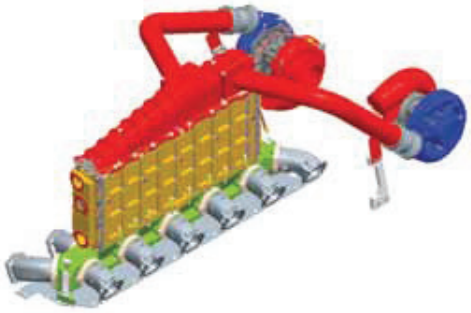
COMBUSTION AIR SYSTEM

GENERAL

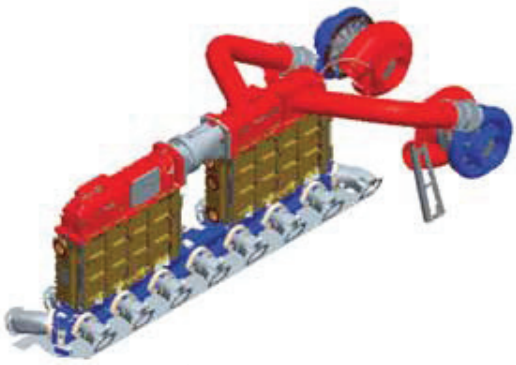
The aftercooler system is a High Performance Air Cooling (HPAC) system designed in a modular layout. This is system is composed of dry, shielded turbochargers and charge air piping, managing a better combustion efficiency. By means of this design improvement the heat transfer to the cooling system is minimized and the combustion gets more efficient as there is less heat loss, providing more available power. At the same time the piping design is less complex, with single air intake tracts per cylinder.

The aftercooler is a two stage system consisting of jacket water cooled first stage and a separate circuit second stage.

The aftercooler arrangement varies from the single aftercooler for the 3512C to the dual aftercoolers for the 3516C.



3512C – Single Aftercooler



3516C – Dual Aftercooler

The maximum inlet air temperature to the turbocharger is 50°C (122°F) in accordance with the marine society rules for equipment performance, and will provide good engine component life. For temperatures above 50°C (122°F), the engine may derate to a power output level required for safe engine operation.

The 3500C engine normally draws engine combustion air in one of two ways:

- The engine room is supplied with air for engine combustion as well as for removal of radiated heat. Engine-mounted air filters provide combustion air filtration.
- The engine room is supplied with ventilation air for engine heat removal and the engine combustion air is supplied separately through a dedicated, filtered air intake system.

Either system should be designed to provide sufficient clean air for combustion and heat removal based on the ambient conditions and the maximum ratings for each piece of installed equipment (i.e. marine auxiliary engines, pumps, and switchgear). For classed vessels, the specific societies have well-defined rules for the design parameters.

The amount of combustion air necessary for the 3500C engine is specified in the technical data section of this manual. The amount of radiated heat emitted by each engine is also specified.

COMBUSTION AIR SYSTEM DESIGN CONSIDERATIONS

Engine Room Supplied Air

The location and design of the engine room air intakes should consider the following:

- The supply air outlets should be close to and directed at the engine turbocharger air intakes.
- Additional air should flow along the generator, coupling, and engine to absorb the radiated heat. The air flow should flow in the order stated above as the radiated heat from the engine will cause unnecessary temperature rise in the generator.
- The engine room air inlets should be placed such that water or dirt cannot enter.
- Installations intended for operation in extreme cold may require heated air for starting purposes. In addition, it may be necessary to control the inlet boost pressure for cold air installations. Contact your Cat dealer or the regional Cat representative for further information when extreme ambient conditions are expected.

Separate Combustion Air System

Supplying the engines with direct outside air for combustion, if possible, is beneficial to the installation for a number of reasons. It reduces the air movement in the engine room, may reduce the cooling load on the charge air cooler, reduce the maximum heat load on the cooling water heat exchanger and in turn reduce the required sea water circulation in the system. Direct air to the turbocharger inlet may provide a larger margin against engine load reduction brought on by high air inlet temperatures.

It should be expected that, if the turbocharger inlets are supplied with engine room air, a temperature rise of 5 to 10°C (9 to 18°F) above ambient would take place. By supplying the engines with direct outside air the vessel will also reduce the required fan work.

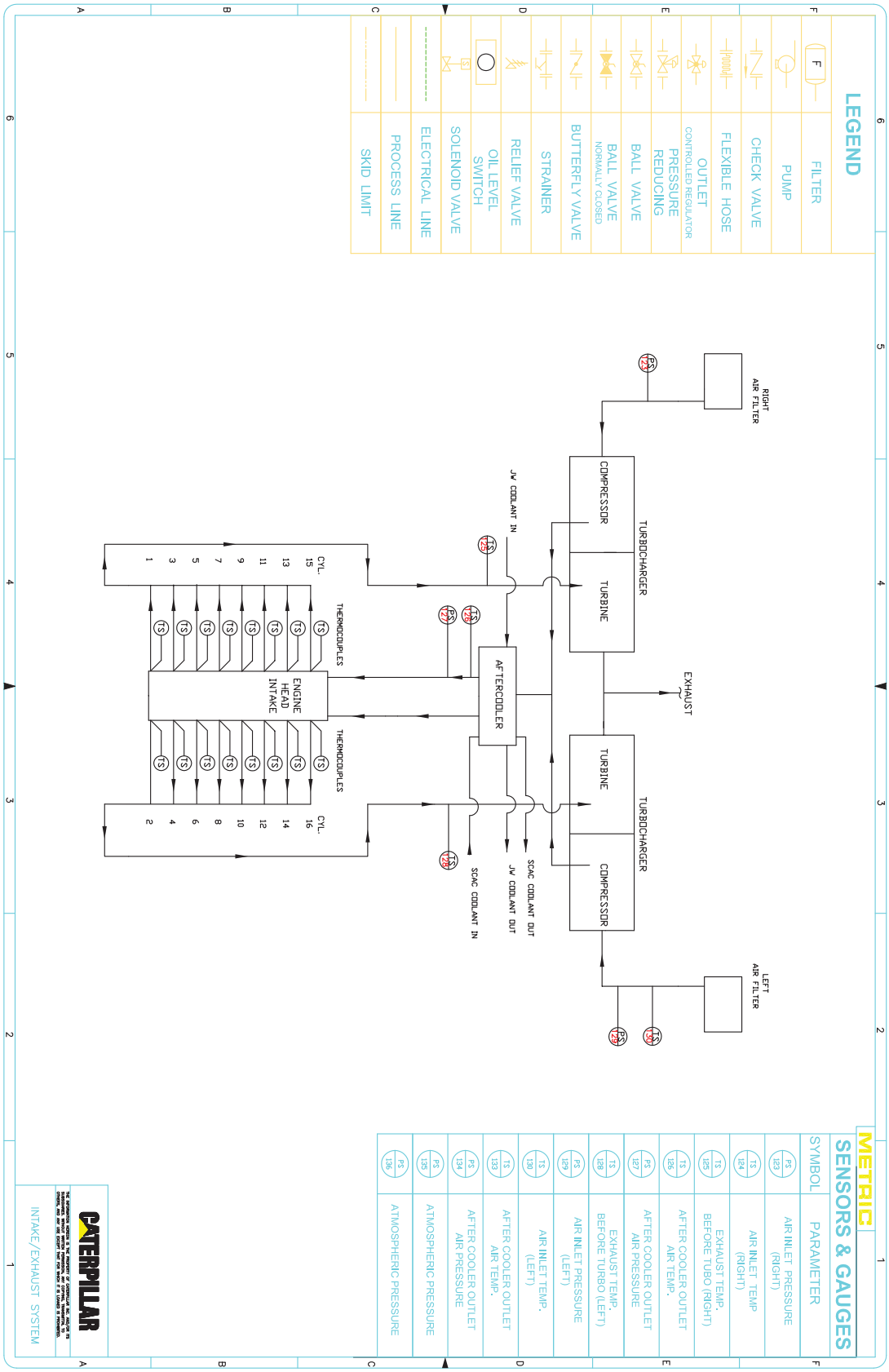
If the engine combustion air is supplied through a separate, dedicated air system, the engine room design should consider the following.

The entire intake system, including clean air filters should have an initial restriction of no greater than 254 mm H_2O (10 in. H_2O). The maximum inlet restriction with dirty air filters should not exceed 635 mm H_2O (25 in. H_2O).

Flexible connections are necessary to isolate engine vibration from the ducting system. Locate the flex connection as close to the engine as possible, but be aware of the excessive heat generated by the exhaust system. Avoid supporting excessive lengths of ductwork off the turbocharger.

Caterpillar has specially designed the air intake components to provide the proper airflow pattern before the turbocharger. Turbocharger performance may be adversely affected if these components are not used.

INTAKE/EXHAUST SCHEMATIC



ENGINE ROOM VENTILATION

GENERAL

Although not part of the Caterpillar scope of supply for a typical diesel generator package, the engine room ventilation system is a vital part of a successful installation. The two primary aspects of a properly designed engine room ventilation system addressed in this document are cooling air and combustion air.

- **Cooling Air:** The flow of air required to carry away the radiated heat of the engines and other engine room machinery.
- **Combustion Air:** The flow of air required to burn the fuel in the engines.

Both of these have a direct impact on an engine's or packaged unit's performance, and must be considered in the design of an engine room ventilation system. However, it is important to note that all equipment within the engine room space, not only the diesel generator packages, must be given consideration in the overall ventilation system design process. For the current data please see publication LEBW4971 on Engine Room Ventilation in TMI.

SIZING CONSIDERATIONS

Cooling Air

Engine room ventilation air (cooling air) has two basic purposes:

- To provide an environment that permits the machinery and equipment to function properly with dependable service life.
- To provide an environment in which personnel can work comfortably.

A small percentage of fuel consumed by an engine is lost to the environment in the form of heat radiated to the surrounding air. In addition, heat from generator inefficiencies and exhaust piping can easily equal engine radiated heat. Any resulting elevated temperatures in the engine room may adversely affect maintenance, personnel, switchgear, and engine or generator set performance. The use of insulated exhaust pipes, silencer, and jacket water pipes will reduce the amount of heat radiated by auxiliary sources.

Radiated heat from the engines and other machinery in the engine room is absorbed by engine room surfaces. Some of the heat is transferred to atmosphere, but the remaining radiated heat must be carried away by the ventilation system.

A system for exhausting ventilation air from the engine room must be included in the ventilation system design. The engines will not be able to carry all of the heated ventilation air from the engine room by way of the exhaust piping.

Combustion Air

In many installations, combustion air is drawn from outside of the engine room via ductwork, in which case, the combustion air is not a factor in the ventilation system design calculations.

However, many installations require that combustion air be drawn directly from the engine room. In these installations, combustion air requirements become a significant ventilation system design parameter. Engine-specific combustion air requirements can be found in TMI for the specific engine and rating.

Ventilation Air Flow

Required ventilation air flow depends on the desired engine room air temperature as well as the cooling air and combustion air requirements outlined above. While it is understood that total engine room ventilation air flow must take all equipment and machinery into account, the following sections provide a means for estimating the air flow required for the successful operation of Cat engines and packages.

In general, changing the air in the engine room every one or two minutes will be adequate, if flow routing is proper.

Provisions should be made by the installer to provide incoming ventilation air of 0.1 to 0.2 m^3/min (4 to 8 cfm) per installed horsepower. This does not include combustion air for the engines.

Engine Room Temperature

A properly designed engine room ventilation system will maintain engine room air temperatures within 8.5 to 12.5°C (15 to 22.5°F) above the ambient air temperature (ambient air temperature refers to the air temperature surrounding the power plant, vessel, etc.). Maximum engine room temperatures should not exceed 50°C (122°F). If they do, outside air should be ducted directly to the engine air cleaners. The primary reason for cooling an engine room is to protect various components from excessive temperatures. Items that require cool air are:

- Electrical and electronic components
- Air cleaner inlets
- Torsional dampers
- Generators or other driven equipment
- Engine room for the engine operator or service personnel.

RADIANT HEAT

Engine Radiant Heat

Engine generated heat must be taken into consideration depending on the 3500C engine. For the current radiant heat data please reference TMI.

Calculating Required Ventilation Air Flow

Engine room ventilation air required for Cat engines and packages can be estimated by the following formula, assuming 38°C (100°F) ambient air temperature.

$$V = \frac{H}{D \times Cp \times \Delta T} + \text{Combustion Air}$$

Where:

V = Ventilating Air (m^3/min), (cfm)

H = Heat Radiation i.e. engine, generator, aux (kW), (Btu/min)

D = Density of Air at 38°C (100°F) (1.14 kg/m^3), (0.071 lb/ft^3)

Cp = Specific Heat of Air (0.017 kW x min/kg x °C), (0.24 Btu/°F)

ΔT =Permissible temperature rise in engine room (°C), (°F)

Temperature Rise

The temperature rise in the engine room resulting from these heat sources can adversely affect maintenance personnel, switchgear, and generator set performance. A 7 to 10°C (15 to 20°F) temperature rise is a reasonable target for engine rooms. In cold climates, discomfort may be caused by the flow of cold air. Restrict flow only if engine combustion air is available.

Example:

A 1833 kW propulsion engine has the following data:

Heat rejection: 101 kW (5,720 Btu/min)

Temperature rise: 10°C (20°F)

Solution:

The estimated engine room ventilation required for this arrangement:

$$V = \frac{101}{1.099 \times 0.017 \times 10} = 541 \text{ m}^3\text{/min}$$

$$V = \frac{5720}{0.071 \times 0.24 \times 20} = 16{,}784 \text{ cfm}$$

Ventilation Fans

In modern installations, except for special applications, natural draft ventilation is too bulky for practical consideration. Adequate quantities of fresh air are best supplied by powered (fan-assisted) ventilation systems.

Fan Location

Fans are most effective when they withdraw ventilation air from the engine room and exhaust the hot air to the atmosphere. However, ideal engine room ventilation systems will use both supply and exhaust fans. This will allow the system designer the maximum amount of control over ventilation air distribution.

Fan Type

Ventilation fans are typically of the vane-axial, tube-axial or propeller type, or the centrifugal type (squirrel cage blowers). The selection of fan type is usually determined by ventilation air volume and pressure requirements, and also by space limitations within the engine room. When mounting exhaust fans in ventilation air discharge ducts, which are the most effective location, the fan motors should be mounted outside the direct flow of hot ventilating air for longest motor life. The design of centrifugal fans (squirrel cage blowers) is ideal in this regard, but their size, relative to the vane-axial or tube-axial fans, sometimes puts them at a disadvantage.

Fan Sizing

Fan sizing involves much more than just selecting a fan that will deliver the air flow volume needed to meet the cooling air and combustion air requirements determined earlier in this section. It requires a basic understanding of fan performance characteristics and ventilation system design parameters.

Similar to a centrifugal pump, a fan operates along a specific fan curve that relates a fan's volume flow rate (m^3/min or cfm) to pressure rise (mm H_2O or in. H_2O) at a constant fan speed. Therefore, fan selection not only requires that the volume flow rate be known, but also that the ventilation distribution system be known in order to estimate the system pressure rise. This information allows the optimum fan to be selected from a set of manufacturers' fan curves or tables.

Exhaust Fans

Ventilation air exhaust systems should be designed to maintain a slight positive or negative pressure in the engine room, depending on the specific application.

Generally, maintaining a slight positive pressure in the engine room is recommended, but should normally not exceed 50 kPa (200 in. H_2O). This positive pressure accomplishes several things:

- It prevents the ingress of dust and dirt, which is especially beneficial for those applications involving engines that draw their combustion air from the engine room.
- It creates an out-draft to expel heat and odor from the engine room.

Some applications require that a slight negative pressure be maintained in the engine room, but normally not in excess of 12.7 mm H_2O (0.5 in. H_2O). The excess exhaust ventilation air accomplishes several things:

- It compensates for the thermal expansion of incoming air.
- It creates an in-draft to confine heat and odor to the engine room.

Two-Speed Fan Motors

Operation in extreme cold weather may require reducing ventilation airflow to avoid uncomfortably cold working conditions in the engine room. This can be easily done by providing ventilation fans with two-speed (100% and 50% or 67% speeds) motors.

Routing Considerations

Correct ventilation air routing is vital for creating and maintaining the optimum engine room environment required to properly support the operation of Cat engines and packaged units. Maintaining recommended air temperatures in the engine room is impossible without proper routing of the ventilation air.

Fresh air inlets should be located as far from the sources of heat as practical and as high as possible; and since heat causes air to rise, it should be exhausted from the engine room at the highest point possible, preferably directly over the engine. Where possible, individual exhaust suction points should be located directly above the primary heat sources in order to remove the heat before it has a chance to mix with engine room air and raise the average temperature.

However, it must be noted that this practice will also require that ventilation supply air be properly distributed around the primary heat sources. Avoid ventilation air supply ducts that blow cool air directly toward hot engine components. This mixes the hottest air in the engine room with incoming cool air, raising the temperature of all the air in the engine room, and leaves areas of the engine room with no appreciable ventilation.

For offshore applications, where the potential exists for sea water to be drawn into the ventilation air supply, combustion air should be delivered in a manner that will preclude any sea water from being ingested by the turbochargers through the air intake filters.

These general routing principles, while driven by the same basic principles of heat transfer, will vary with the specific application. This section discusses the general considerations relating to 1 and 2 engine applications, multiple engine (3+) applications, and several special applications.

1 and 2 Engine Applications

These applications will generally require smaller engine rooms, which may sometimes preclude the use of good routing practices.

Recommended ventilation systems for these applications, presented in order of preference, are described below.

Ventilation Types 1 and 2 (Preferred Design)

Outside air is brought into the engine room through a system of ducts. These ducts should be routed between engines, at floor level, and discharge air up at the engines and generators. The most economical method is to use a service platform, built up around the engines, to function as the top of this duct. See Figure 2.

This requires the service platform to be constructed of solid, nonskid plate rather than perforated or expanded grating. The duct outlet will be the clearance between the decking and oilfield base.

Ventilation air exhaust fans should be mounted or ducted at the highest point in the engine room. They should be directly over heat sources.

This system provides the best ventilation with the least amount of air required. In addition, the upward flow of air around the engine serves as a shield which minimizes the amount of heat released into the engine room. Air temperature in the exhaust air duct will be higher than engine room air temperature.

Ventilation Type 1

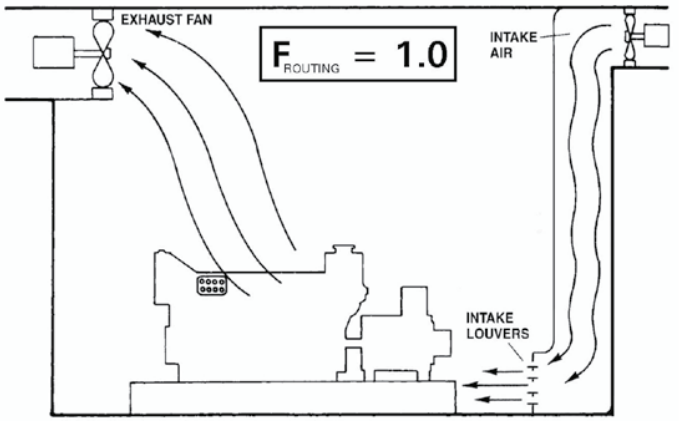


Figure 1

Ventilation Type 2

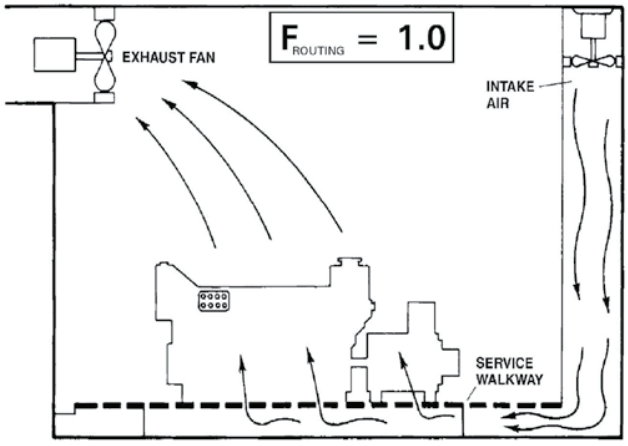


Figure 2

Ventilation Type 3 (Alternate Design)

If ventilation type 1 is not feasible, the following method is recommended; however, it will require approximately 50% more air flow.

Outside air is brought into the engine room as far away as practical from heat sources, using fans or large intake ducts. The air is discharged into the engine room as low as possible as illustrated in Figure 3. Allow air to flow across the engine room from the cool air entry points toward sources of engine heat such as the engine, exposed exhaust components, generators, or other large sources of heat.

Ventilation air exhaust fans should be mounted or ducted at the highest point in the engine room. Preferably, they should be directly over heat sources.

Engine heat will be dissipated with this system, but a certain amount of heat will still radiate and heat up all adjacent engine room surfaces. If the air is not properly routed, it will rise to the ceiling before it gets to the engines.

Ventilation Type 3

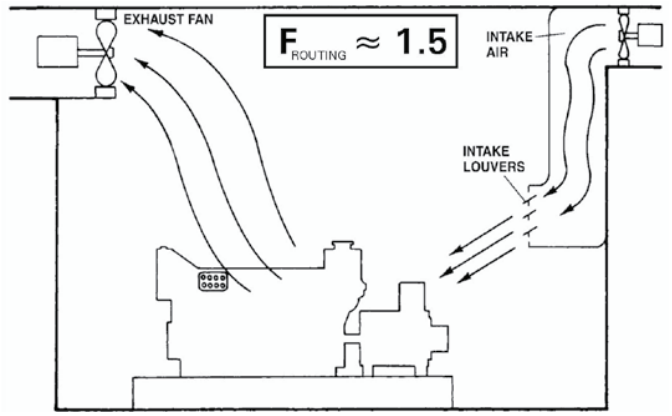


Figure 3

This system will work only where the air inlets circulate the air between the engines, for two-engine applications. Air inlets located at the end of the engine room will provide adequate ventilation to only the engine closest to the inlet.

Ventilation Type 4 (Alternate Design)

If ventilation types 1 and 2 are not feasible, the following method can be used; however, it provides the least efficient ventilation and requires approximately 2.5 times the air flow of ventilation types 1 and 2.

Outside air is brought into the engine room using supply fans, and discharged toward the turbocharger air inlets on the engines as illustrated in Figure 4.

Ventilation exhaust fans should be mounted or ducted from the corners of the engine room. This system mixes the hottest air in the engine room with the incoming cool air, raising the temperature of all air in the engine room. It also interferes with the natural convection flow of hot air rising to exhaust fans. Engine rooms can be ventilated this way, but it requires extra-large-capacity ventilating fans.

Ventilation Type 4

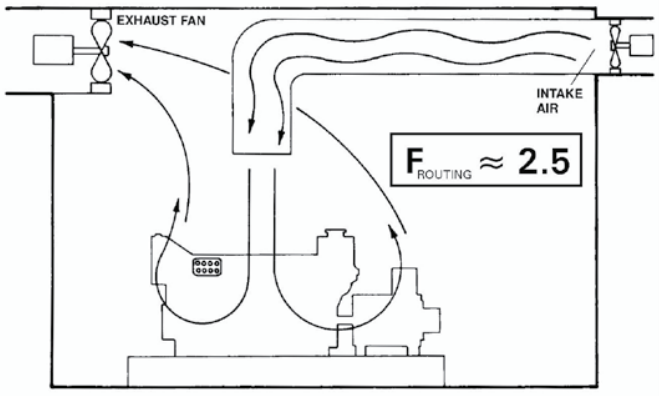


Figure 4

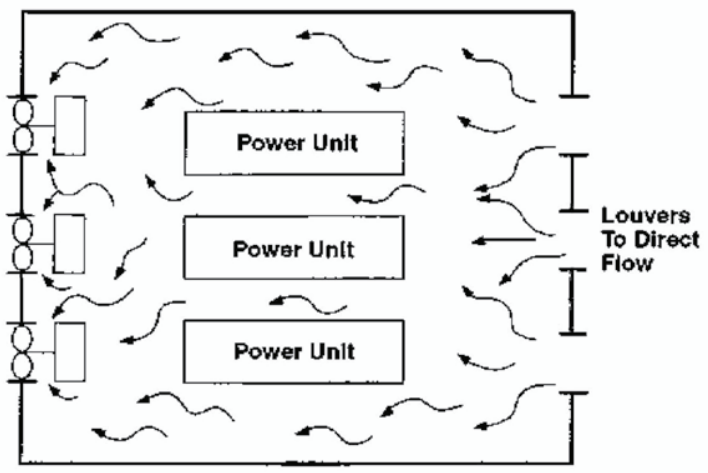
Multiple Engine (3+) Applications

Multiple engine applications, involving three or more engines or packaged units, will generally require larger engine rooms than those needed for 1 and 2 engine applications.

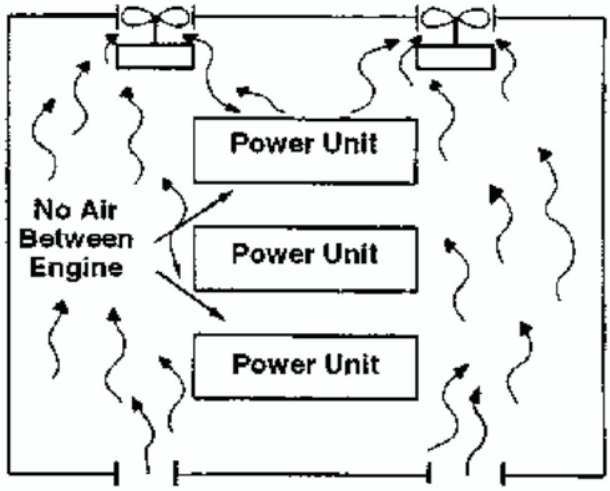
In general, the recommended ventilation systems outlined for 1 and 2 engine applications also apply to multiple engine applications. However, there are several additional considerations that are specific to multiple engines.

As previously mentioned, the application of normal temperature rise guidelines for determining large multiple engine site ventilation requirements will generally result in extremely large volumes of air. Therefore, the guidelines used for these sites are significantly more generous; however, even with the increased temperature rise allowed, the ventilation requirements will be significant. Large multiple engine sites will generally use multiple ventilation fans, often using one or two fans for each engine. This practice allows for a very simple arrangement requiring minimal ductwork.

The use of multiple ventilation fans, either supply or exhaust, will require that air flow between the engines be arranged, either by fan placement or by distribution ductwork. Figure 5 and Figure 6 show examples of correct and incorrect air flow patterns for multiple engine sites.



Correct Air Flow *Figure 5*



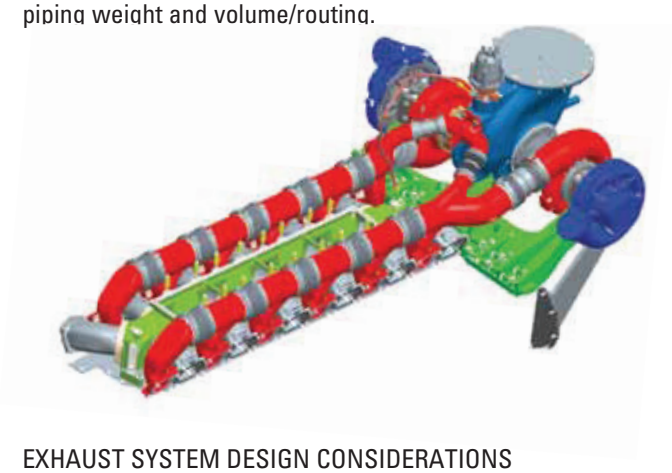
Incorrect Air Flow *Figure 6*

EXHAUST SYSTEM

GENERAL

A well-designed exhaust system should convey the engine's exhaust gases out of the engine room, through piping, to atmosphere. A good exhaust system will have minimum backpressure.

The 3500C engine uses a direct dry-shielded flow exhaust system to turn the turbine wheel. Exhaust gases from the exhaust manifold go into the turbine side of the turbocharger. A single exhaust connection has been arranged to simplify the external piping weight and volume/routing.



EXHAUST SYSTEM DESIGN CONSIDERATIONS

Exhaust Backpressure Limit

The total 3500C exhaust backpressure limit is 6.7 kPa (27 in. H_2O). This level was established with an emphasis on low specific fuel consumption and exhaust valve temperatures. Therefore, to achieve proper performance of the engine, the exhaust backpressures must be kept below this limit.

System backpressure should be measured in a straight length of the exhaust pipe at least 3 to 5 pipe diameters away from the last size transition from the turbocharger outlet. System backpressure measurement is part of the engine commissioning.

Note: Specified system backpressure shall not be exceeded in any circumstances. Caterpillar advises to limit value of maximum allowable backpressure to 50% for new (clean) installations. Minimum diameter of customer piping should be according to "Customer piping diameter overview for Caterpillar engines."

Turbochargers

The turbochargers are located at the flywheel end of the engine. The turbocharger exhaust outlet is a 430 mm (17") flange connection. Optional attachments for these turbochargers include ø 355 mm (14") flexible bellows, expansion transitions from ø 355 mm (14") to ø 406 mm (16") and exhaust flanges with bolting and mounting hardware. Also available is a 355 mm (14")-457 mm (18") expander and exhaust flanges with bolting and mounting hardware for longer exhaust runs.

The exhaust bellows are intended to compensate for thermal growth and movement of the engine. The exhaust system structure immediately after the engine exhaust bellows must be a fixed/rigid point. The supplied exhaust bellows will only handle the engine movement and thermal growth. No additional external loading is allowed on the turbochargers.

Exhaust Slobber (Extended Periods of Low Load)

Prolonged low load operation should be followed by periodic operation at higher load to burn out exhaust deposits. Low load operation is below 456 kPa BMEP (approximately 20% load, depending on rating). The engine should be operated above 912 kPa BMEP (about 40% load, depending on rating) periodically to burn out the exhaust deposits.

Exhaust Piping

A common exhaust system for multiple engines is not acceptable. An exhaust system combined with other engines allows operating engines to force exhaust gases into engines not operating.

The water vapor condenses in the cold engines and may cause engine damage. Additionally, soot clogs turbochargers, aftercoolers, and cleaner elements. Valves separating engine's exhaust systems are also discouraged. High temperatures warp valve seats and soot deposit causes leakage.

The exhaust pipe diameter is based on engine output, gas flow, length of pipe, and number of bends. Sharp bends should be avoided, and where necessary, should have the largest possible radius. The minimum radius should be 1-1/2 pipe diameters.

The piping should be as short as possible and insulated. The insulation should be protected by mechanical lagging to keep it intact. All flexible exhaust fittings should be insulated using removable quilted blankets. It is recommended to provide the system with a valve drain arrangement to prevent rainwater from entering the engine during prolonged shutdown periods.

For testing purposes, the exhaust system must have a test port installed after the turbocharger outlet. This test port should be a 10 to 13 mm (0.394 to 0.512 in.) plugged pipe welded to the exhaust piping and of sufficient length to bring it to the outer surface of the insulated piping.

Exhaust Supports

It is important to consider how the exhaust piping is supported off the engine. Caterpillar has set maximum allowable bending moments and static weights that can be mounted on to the turbochargers.

For a 3512 Engine:

Max Bending Moment = 49 N•m (Newton Meters)

Max Static Weight = 33 kg

For a 3516 Engine:

Max Bending Moment = 49 N•m (Newton Meters)

Max Static Weight = 33 kg

It is important that these figures are not exceeded. If the turbocharger outlet is overloaded, it might cause the turbocharger outlet housing components to fail. It is also important that the exhaust piping through the engine room and the vessel is adequately supported throughout its length.

Please Note: The maximum static weight limits and static bending moments do not take into account the Caterpillar supplied bellow or expender, etc.

Exhaust Silencer (Optional Cat Dealer Supply)

An exhaust silencer, if required, can be supplied with the engine by your Cat dealer. The size of the silencer needs to be taken into account to make sure there is sufficient room for it to fit within the vessel's structure.

The nominal bore of the exhaust needs to be considered when sizing the exhaust silencer. Typical nominal bore sizes are given below for the following 3500 series engines.

Please note: When selecting a silencer for an engine insallation consideration needs to be given to the length of the exhaust run and the exhaust system backpressure. A longer than normal exhaust run might require a larger silencer so that the exhaust backpressure is kept within the required limits set by Caterpillar.

If the engine is being supplied for a fishing application, your Cat dealer will typically supply an FP1 silencer that has 25 dB(A) attenuation. These silencers are much smaller than the class-approved silencers and fit more easily into the vessel structure/ engine room.

If the vessel is to be built to class, it might require a spark arrestor silencer to be fitted. It will depend on the ship type whether or not a silencer is required. Generally, a silencer is required when the exhaust piping runs through dangerous gas zones on vessels such as oil carriers and supply vessels.

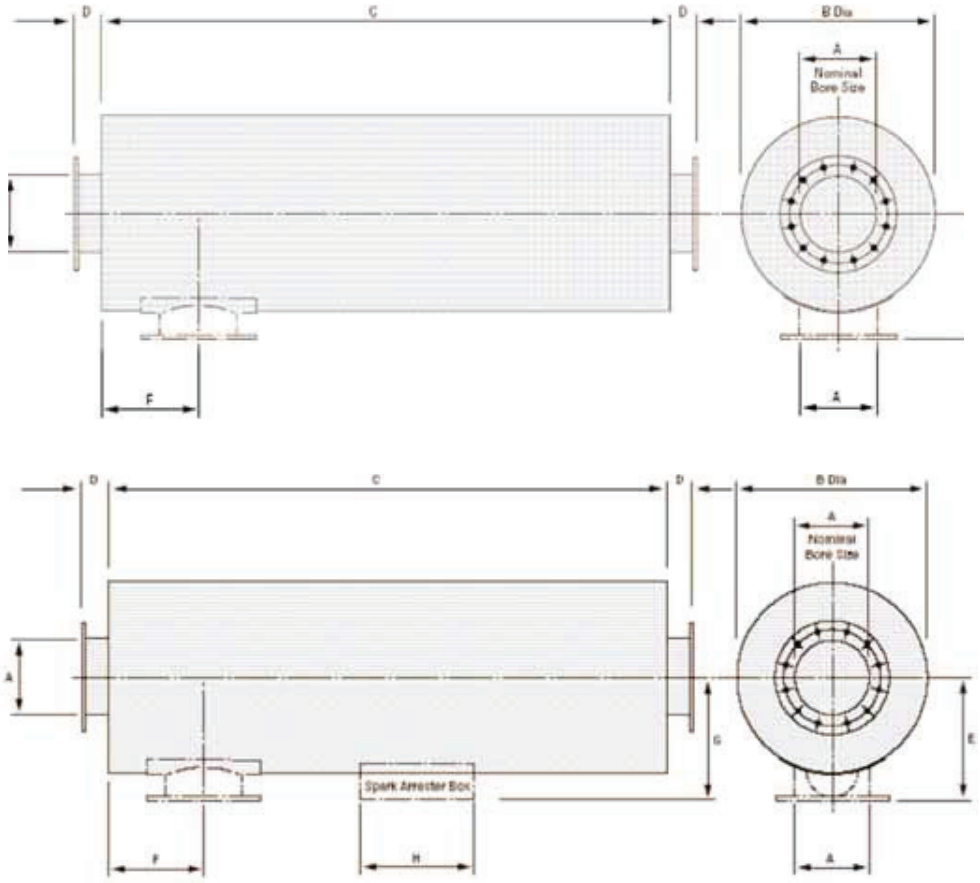
3512B – Typically requires a 12" (304.8 mm) nominal bore exhaust pipe.

3516B – Typically requires a 14" (355.6 mm) nominal bore exhaust pipe.

The units can be mounted vertically, horizontally, or inclined without affecting efficiency. The silencers will give equal performance regardless of its position within the exhaust line. However, for optimum acoustic performance, the silencer should be positioned within 50 pipe diameters of the exhaust outlet and have a tailpipe of approximately ten pipe diameters in length.

It is possible that a silencer can be designed to suit a specific application/space if required. Consultation with our silencer manufacturer would be necessary to see what can and cannot be done. Any specially designed silencers would incur additional cost that would have to be factored into the quote.

Please Note: If the customer is unsure if they require a classification society-approved spark arrestor silencer, one should be supplied anyway or the owner's classification society should be contacted with details about the vessel's application and where in the world the vessel will be used.



Exhaust Backpressure Limits

As the exhaust gases pass through the exhaust system it experiences frictional resistance – causing backpressure on the engine turbocharger discharge.

The maximum exhaust backpressure for a 3500 series engine is 6.72 kPa or 27 in. H_20.

To ensure these limits are not exceeded during operation, Caterpillar recommends that the design limit not be more than one-half the specified backpressure limits.

Please Note: Excessive exhaust backpressure needs to be avoided, as it will shorten exhaust valve and turbocharger life due to increased exhaust temperatures. Excessive exhaust backpressures will also cause the engine to run inefficiently.

Exhaust Bellows (Optional Caterpillar Supply)

Exhaust bellows to be mounted between the turbocharger outlet and the exhaust pipe for the engine can be supplied by Caterpillar. The exhaust expander is designed to absorb the vibrations that are present between the vessel's hull and the engine.

Growth and shrinkage of the exhaust pipe must be planned for or it will create excessive loads on exhaust piping and supporting structure. If required, extra exhaust bellows can be fitted into the exhaust piping system to absorb the thermal expansion of the system. The exhaust bellows can be supplied from either Caterpillar or your Cat dealer.

Exhaust Expander (Optional Caterpillar Supply)

If required, the exhaust expander can be fitted to the outlet of the turbocharger to increase the cross sectional area of the exhaust. It might be a requirement to fit an exhaust expander when a long exhaust run is used on board the vessel to achieve the desired Caterpillar recommended exhaust backpressure.

Exhaust Piping (Yard Supply)

The exhaust piping is to be supplied by the yard. Caterpillar can advise the yard on the correct exhaust pipe sizing to ensure that the engine operates with the correct backpressure. The exhaust piping should be adequately supported throughout its length in such a way that it is allowed to expand and retract under normal service.

Please Note: Under no circumstances should a common exhaust be used in a multiple-engine installation as this would be very detrimental to engine parts and components.

Individual Cylinder Exhaust Temperatures

Caterpillar can supply individual exhaust thermocouple probes for the engine if required by the owner. The advantage of having such a probe will immediately indicate an individual injector failure. The individual exhaust temperatures can be displayed on a cylinder temperature display unit that Caterpillar can supply.

Please Note: Exhaust temperature probes that are supplied by Caterpillar will produce a signal of between 0 and 42mA to display the exhaust temperatures.

Insulation (Yard Supply)

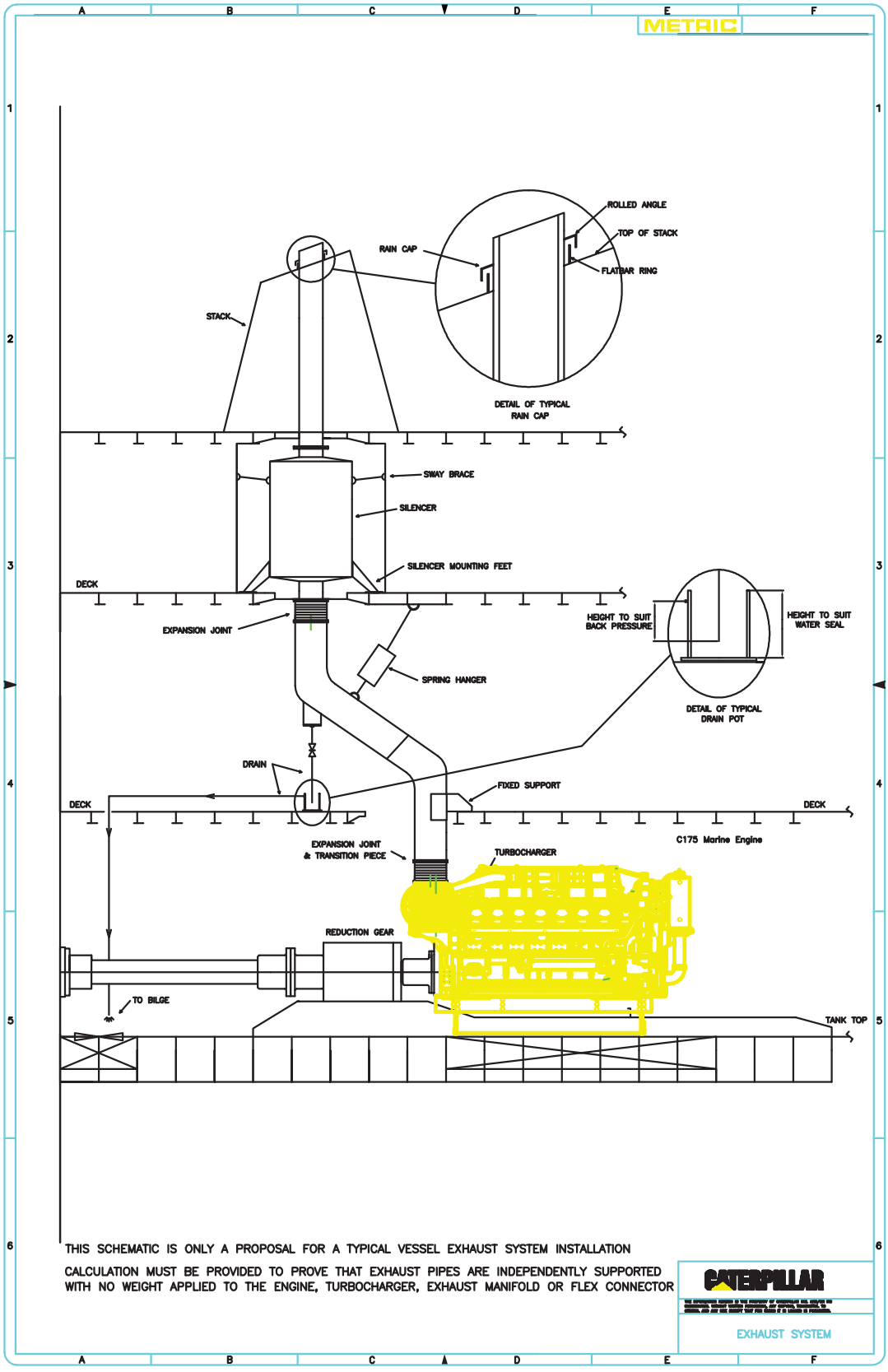
The engine will be supplied from Caterpillar with lagging on the exhaust manifolds and up to the turbocharger inlets. The lagging that is supplied from Caterpillar meets the current SOLAS hot surfaces requirements.

SOLAS requires that all surfaces above 220°C (428°F), which can be impinged as a result of a fuel failure, be insulated. This also insulates the turbocharger exhaust casing when the turbocharger exceeds temperatures of 220°C.

Generally it is the responsibility of the engine installer to protect combustible parts of the boat and provide personal protection from the heat of dry exhaust system piping. Exposed parts of dry exhaust systems can exceed 650°C (1200°F). Any lagging that is used within the exhaust system is subject to be approved to the classification societies.

Please Note: Refer to SOLAS regulations for the precise wording of the regulations relating to the requirements of lagging on the exhausts. It will also be up to the yard/owner to contact the classification society to ensure their requirements are fulfilled.

EXHAUST SYSTEM SCHEMATIC



ENGINE GOVERNING AND CONTROL SYSTEM

INTRODUCTION

This section and the following section describe the A4 ECU monitoring system. The standard control system offering is the Caterpillar MPD 3.0.

Engine Governing System

- A4
- Direct Rack

32-Bit A4 Electronic Control Unit (ECU)

- Increased Processing Speeds
- Enhanced Memory
- Optimized Performance with More Fuel Maps
- Improved Protection and Diagnostics
- High-speed Data Link
- Open Architecture Software Compatible with all Displays
- Reliable and Durable: Tested Under Extreme Conditions

Standard Control System Highlights

- Engine-mounted instrument panel with Marine Power Display (MPD), four-position engine control switch with alarm horn, graphic display unit for analog or digital display of oil and fuel pressure, oil and fuel filter differential, system DC voltage, exhaust and water temperature, air inlet restriction, service meter, engine speed, fuel consumption (total and instantaneous)
- Cold mode start strategy – minimizes white smoke during cold starts
- Programmable engine de-rate strategies
- Programmable low idle
- Electronic diagnostics and fault logging
- Engine and gear monitoring (speed, temperature, pressure)
- Fuel/air ratio control
- ECU controlled pre-lube and cranking
- ECU controlled engine cooldown

ENGINE MONITORING AND SHUTDOWN

Engine Shutdown

The Marine 3500C is installed with safety shutoff protection – electrical for oil pressure, water temperature, overspeed, crankcase pressure, aftercooler temperature, air inlet shutoff activated on overspeed or emergency stop, oil pressure and water temperature (non-redundant, uses OP and WT sensors) and overspeed (redundant and independent of engine). High oil mist level alarm and/or shutdown are not standard as this is to satisfy marine societies which require this feature on engines above 2250 bkW.

Alarms

Alarms for the Marine 3500C are ECU voltage, oil pressure, water pressure (low and high), overspeed, crankcase pressure, aftercooler temperature, low water level (sensor is optional attachment) and filter differential pressure (oil and fuel).

Engine Derate

The Marine 3500C will derate with the following:

- High water temperature
- Crankcase pressure
- Aftercooler temperature
- Air inlet restriction
- Exhaust temperature

Sensors

The following sensors are mounted on the engine:

- Primary speed/timing
- Secondary speed/timing
- Timing calibration
- Aftercooler temperature
- Filtered fuel pressure
- Unfiltered fuel pressure
- Filtered lube oil pressure
- Unfiltered lube oil pressure
- Turbocharger outlet pressure
- Right turbo inlet pressure
- Left turbo inlet pressure
- Atmospheric pressure
- Crankcase pressure
- Coolant temperature
- Right exhaust temperature
- Left exhaust temperature
- Transmission oil pressure (to be mounted on the transmission)
- Transmission oil temperature (to be mounted on the transmission)

SERVICE TOOL CONNECTOR

Lamps

- Low oil pressure
- High coolant temperature
- Low coolant level
- Maintenance
- Warning

Switches

- Engine throttle synchronization
- Engine control
- Engine protection override
- Prelube pressure
- Prelube override
- Override verify

Relays

- Air shutoff
- Shutdown notify
- Starting motor

CUSTOMER-INSTALLED CONNECTIONS

THROTTLE POSITION SENSORS

Relays

- Hour meter

Monitoring Systems

- Engine monitoring system
- Marine analog power display
- Marine power display
- Engine vision

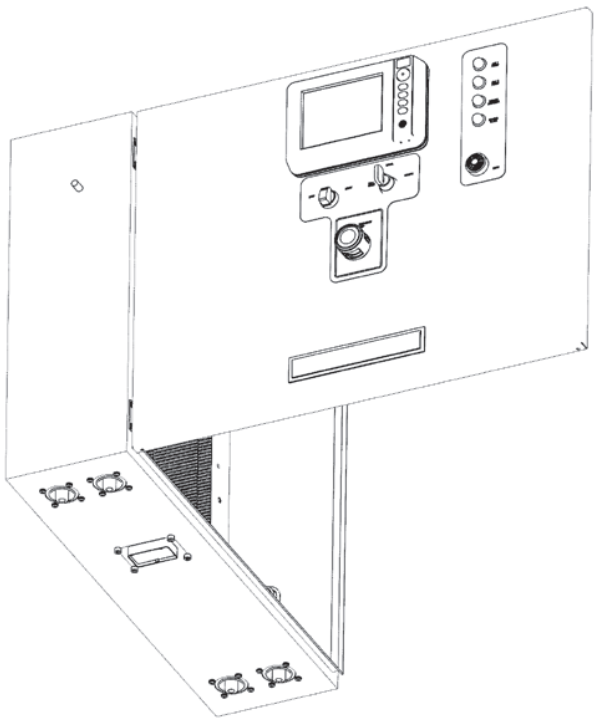
Following are available monitoring systems for the 3500 series engines.

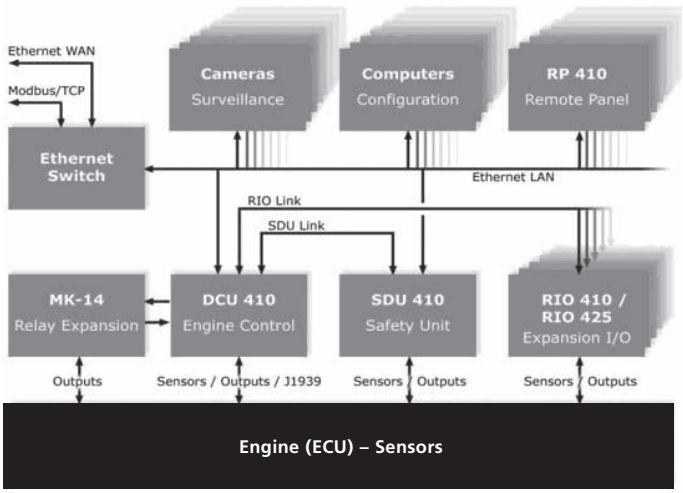
MPD 3.0 (Standard Panel)

The Instrument panel used on the marine 3500C module is the MPD 3.0 panel. Below is a brief description of the MPD 3.0 instrument panel. More information can be found in the publication LEGM8130.

The MPD 3.0 panel uses the color MPD display panel which is easy to use and offers the same features and capabilities as the MPD but in a color display. This uses a high-resolution screen (640 by 480 pixels) that is a fully graphic, transflective, positive image LCD with adjustable illumination levels that can display up to four NTSC camera inputs. Red LED edge lighting for gauges and function buttons provides low light level visibility. The screen has viewing angles up to 115°. Customized screens can be designed on-screen or via the screen builder software for up to three different users to display different engine parameters on different sizes and types of gauges. The custom screen files can be flashed to the MPD using the Cat Electronic Service Tool (ET). An SAE J1939 data link provides information from the engine ECU to the display module.

Color Marine MPD





Engine Monitoring and Control Unit

The DCU 410 is the engine monitoring and control unit. One panel is required for each engine. The DCU 410 has a color screen and buttons for user interaction.

Safety Unit

The safety unit is linked to the DCU engine control unit, and is mandatory in classed installations that are to be type approved.

I/O Expansion Unit

The I/O expansion unit is linked to the DCU. The DCU will find the I/O expansion unit automatically. A maximum of four RIO units can be connected to one DCU.

Generator Interface Unit

The generator interface unit is linked to the DCU. The DCU will find the generator interface unit automatically. When connected, a new page is made available on the DCU and on the remote panel that displays generator parameters. Following are some of the parameters that are shown: phase voltages, phase currents, frequency, power, efficiency factor.

Remote Panel

The remote panel is used in conjunction with the DCU engine panels. Numerous RP remote panels can be connected together in the same ethernet network.

If the engine is being built to class then it is a requirement that the classification society approves the engine control and monitoring system.

Your Cat dealer can supply an Auto Maskin system that is accepted by all the major classification societies.

Auto Maskin (Cat Dealer Supply) – Class Requirement

If the engine is being built to classification society requirements, it is necessary for the engine to be fitted with a classification society-approved monitoring system. The Auto Maskin system can be used for control and monitoring of propulsion engines or generator sets. Auto Maskin is an electronic unit for control and monitoring of diesel engines used as auxiliary or emergency generator sets, or as propulsion engines.

Auto Maskin is classified by major societies for marine use. It has built-in communication facilities and can be expanded with slave panels. Auto Maskin is easily configured using the Rudolf R2 software that is a Microsoft Windows based program. Your Cat dealer engineers can carry out this configuration if required. For flexibility, different expansion modules can be connected.

The Caterpillar supplied engine sensors are not approved by classification societies. Classification societies require the engine control and monitoring systems to be run independently of one another so the failure of one system does not affect the function of other systems. The only exception is when one system directly dependent on the function of another.

Please refer to the following list of required parameters.

CUSTOMER COMMUNICATION MODULE (CCM)

If required, a customer communication module can be supplied. The purpose of the CCM is to provide a two-way link between the A4 ECU and the operator of a personal computer or programmable logic controller, or other device with an RS-232C port.

A CCM module will be required if Auto Maskin is supplied with the engine or if the operator wishes to use some other type of third-party alarm and monitoring software. A CCM module allows the customer to remotely control and monitor the engine at distances beyond the standard 30 m (100 ft) data link limit.

It is important that the CCM is protected from direct contact with liquids. Using a CCM module, a number of parameters can be displayed on the customer's chosen software.

CLASSIFICATION SOCIETY REQUIRED PARAMETERS

Following is a list of monitored parameters that are required by classification societies. There are a couple of exceptions within this list which have been highlighted as available options for operators.

Please Note: The following list is not exhaustive. Further checks will need to be made with the customer's classification societies to make sure that the engine will meet the requirements of the individual classification societies.

Fuel Oil System

- **Fuel oil pressure after filter (engine inlet)** – This is used to give an indication of loss of fuel oil pressure that might have resulted from a broken fuel line or failed fuel pump.

Lubricating Oil System

- **Lube oil pressure to the engine** – The lube oil pressure to the engine is monitored to make sure the lube oil engine is reaching the engine at the correct pressure. Generally there are two conditions that need to be alarmed, low lube oil pressure at low speed and low lube oil pressure at high speed.
- **Lube oil filter differential pressure** – A differential pressure switch is fitted to give the operator an indication when the lube oil filters need to be cleaned.
- **Lube oil inlet temperature** – The lube oil temperature to the engine is monitored to make sure the oil is reaching the engine within the desired temperature range. At higher temperatures the lube oil starts to lose some of its lubricating properties.
- **Oil mist detection (Optional Caterpillar Supply)** – It is not a classification requirement for an oil mist detector to be fitted to all the 3500C series engines.

Please Note: An oil mist detector will be required for the 3516C series engine as these engines are above the 2250 bkW power threshold set by classification societies.

Sea Water Pressure

- **Sea water pump differential pressure** – The sea water pump differential pressure is installed across the sea water pump to give warning of any discontinuity in sea water.

Jacket Water Cooling System

- **Jacket water pressure** – The jacket water pressure to the engine is monitored to ensure that the jacket water is reaching the engine at the correct temperature and pressure. Loss of jacket water pressure could cause substantial damage to the engine.
- **Jacket water outlet temperature** – The jacket water outlet temperature is monitored to ensure it within the parameters that have been set down by Caterpillar. A high jacket water outlet temperature can cause significant damage to the engine. Quick action is required to minimize damage to the engine components.
- **Jacket water level** – It is important that a jacket water level alarm is used on the engine to give an early indication of a loss of engine coolant.

Starting and Control Air Systems

- **Starting air pressure before main shutoff valve**

Air Inlet Manifold

- **Air inlet manifold temperature**

Exhaust Gas System

- **Exhaust gas temperature** – The engine will come from the factory as standard with the exhaust gas temperature after each cylinder (optional Caterpillar supply). This is not required by class but can be fitted to the engine if required by the operator. If used, this will give immediate indication of an individual injector failure.
- **Exhaust gas temperature deviation (Optional Caterpillar supply)** – If the operator decides to install an exhaust gas temperature probe after each cylinder, it is possible to install an exhaust gas temperature deviation alarm. This would warn the operator when the exhaust temperatures are out of balance. This would identify a failed injector or particularly hot unit that might require the fuel timing to be adjusted.

Engine Speed

- **Engine rpm** – It is important that an accurate indication of the engine speed is displayed at all times. The operator will be able to compare the engine speed, vessel load, and throttle position to make informed judgements about the engine load and the need for maintenance.

Engine Overspeed

- **Indication of engine overspeed** – The only time the engine will overspeed is when some part of the engine fails, causing the fuel control mechanism to be locked in a fuel flow condition. When the operator tries to reduce the engine load it will continue to receive a high fuel flow. Without load the engine speed will increase to a dangerously high level. Generally the air supply must be cut off to save the engine.

  The overspeed contactors need to be set 12-15% over rated engine speed to avoid nuisance engine shutdowns during sudden reductions in the engine load.

LOOM CABLES

Wiring will be required from the engine to the helm and from the engine to the throttle position sensors. It is important to quote the length of cables as accurately as possible although in certain cases it can be difficult to do this without a detailed vessel layout drawing. In cases when it is difficult to quote exact lengths, approximate costs should be used and a note inserted into the quote stating that the cost of the cables is subject to change once accurate lengths can be sourced. In cases where lengths are given it is important that the cables are supplied slightly longer then specified so there is sufficient length in the cables to allow them to be fitted to equipment.

FISHING APPLICATIONS

If the engine is being supplied for a fishing application, it is not a requirement for it to be built to class. However, certain modifications are required to satisfy the requirement of the flag authorities.

Particular attention should be given to MSN 1770 – *The Fishing Vessels Code of Safe Working Practice for the Construction and Use of 15 meter length overall (LOA) to less than 24 meter registered length (L) Fishing Vessels.*

Flag authorities should be contacted directly if there are any queries relating to the build specification of the engine.

Sump Pipe (Cat Dealer Supply)

A steel pipe is required to be fitted from the base of the sump to a height above the level of oil in the sump. This is used to pump out the sump when an oil change is required. The pipe is fitted with a quick coupling at one end so that a hose and the oil are directed to a suitable container.

Sump Pump (Optional Caterpillar) – Electric or Hand

A sump pump is required so that the oil in the sump can be pumped out of the sump to a drum or other suitable reception container. Caterpillar can supply a hand pump and your Cat dealer can supply a 24-volt electric sump pump depending on what the owner requires.

Fuel Cooler (Caterpillar Supply)

It is a requirement that these engines are fitted with a fuel cooler. The excess fuel returned to the fuel tank picks up heat from the injectors and cylinder heads and can raise the temperature of the fuel within the tanks.

To avoid decreased injector life, fuel temperature to the engine must not exceed 150°F (66° C). Depending on the engine build, your Cat dealer can supply a separate fuel cooler.

Caterpillar delivers fully integrated plate coolers to cool the engine's jacket water as well as the fuel and lube oil. If the periods of operation are short, the amount of heat returned to the tank will be relatively small. Also, if the time between operations is long, any heat will have time to dissipate.

POWER TAKE OFFS

Depending on the customer's requirements they might need to take an extra drive off the front of the engine.

PTO Drives (Optional Caterpillar Supply)

The engine can be fitted with a left- and or right-hand PTO drive if required. These PTO drives are typically fitted with pulleys that Caterpillar can supply fitted to the engine.

Stub Shaft (Optional Caterpillar Supply)

A stub shaft can be fitted to the front of the engine if the customer requires an extra power take off to be fitted. The stub shaft can be supplied with the engine from Caterpillar for low and full horsepower applications depending on the requirements of the customer.

Pulley (Optional Caterpillar Supply)

If the customer requires a crankshaft pulley to drive external equipment, Caterpillar can supply a 6-groove crankshaft pulley.

Please Note: In order to fit a crankshaft pulley the stub shaft has to be fitted to the engine.

ENGINE MOUNTING AND FOUNDATION DESIGN

PROPULSION ENGINE MOUNTING AND FOUNDATION

This section deals with propulsion engine and reduction gear foundations and their relationship to ship framing.

Exact analytical methods cannot always be used to design engine foundations. The design is also influenced by several factors, including previous successful installations, the designer's experience, and the basic dimensions of the specific engine being installed. Refer to this guide for specific information on 3500C engine weights and dimensions.

The engine foundation must resist vertical, horizontal and fore-and-aft deflection. It should also be integrated into the reduction gear foundation to connect the overall structure to the ship's inner bottom structure. In this manner, the thrust from the propeller and the dynamic forces from the main engine and reduction gear are evenly distributed over a large area of the inner bottom structure. If the engine foundation has too little resistance against deflection, it may show up during the alignment of the engines as the mount depressions may be influenced by the combination of foundation deflection and engine forces, and may be out of tolerance.

The main engine foundation must have sufficient rigidity to transmit static and dynamic forces from the main engine into the foundation.

The girder and faceplate must:

- increase bending inertia of the structure
- facilitate chock installation
- provide a "work shelf" for servicing the side of the engine
- permit installation of side blocks and collision chocks

The main engine and reduction gear foundation must also be designed to absorb the loads from:

- ship's vibration
- propeller thrust
- thrust and torque of the engine
- ship's motion at sea
- thermal, static, and dynamic effects
- crash reversal

Because the loads originate from sources other than the engine, the foundation sections should be uninterrupted and have adequate section strength.

To avoid natural frequency resonance between engine and hull, the engine's 1st and 2nd order free forces and moments must be taken into account when designing the mounting structure. The ship builder must ensure that resonance between torque excitation and the natural transverse hull frequencies does not occur. Upon request, Caterpillar will supply engine 1st and 2nd order free forces and moments.

The engine foundation must have sufficient rigidity to minimize shafting and coupling deformation between the engine and gear.

3500C ENGINE-RELATED FREQUENCIES

Excitation Frequency	Cause of Excitation	Design of Component's Natural Frequencies
½ order = ½ x engine speed	(Correctable) misfiring of one or more cylinders	Stay Above
1st order = 1 x engine speed	Unbalance, misalignment, crankcase overfill (Correctable)	Stay Above
1½ order = 1.5 x engine speed	Normal cylinder combustion (NOT Correctable)	Avoid: side to side and roll modes excited by this order
2nd order = 2 x engine speed	Normal cylinder combustion (NOT Correctable)	Avoid: side to side and roll modes excited by this order
3rd order = 3 x engine speed	Firing frequency for a six (6) cylinder engine or one bank of a twelve (12) cylinder engine (NOT Correctable)	Avoid: side to side and roll modes excited by this order
4th order = 4 x engine speed	Firing frequency for an eight (8) cylinder engine or one bank of a sixteen (16) cylinder engine (NOT Correctable)	Avoid: side to side and roll modes excited by this order
6th order = 6 x engine speed	Firing frequency for a six (6) cylinder engine or one bank of a twelve (12) cylinder engine (NOT Correctable)	Avoid: side to side and roll modes excited by this order
8th order = 8 x engine speed	Firing frequency for an eight (8) cylinder engine or one bank of a sixteen (16) cylinder engine (NOT Correctable)	Avoid: side to side and roll modes excited by this order

MOUNTING

The engine can be supplied with two different types of mounting systems depending on the engine being supplied and the requirements of the vessel it is to be installed in.

Rigid Mounting (Caterpillar Supply)

The engine supports and shims, etc. are mounted directly to the boats structure. To ensure the engine is correctly aligned the engine is shimmed with either steel or poured plastic. Flexibility is built into the engine supports to ensure that the motions in the hull do not overstress the engine block.

Resilient Mounting (Optional Caterpillar)

Resilient mounting of the engine is usually done to isolate noise and vibrations from the ship's structures. This can have considerable effect on crew and passenger comfort, reduced crew fatigue and, therefore, increased efficiency. Flexible fittings must be used for all connections, e.g., exhaust gas, coolant, fuel, etc. The resilient mounts are fitted with a motion-limiting device to prevent the breaking of the engine's cooling and exhaust connections during bad weather or after collision/grounding.

The flywheel-mounted flexible coupling must be selected with care. It must routinely tolerate the ranges of side-to-side and fore/aft motions predicted for the given set of soft mounts.

Consideration must be given to how any auxiliary equipment that is coupled to the engine is mounted and the method of connecting the two. The 3500C family engines are normally on flexible mounts (i.e., rubber with steel springs). The standard mounting feet configuration uses four mounting feet, two on each side of the engine. There is an option to add one foot to each side if needed.

Two mounting options provides vessel design flexibility:

- **Rail mounted**

- **Front cross-member/rear trunnion mount**

As shown in both solutions structural oil pan provides optimum location for mounting rails.

Resin Chocks

Normally, the flexible mounts are installed with a resin chock between the engine and the engine foundation.

The chocking arrangement, planning, and pouring should be reviewed by an approved manufacturer. The shipyard will have the final responsibility for the planning and installation of chocking material.

General

All mounting systems must have provisions for alignment retention, collision stops, and engine thermal growth.

MISCELLANEOUS

ENGINE WEIGHTS

The following weight schedule lists the weights of the 3500C series engines and optional supplied items. Select the optional items and add to the engine's dry weight to estimate the weight of an engine shipset.

ENGINE WEIGHTS				
Engine Model	**3512C kg**	**3512C lb**	**3516C kg**	**3516C lb**
Engine Dry Weight (see note 1 below)	7,411	16,338	9,170	20,216
Torsional Coupling	319	703	319	703
Plate Type, Heat Exchanger	250	551	202	443
Water Temperature Regulator	86	190	86	190
Primary Fuel Strainer	11	24	11	24
Pressure Reduction Valve	20	44	20	44
Freshwater Expansion Tank	135	297	135	297
Exhaust Pieces: (Turbocharger Adapter, Bellows, Expander to 18 inch)	134	295	134	294
Lube Oil @ (.9097 kg/liter)	569	1,254	734	1,618
Freshwater Coolant	157	346	234	516
Heat Exchanger (FW & SW)	61	135	70	154
Total Weight per Engine				

Notes:

1. One (1) "Engine Dry Weight" consists of the following engine-mounted items: a one-piece, gray iron cylinder block, governor actuator, two freshwater pumps, one sea water pump, one lube oil filter, fuel and lube oil duplex filters, centrifugal lube oil filters, electric prelube pump, exhaust shielding, intake air silencer, air starting motors, barring device, oil mist detector, flywheel, and 6 anti-vibration mounts.

2. All weights are in kilograms/pounds

ENGINE MAIN DIMENSIONS AND CENTER OF GRAVITY

ENGINE MAIN DIMENSIONS AND CENTER OF GRAVITY				
Engine Model	**3512C kg**	**3512C lb**	**3516C kg**	**3516C lb**
Main Engine Dimensions				
Length	3232	127.2	3773	148.5
Width	2160	85.0	2284	89.9
Height	2205	86.8	2224	87.55
Center of Gravity				
X Dimension – From rear face of block	895	35.2361	1187	46.7322
Y Dimension – From center line of crankshaft	217	8.5433	197	7.7559
Z Dimension – From center line of crankshaft	5	0.1969	5	0.1969

SPARE PARTS

Depending on the engine build any number of spares can be purchased with the engine.

Classification Society Spares

If the engines are supplied as a class build, the classification society strongly recommends a minimum number of spares are carried onboard the vessel. Caterpillar can supply the spares required and specified by the owner's specified classification societies.

This matter is subject to constant review by classification societies and the customer would need to check with their own classification societies to see if class spares were strongly recommended or a requirement.

Note: If the owner requires class spares, it is more economical for them to be ordered with the engine.

Flag Authorities Requirements

The flag authorities usually require adequate spares be provided for normal operation of the main machinery, auxiliary machinery, and electrical equipment, with regard to the intended service of the vessel. Such spares should include fuel filters, oil filters, sea water pump spares, bilge pump spares, fuses, and light bulbs.

Additional Spares

If the engine is not supplied as a class build or flag build, your Cat dealer can supply the owner with any spares they require. They can be purchased from your Cat dealer either when the engine is ordered or through any Cat dealer branch at a later date. Where the engine has not been built to class it is still strongly recommended that the vessel owner purchase a number of spares with the engine.

Caterpillar would highly recommend operators of our engines carry a minimum number of spares so the engine can be used safely in service and necessary repairs can be carried out onboard. Your Cat dealer can advise the owner on a suitable number or type of spares to carry onboard, depending on the operator's engine arrangements and operation of service.