Staffa Motor
fixed and dual displacement radial piston motors
product overview

- operating principles
- hmb motor build up
- hmc motor build up
- variable motor controls
- model coding
- specifications
- power ratings
- options
single cylinder motor

Theoretical torque = force x effective radius
= F x OA = P x A x OA

Maximum torque = force x crank radius
= P x A x OB x cos(β)

Torque - T

-2 -1 0 1 2 3 4 5
0 90 180 270

Crankshaft angle
torque ripple
5 piston motor
torque ripple
2 x 5 piston motor

cams at 112 degrees
cylinders opposed

crankshaft angle

torque bank 1

torque bank 2

cumulative torque

KPM
Kawasaki Precision Machinery
conrod & restrictor
conrod & restrictor

....think Hovercraft
conrod & restrictor

....think Hovercraft
conrod & restrictor

....think Hovercraft
conrod & restrictor
brazed window
piston
piston retainment
full pressure is felt on the top of the piston.
full pressure is felt on the top of the piston.

passes through the restrictor to the shoe area.
full pressure is felt on the top of the piston.

passes through the restrictor to the shoe area.

the area of the slipper is slightly larger than the piston.
full pressure is felt on the top of the piston.

passes through the restrictor to the shoe area.

the area of the slipper is slightly larger than the piston.

resulting in the slipper lifting up off the throw.
full pressure is felt on the top of the piston.

passes through the restrictor to the shoe area.

the area of the slipper is slightly larger than the piston.

resulting in the slipper lifting up off the throw

flow occurs through the restrictor which results in the pad pressure reducing.
full pressure is felt on the top of the piston.

passes through the restrictor to the shoe area.

the area of the slipper is slightly larger than the piston.

resulting in the slipper lifting up off the throw resulting in the slipper lifting up off the throw

flow occurs through the restrictor which results in the pad pressure reducing.

until such time as a balance occurs.

at which time the slipper is floating above the surface of the throw.
rotary valve
radial piston motor

staffa motors
motorcase

**case material**
- spheroidal graphite to ASTMA 536 (1980) grade 65-45-12 (except HMB010)

**benefit**
- increased material strength allowing reduced wall sections giving lighter weight, increased pressure rating (280 bar) and a higher power to weight ratio
- improves impact / shock load capability

**burst pressure**
- proof tested to 830 bar
- minimum acceptable level 690 bar

**mounting facility**
- basically front mounting with rear mount options on hmb060 thru hmb200 frame sizes

13 different motorcase frame sizes available
rotary valve and housing

wrap around "O" ring
- to eliminate external seepage

valve spool
- spheroidal graphite
- fully hydrostatically balanced by a patented porting system....
- hmc motor spools are nitrided because of potentially higher running speeds

valve rings
- standard rings are nylon
- hmc motor are upgraded to cast iron material to allow for higher speed capability

valve housing
- grey cast iron
- burst tested to 800 bar
- minimum acceptable being 690 bar

oldhams coupling
- only four sizes are necessary to cover full motor range

KPM
Kawasaki Precision Machinery
The rotary valve has large inlet (high pressure) and discharge (low pressure) slots to direct the fluid to and from the cylinders.

To offset the side thrust that these unequal pressure areas would cause, the design provides a total counterbalancing effect: oil from each large slot is allowed access to two small slots on the opposing side, one at each end whose combined areas equal that of the central slot.

This keeps the valve spool centred with no frictional or efficiency loss.
con-rod and piston assembly

**piston**
- grey cast iron

**con-rod restrictor**
- generally 4 restrictor sizes are used across the range.

**con-rod**
- steel forging to SAE grade 1055 - an excellent forging material being economically priced with good surface hardening capability

**piston rings**
- patented dual seal design consisting of a low friction glass filled PTFE ring with nylon backing ring

**con-rod slipper bearing**
- phosphor bronze windows provide the patented hydrostatic balancing
- brazed to the con-rod provides a good wear resistance and load carrying capability
hydrostatically balanced con-rod

![Graph showing efficiency and clearance vs. restrictor size.](image)

- **Efficiency (%)**
  - Volumetric
  - Mechanical
  - Overall

- **Clearance (microns)**
  - Volumetric
  - Mechanical
  - Overall

- **Restrictor size (mm)**

---

KPM
Kawasaki Precision Machinery
the stibbeck curve

frictional coefficient "f"

relative surface speed (m/s)
**typical torque ripple effect on slow speed performance**

Mechanical efficiency (%)

- **Angular rotation (degrees)**
  - 0 9 18 27 36 45 54 63 72

- **15 rpm**
- **9 rpm**
- **1.5 rpm**

**Ball friction moment**
- **Divergent clearance**
- **Convergent clearance**

**HMB100 at 140bar smooth load**

*Image: Kawasaki Precision Machinery*
crankshaft and bearings

retaining rings
● mild steel is standard
● aluminium bronze and high strength steel rings are also available for critical over running situations

throw
● steel forging induction hardened with a 16 cla surface finish

crankshaft
● two piece construction (except B010 and 030)
● heavy interference fit used so cannot be disassembled

shaft
● steel forging or bar stock. numerous shaft end profiles available

bearing shims
● normally bearings are nominally preloaded to 0.08mm
● when operating on non flammable fluids end float of 0.05mm is used

bearings
● taper roller bearings used throughout
● heavy duty bearings available so as to accommodate higher side and radial loadings
**HMB motor complete**

**front cover**
- cast iron
- interference fit to motor casing
- to disassemble, two additional threaded holes on cover should be used

**shaft seals**
- staffa designed double lipped nitrile seal suitable for 3.5 bar continuous casing pressure (7bar intermittent)
- suitable for most fluids except phosphate ester
- high pressure shaft seal are available (10 bar continuous, 15 bar intermittent)
HMB Motor
The HMC Motor is designed with a unique crankshaft assembly. Instead of a single drum and shaft, the HMB motor uses two separate components. The drum slides along the machined flats of the shaft to change its eccentricity and thereby the motor's displacement.

Two control pistons of unequal area, the smaller one assisted by a spring, provide the mechanism whereby the drums' eccentricity can be hydraulically displaced.

Valve spool:
- Valve spools are nitrided because of potentially higher running speeds.

C spacer:
- Additional spacer provided to route the hydraulic shifting ports.

Valve rings:
- Valve rings are upgraded to cast iron material to allow for higher speed capability.

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continuously variable motor

**B motor**

**C motor**
- High displacement
- Low displacement

**CHP motor**
CHP control

pressure compensator

since flow is usually considered constant then power is constant. hence **Constant Horse Power control**
CVM schematic

![CVM schematic diagram](image)

Amplifier Type: EEA-PAM-553-A-30

System Pressure

"C" SERIES MOTOR

KSDG4V Valve

FEEDBACK SELECTOR

CONTROL COMMAND

Speed Pressure Flow Torque

Kawasaki Precision Machinery
model coding

fluid designator (blank - mineral oil, F3 - phosphate esters, F11 - water based fluids {HFA, HFB, HFC})

htls motor

special duty / service (M - mining, HD - heavy duty, K - Kawasaki)

displacement type ( B - fixed, C - dual displacement)

frame size (010 thru 700)

shaft type (P* - parallel keyed, S* - BS splined, Z* - Din splined)
(Q* - female splined, T*/X* - long/short taper shaft)

motor attitude (blank - standard, V - vertically up)

(F*) - HM (**) * *** - ** * - (***)) - (***) - ** - ** - (**) - ** - (PL***)

high displacement code (C motors) (in3)

low displacement code (C motors) (in3)

main port connections (SO* staffa original, F* - SAE inch thread)
(FM* - SAE metric thread {sizes 2, 3 & 4 inch housings})

control options (C motors) ( X - 1/4inch ports, C - cetop3, CS - with shuttle)
(CP**, CHP** - CHP motor control without/with override, ** -setting 10 x bar)
(CV* - CVM motor control , * - P pressure feedback, - S speed feedback)

tacho / encoder drive ( T- staffa original, T1 - hohner encoder)

design series

special features
**b motor specifications**

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additional displacements

hmb010
188cc/rev
standard
50, 94, 139, 177

hmb030
442cc/rev standard
213, 250, 278, 300, 320, 330, 477

hmb045
734cc/rev standard
440, 500, 570, 634, 700, 800

hmb046
745cc/rev standard

hmb060
983cc/rev standard

hmb080
1,344cc/rev standard
1,000, 1,100, 1,250

hmb100
1,640cc/rev standard
1,530

hmb125
2,048cc/rev standard
1,800

hmb150
2,470cc/rev standard
2,130

hmb175
3,217cc/rev

hmb200
3,087cc/rev standard
2,870, 3,630

hmb270
4,322cc/rev standard
3,600, 3,688, 4,000, 4,500, 4,588

hmb325
5,322cc/rev standard
5,187, 6,100

hmb400
6,800cc/rev standard
4,000, 5,310, 6,138, 6,468, 7,991

hmb700
11,600cc/rev standard
8,850, 9,600
## c motor specification

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<th>Rate Speed [Nm]</th>
<th>Rated Speed [r/min]</th>
<th>Rated Power [kW]</th>
<th>Rated Pressure [bar]</th>
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## c motor specification

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power ratings

- **torque**
  - intermittent power
  - intermittent pressure
  - continuous pressure

- **speed**
  - continuous operating envelope
  - continuous power

- **50 rpm**
  - 15% duty: 5 minutes maximum
  - 2% duty: 30 seconds maximum
  - possible extension: power limited
## Alternative Fluid Ratings

<table>
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<tr>
<th>Fluid Type</th>
<th>Continuous Pressure [bar]</th>
<th>Intermittent Pressure [bar]</th>
<th>Maximum Speed [rpm]</th>
<th>Bearing Life Factor</th>
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<td>HFD</td>
<td>as standard motor with mineral oil</td>
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<td></td>
<td>0.60</td>
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valving options
what's available?

- "S" standard staffa porting
- "F" SAE ports with inch threads
- "FM" SAE ports with metric threads
- rear mounting versions
- dual entry versions
- integral shuttle valving (hmc motor)
- pressure tappings included

3 valve housing and port sizes available (hmb060 thru hmb200)
shaft options
what's available?

- "P" - parallel keyed
- "S" - external involute spline {SAE}
- "Z" - external involute spline {DIN}
- "S1" - external involute spline {British Coal}
- "Q" - internal involute spline {SAE}
- "X" & "T" - short and long taper

Others:-
  JIS splined, hollow shaft, calzoni spline etc
other options
what's available?

- tacho drive
  2 standard, over 40 customer specials

- other displacements
  over 50 alternative displacements are now possible

- competitor interfaces
  over 50 competitor interfaces with and without adapters are available.

- shaft seals
  standard 3.5bar
  high pressure 10bar
  high temperature version

- marinized forms
  over 20 such marinizations have been prepared

- valve packages
  sun cartridge modules are available
features and benefits
hydrostatically balanced distribution valve

features
● no side loading
● easy to manufacture
● easy to assemble
● simple construction

benefits
● low wear
● minimal efficiency loss
● easy to repair
● lowest cost
features and benefits
hydrostatically balanced con-rod

features
- high starting and running torque
- minimal wear
- high mechanical efficiency

benefits
- less additional pressure required for starting
- longer life
- optimum efficiency
- lowest cost
features and benefits
modular construction

features
- design flexibility
- interchangability
- faster product engineering
- convertible inventory

benefits
- faster delivery response
- greater options
- match to market requirements
features and benefits
oldhams coupling

features
- ease of assembly
- consistency of assembly
- no side loading
- self aligning

benefits
- trouble free in operation
- minimizes mechanical losses
features and benefits

taper roller bearings

**features**
- reliable
- readily available

**benefits**
- excellent side and radial loading capacity
- long life
- generally outlasts the motor
features and benefits
dual seal pistons

**features**
- staffa original design
- excellent sealing capability
- good wear characteristics

**benefits**
- minimal leakage
- longer life
- high efficiency
features and benefits
alternative fluid capability

features
● suitable for low lubricity fluids
● low wear
● environmentally friendly

benefits
● suitable for most applications
● ideal for most fluids independent of inherent water content
features and benefits
con-rod retaining rings

features
- prevents immediate damage due to inadequate boost pressure

benefits
- more reliable in over running conditions
- cavitation tolerant
features and benefits
Kawasaki worldwide service

features
- Kawasaki agents or distributors in most countries

benefits
- technical back-up
- breakdown and after sales support
market segmentation

- marine: 32.0%
- material processing: 24.0%
- mobile: 15.0%
- mining: 8.0%
- power generation: 3.0%
- entertainment: 2.0%
- others: 16.0%
application matters

plastics
injection screw

mobile
forestry
debarkers
haulers
conveyors
log carriage
chip screws
drums

drums

deck machinery
winches
anchor
capstan
mooring
trawling
sonar
RAS
constant tension

pump drives
cargo pump
bow thruster
sludge gulpers
firefighting

hatch covers

dredgers
bucket
suction

offshore
cranes
positioning winches
power tongs
pigs
firefighting

power generation
windmill
tidal

mining / quarrying
track drives
cutting heads
conveyors
gathering arms
belt changers
reclaimers
crushers
screeners

drilling
head drives

drill drives

water control
sewer reamer
flood gate control
water pumping drive

drag screens

lift drives
elevators
chair lifts
some successful applications
product offering

● hmb range
  fixed displacement motors
  13 sizes
  188 to 11,400 cc/rev

● hmc range
  dual displacement motors
  7 sizes
  480 to 5,330 cc/rev

● control options
  chp hydromechanical control (Pressure)
  cvm electrohydraulic control
  480 to 5,330 cc/rev

● modular construction
  total flexibility
  valve packages
  add ons
  accessories
features and benefits

- hydrostatic balanced valving
- hydrostatic balanced con-rod
- con-rod retaining rings
- oldhams coupling
- dual sealed pistons
- taper roller bearings
- alternative fluid capability
- modular construction
- kawasaki name and reputation
application capability

- mining
- marine
- fishing
- forestry
- steel plant
- construction
- recycling plants
- power generation
- material processing
- entertainment and leisure
- large contract opportunities
marine customers

- Maritime Pusnes
- Ulstein Brattvag
- Nippon Pusnes
- Rolls Royce
- Karmoy
- Plimsoll
- Petrel
- Zicom
- Brusselle
- and many others