

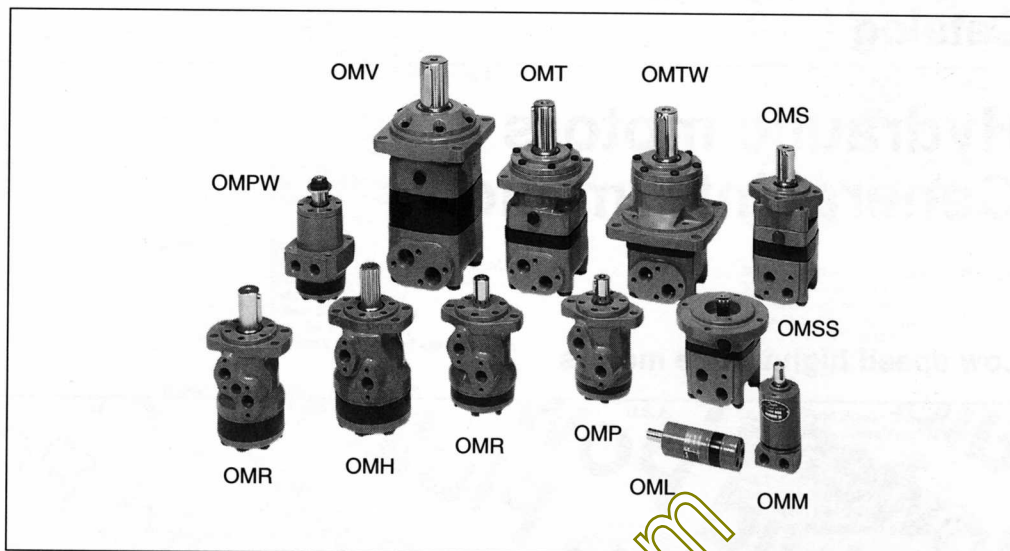
## Hydraulic motors General Information

### Low speed high torque motors





## A wide range of hydraulic motors



Danfoss is a world leader within production of low speed hydraulic motors with high torque. We can offer more than 1600 different hydraulic motors, categorised in types, variants and sizes (incl. different shaft versions).

The motors vary in size (rated displacement) from 0.50 in<sup>3</sup> to 48.9 in<sup>3</sup> per revolution.

Speeds range up to approx 2500 rpm for the smallest type and up to approx. 600 rpm for the largest type.

Maximum operating torques vary from 110 in-lbs to 22,100 in-lbs (peak) and maximum outputs are from 2.7 hp to 86 hp.

### Characteristic features

- Smooth running over the entire speed range
- Constant operating torque over a wide speed range
- High starting torque
- High return pressure without use of drain line
- High efficiency
- Long life under extreme operating conditions
- Robust and compact design
- High radial and axial bearing capacity
- For applications in both open and closed loop hydraulic systems
- Suitable for a wide variety of hydraulic fluids

### Variants

Apart from the "ordinary" versions, the following variants can be supplied:

- Motors with corrosion resistant parts
- Wheel motors with recessed mounting flange
- OMP-OMR motors with needle bearing
- Actuator motors
- Compact motors
- Short motors without bearings
- Ultra short motors
- Motors with integrated positive holding brake
- Motors with integrated negative holding brake
- Motors with tachometer connection
- Motors with speed sensor
- Motors with integrated flushing valve

### Planetary gears

Danfoss is the distributor of a complete range of planetary gears with flanges and couplings designed for Danfoss hydraulic motors. The combination of motors and gears makes it possible to obtain torques up to 368,800 lbs-ft and completely smooth running at very low speeds.

### Examples of Danfoss hydraulic motor applications

- Machines for agriculture and forestry
- Mining machinery
- Contractor's equipment and access platforms
- Grass cutting machinery
- Cranes and transports
- Special vehicles
- Ship's equipment and winches on fishing vessels
- Machine tools
- Woodworking and sawmill machinery
- Plastic and rubber machinery etc.

### Conversion factors

1 in-lb	=	0.0113 daNm
1 lb	=	0.4448 daN
1 psi	=	0.069 bar
1 in	=	25.4 mm
1 in <sup>3</sup>	=	16.39 cm <sup>3</sup>

1 gpm (US)	=	3.785 l/min
1 hp	=	0.7457 kW
°F	=	1.8 × °C + 32



## Contents and technical literature survey

### Contents

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### Survey of literature with technical data on Danfoss hydraulic motors

Detailed data on all Danfoss motors can be found in our motor catalogue, which is divided into 4 individual subcatalogues:

- General information on Danfoss hydraulic motors: function, use, selection of hydraulic motor, hydraulic systems
- Technical data on small motors: OML and OMM

- Technical data on medium sized motors: OMP, OMR, and OMH

- Technical data on large motors: OMS, OMT, and OMV

The most important data on all Danfoss hydraulic motors is covered in a general survey brochure.

ISO 9001

## INTERNATIONAL STANDARD



INTERNATIONAL ORGANIZATION FOR STANDARDIZATION  
ORGANISATION INTERNATIONALE DE NORMALISATION  
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

### Quality management and quality assurance standards



Danfoss Mobil Hydraulic have been manufactured to meet the quality demands specified by ISO 9001.

## Hydraulic motors, general

### Operating principle

Hydraulic motors convert hydraulic energy (pressure, oil flow) into mechanical energy (torque, revolutions).

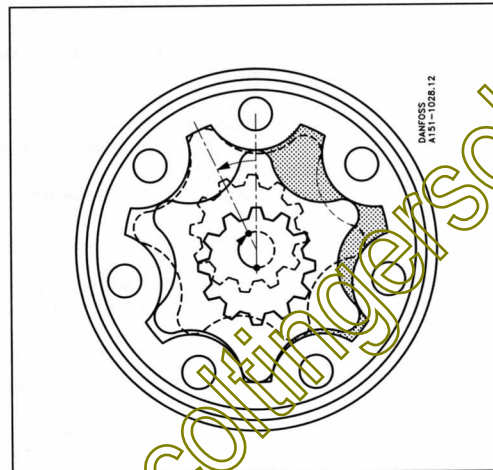
Danfoss hydraulic motors are high torque motors with fixed displacement. For a given oil flow and given pressure the size of the displacement (size of motor) determines the speed and torque. For a given displacement (size of motor) the speed is determined by the size of the oil flow rate and the torque is determined by the pressure differential.

#### Gearwheel set

The motor gearwheel set consists of a gear rim with internal teething and a gearwheel.

The center of the gearwheel rotates in a circular orbit around the center of the gear rim. There are two forms of gear rim: the OML, OMM, and OMP have plain teeth, whereas the OMR, OMH, OMS, OMT and OMV have teeth formed by rollers.

#### Gearwheel set

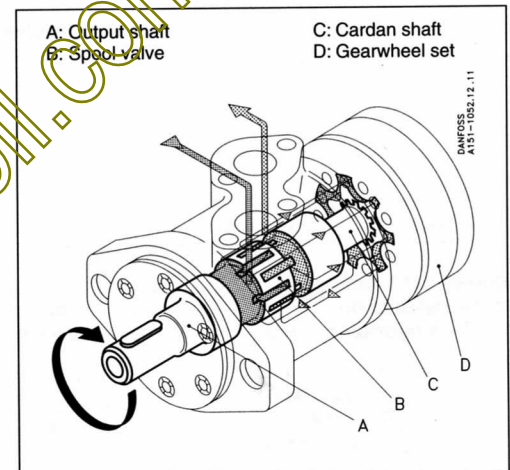


#### Distributor valve

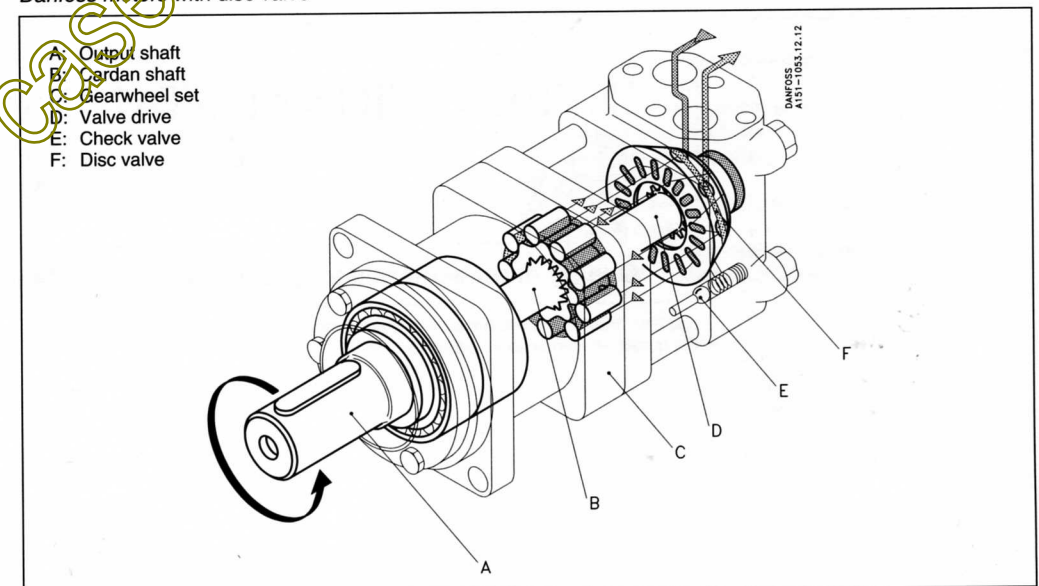
The motor cardan shaft ensures that the distributor valve is driven synchronously with the gearwheel set so that the individual chambers of the motor are filled and emptied precisely - without losses. There are two forms of distributor valve:

- **Spool valve**  
OML, OMM, OMP, OMR, and OMH motors have a spool valve: the distributor valve has been integrated with the output shaft. The cardan shaft must therefore rotate the distributor valve as well as transfer mechanical energy from the gearwheel set to the output shaft.
- **Disc valve**  
OMS, OMT and OMV motors have a disc valve: The distributor valve has been separated from the output shaft and it is driven by a short cardan shaft (valve drive). A balance plate counterbalances the hydraulic forces around the distributor valve.

#### Danfoss motors with spool valve



#### Danfoss motors with disc valve



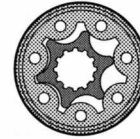
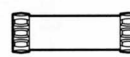
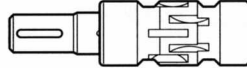


## Selection of motor type

### Main types

#### OML, OMM, OMP

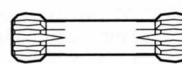
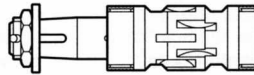
- Fixed gear rim
- Spool valve integrated with output shaft
- Output shaft supported in slide bearings



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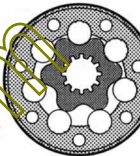
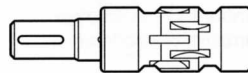
#### OMPW N

- Fixed gear rim
- Spool valve integrated with output shaft
- Output shaft supported in needle bearings



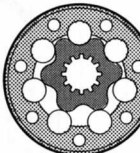
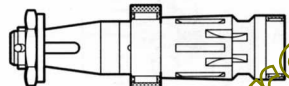
#### OMR, OMH

- Gear rim with rollers
- Spool valve integrated with output shaft
- Output shaft supported in slide bearings



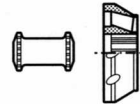
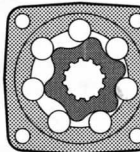
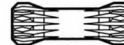
#### OMRW N

- Gear rim with rollers
- Spool valve integrated with output shaft
- Output shaft supported in needle bearings



#### OMS, OMT, OMV

- Gear rim with rollers
- Disc valve with separate valve drive
- Output shaft supported in tapered roller bearings



### Features of main types

#### OML, OMM, OMP

Compact motors with fixed gear rim. These types are suitable for long operating periods at moderate pressures - or short operating periods at high pressures.

#### OMPW N

Compact motor suitable for long operating periods at moderate pressures or short operating periods at high pressures. The needle bearings of the output shaft make OMPW N suitable for applications with static and dynamic radial loads, e.g. when the motor is used as a wheel motor.

#### OMR, OMH

The rollers in the gear rim and the effective hydrodynamic lubrication of the seats of the rollers reduce friction to a minimum. This gives long operating life and better efficiency even at continuous high pressures. Gearwheel sets with rollers are recommended for operation with thin oil and for applications having continually reversing

#### OMRW N

Because of the rollers in the gear rim OMRW N is suitable for continuous operation under demanding operating conditions: e.g. high pressures, thin oil, or frequent reversals. The needle bearings of the output shaft make OMRW N suitable for absorbing static and dynamic radial loads.

#### OMS, OMT, OMV

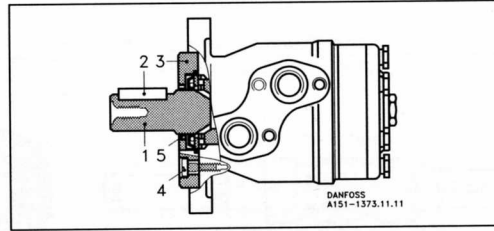
OMS, OMT, and OMV are suitable for continuous operation under rough operating conditions: e.g. high pressures, thin oil, or frequent reversals. The tapered roller bearings make the motors suitable for absorbing static and dynamic radial loads. The separately driven and hydraulically balanced disc valve reduces hydraulic and mechanical losses to a minimum. This gives the motors high efficiency, even at high pressures.

If the application requires very smooth running at low speeds, the choice of OMS, OMT or OMV is recommended.

## Choice of motor type

### Motor variants

#### Motors with corrosion resistant parts

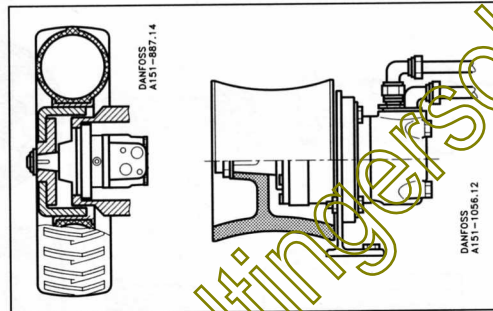


OMP and OMR motors are available in a version with incorporated corrosion resistant parts: OMP C and OMR C. The corrosion resistant parts are: output shaft (1), key (2), front cover (3), and front cover screws (4). The dust seal ring is of plastic material with rustproof cap.

With this variant the following advantages are obtained:

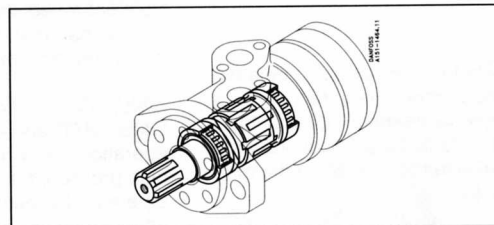
- In corrosive environments the shaft seal will not only have a longer life, but its sealing capability will be maintained as there is no rust formation on the shaft.
- The motor can easily be dismantled - even after operating for a long time in corrosive environments.

#### Wheel motors



OMP, OMR, OMS, OMT and OMV motors are available in wheel motor versions. The recessed mounting flange makes it possible to fit a wheel hub or a winch drum so that the radial load acts midway between the two motor bearings. This gives the best utilisation of the bearing capacity and is a very compact solution. Type designations of wheel motors are OMPW N, OMRW N, OMSW, OMTW, and OMVW.

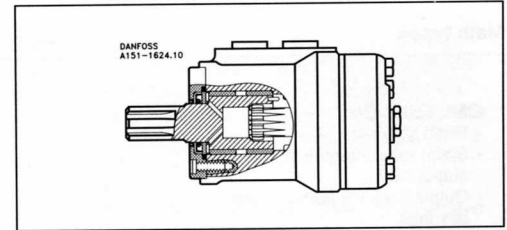
#### OMP/OMR with needle bearing



For applications that want to benefit from OMP/OMR though they must also consider special operation conditions such as great static radial load, frequent starts/stops and vibration on the shaft, we can offer OMP/OMR with an output shaft running in needle bearings.

Type designation: OMP N, OMR N.

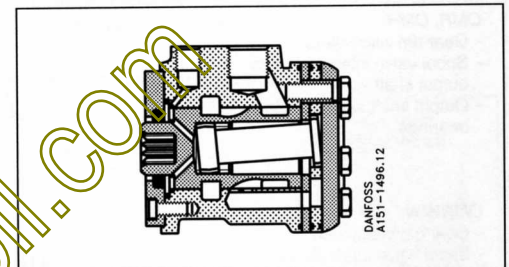
#### Actuator motor



The OMR motor is available in a special version that keeps drum valve and output shaft apart and runs the output shaft in needle bearings. This motor is particularly fit for applications with special demands on the internal motor leakage (e.g. steering motors - actuators - for fork lift trucks).

Type designation: OMR NA.

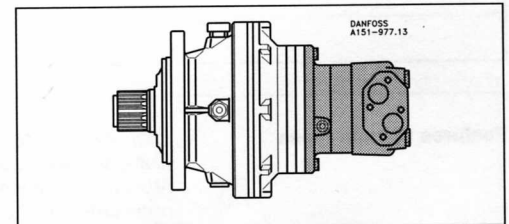
#### OMN compact motor



OMN was developed for applications that demand a compact design and a great power density (e.g. in lawn mowers for direct drive of the cutting cylinders).

OMN is available with integrated by-pass valve, and as accessories for the incorporation of OMN we have a bushing and an external cardan shaft to offer.

#### Short motors



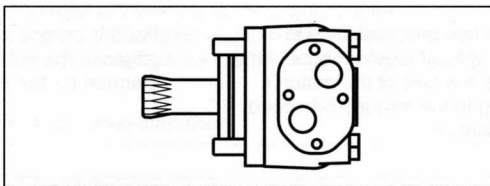
OMS, OMT and OMV motors are available in short motor versions: a hydraulic motor without output shaft. It can be an advantage to use a short motor for gears that already have the capacity to absorb radial and axial forces.

Type designation: OMSS, OMTS and OMVS.



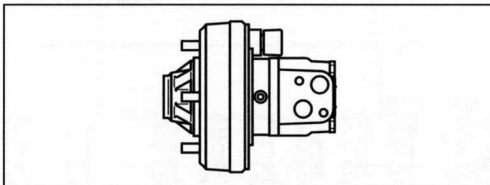
## Choice of motor type

### Ultrashort motor



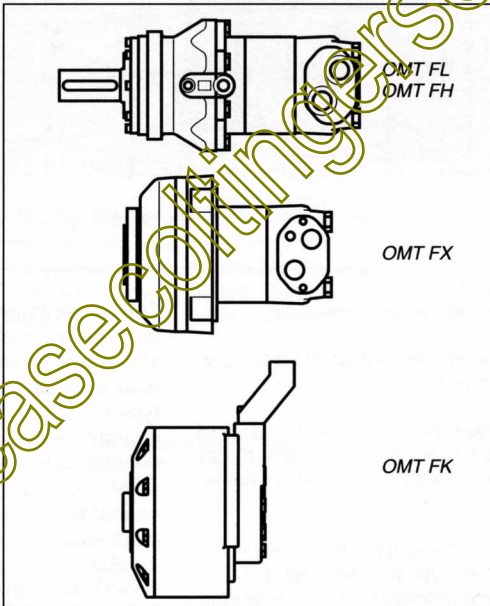
OMS, OMT and OMV are available with ultrashort installation dimensions, - i.e. without bearings and output shaft. The ultrashort design allows an optimized integration of the motor in the counterpart. Type designation: OMSU, OMTU and OMVU.

### Motors with integrated positive holding brake



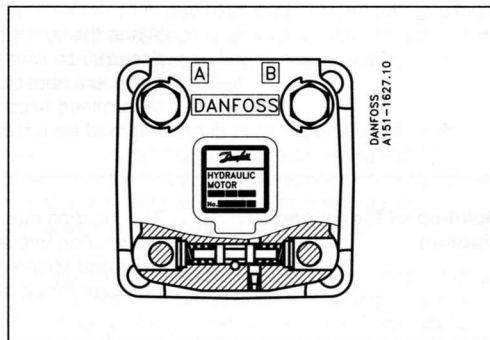
OMS is available in a version with integral holding brake. This is a drum brake activated mechanically (positive brake). Type designation for OMS with integral holding brake is OMS B.

### Motors with integrated negative holding brake



OMT with integrated lamellar brake is available in four versions: OMT FH, OMT FL, OMT FX and OMT FK. The brake is a spring activated lamellar brake that is released by a hydraulic pressure. OMT FH releases the brake at high pressure, whereas OMT FL, OMT FX and OMT FK release the brake at low pressure. OMT FX and OMT FK are particularly well-suited for applications that require very short installation dimensions, - for example in road rollers and wheels. The design of the OMT F motors allows the brake to be used as dynamic emergency brake as well.

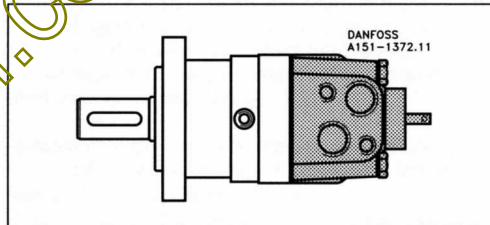
### Motors with integrated flushing valve



Without any change to their outer dimensions, both OMS and OMT are available with an integrated flushing valve. The integrated flushing valve ensures continuous renewal and cooling of the oil in the closed circuit. The flushing valve is activated by the high pressure side of the motor and allows the flushing flow to pass to the drain line and consequently to the tank.

Type designation: OMS V, OMT V.

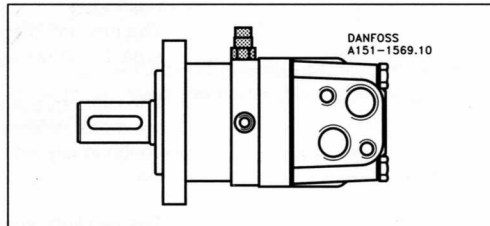
### Motors with tacho connection



OMS, OMT and OMV motors are available in a version with mechanical tacho connection. With the mechanical tacho connections the speed of the motor can be registered by means of a tachometer or tachogenerator.

Type designation: OMS T, OMT T and OMV T.

### Motors with speed sensor



OMM, OMP, OMR, OMS, OMSW, OMT and OMV are available with speed sensor. The electric output signal is a standardized voltage signal that may for example be applied by Danfoss' electronic module type EHSC to control the speed of the motor. The speed is registered by an inductive sensor. Signal processing and -amplification are integrated in the housing of the sensor.

Type designation: OM - EM.

## Selection of motor size

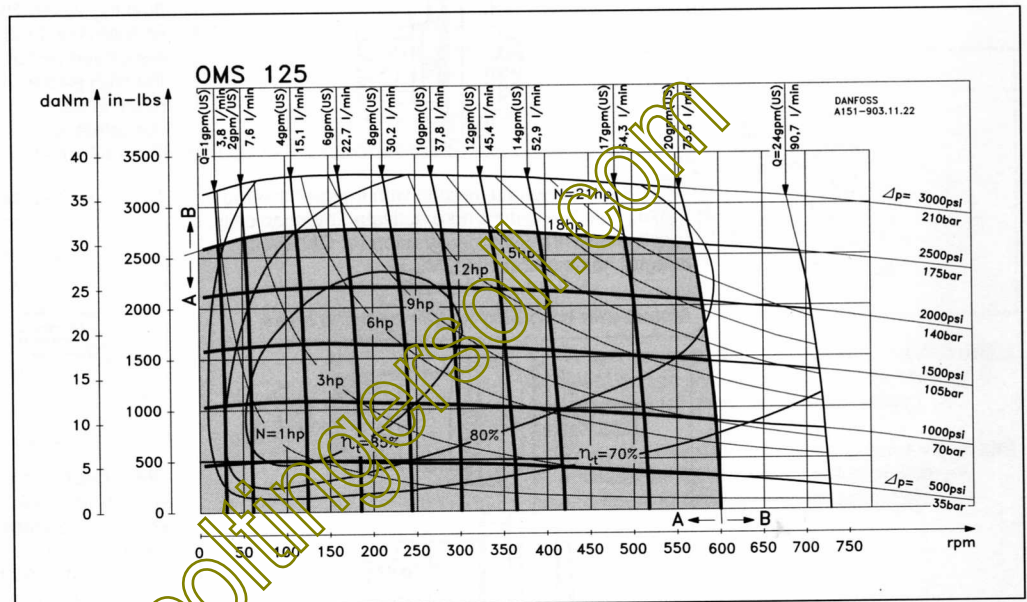
When the motor type has been selected in accordance with the special requirements of the individual application, the size of the motor is determined according to the torque and speed required for the application.

For this purpose use the bar charts on the first pages of the subcatalogues and the function diagram for the individual motor.

### Build-up of the function diagram

The function diagram for a hydraulic motor shows the relation between operating torque  $T$  (vertical axis) and speed  $n$  (horizontal axis) at different pressure drops  $\Delta p$  and oil flows  $Q$ .

The curves for constant pressure drop and constant oil flow form a network superimposed on the coordinate system grid. The curves for constant power output  $N$  (hyperbolas) and constant total efficiency  $\eta_t$  are also plotted. The latter curves have an almost ring form, as seen on mussel shells, and for this reason function diagrams are often called shell diagrams.



Continuous operation/intermittent operation/  
peak load

The function diagrams are divided up into a dark area A and two light areas B.

The dark area A represents the continuous range of the motor. Within this range the motor is able to run continuously with optimum efficiency and operating life.

The two light areas B represent the intermittent range of the motor. It is quite an advantage to be able to make use of the intermittent range when the hydraulic motor operates with varying loads or, when reversing, it is subjected to high torques (pressure drop) from braking. It is permissible to subject the motor to intermittent speed or intermittent pressure drop for max. 10% of every minute. The motor should not be subjected to intermittent speed and intermittent pressure drop at the same time.

The upper limits for intermittent pressure drop and torque must not be exceeded for more than 1% of every minute (peak load). The max. peak load value is stated in the technical data for each type of motor. High pressure peaks occur, for example, when a pressure relief valve opens or a directional valve is opened or closed. Pressure relief valves and dual shock valves should be set so that pressure peaks do not exceed the max. peak values. In systems with large pressure oscillations the pressure and torque peaks should be measured with electronic equipment.

To give problem-free operation the motor size should be selected using the permissible continuous and intermittent values while making sure that pressure peaks do not exceed the max. peak values.

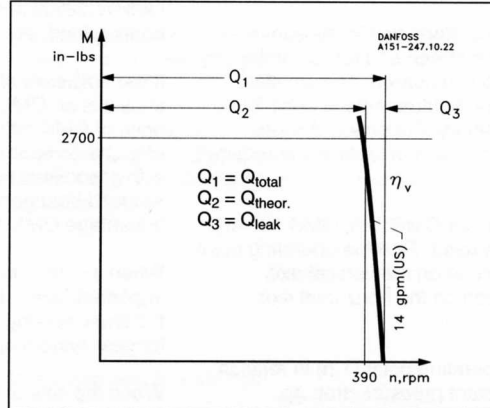


## Selection of motor size

### Efficiency

The total efficiency  $\eta_t$  is the product of the volumetric efficiency ( $\eta_v$ ) and the hydraulic-mechanical efficiency ( $\eta_{hm}$ ). Thus  $\eta_t = \eta_v \times \eta_{hm}$ .

#### • Volumetric efficiency



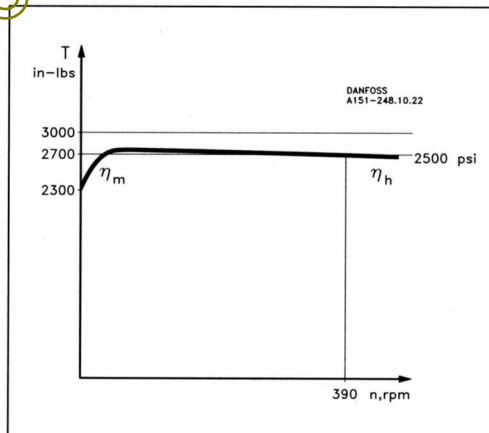
The slope of the Q curves is an expression of the size of the volumetric efficiency. The slope shows how large a part of the supplied oil flow is converted direct into output shaft revolutions. The remaining part of the oil flow is led through clearances and across sealing surfaces and acts as a lubricating and cooling agent. When the load (pressure drop) increases leakage also increases, oil flow to the gearwheel set lessens, and the speed decreases.

Taking an OMS 125 as an example, the motor must drive a shaft at 390 rpm and develop a torque of 2700 in-lbs. To simplify the example as much as possible, all calculations are shown using SAE units only, see conversion factors on page 3.

If the volumetric efficiency is 100%, the oil flow to the motor should be 13 gpm (US) corresponding to the geometric displacement of the motor (7.67 in<sup>3</sup>) times the speed. However, 14 gpm (US) is supplied. The volumetric efficiency thus becomes:

$$\eta_v = \frac{13}{14} \times 100\% = 93\%$$

#### • Hydraulic-mechanical efficiency



The torque curves (pressure drop curves) descend at very low and very high speeds. The descending curve at low speeds is an expression of mechanical loss while the descending curve at high speeds expresses hydraulic loss.

The mechanical loss is at its maximum when the motor is started because no lubricating film has been built up between the rotating parts. After a few revolutions, the lubricating film builds up and reduces the friction (the curve ascends).

The point of intersection between the pressure drop curve and the torque axis is the starting torque of the motor at this pressure drop. The OMS 125 has a starting torque of 2300 in-lbs at a pressure drop of 2500 psi. Thus the motor is able to develop a torque of 2300 in-lbs on starting, whereas with the same pressure drop it can develop 2700 in-lbs as soon as the lubricating film has been built up.

The pressure drop curves do not intersect the torque axis in the function diagrams, but min. starting torque at max. cont. and max. intermittent pressure drop is stated in the technical data for the individual types of motors.

The hydraulic loss is at its maximum at high speed. The increased oil flow causes a larger pressure loss in ports and oilways. Therefore the pressure drop available across the gearwheel set decreases i.e. the motor gives less torque.

To calculate the hydraulic-mechanical efficiency  $\eta_{hm}$  it is necessary first to read off (measure) motor torque  $T_{mot\ off}$  at a given oil flow and a given pressure drop. The diagram on page 8 shows that the OMS 125 develops a torque of 2700 in-lbs at a pressure drop of 2500 psi and an oil flow of 14 gpm, US. The theoretical torque for the same pressure drop can then be calculated.

$$T_{theor} = \frac{\text{Displacement} \times \text{pressure drop}}{2 \times \pi \times 100} \text{ in-lbs}$$

↓

$$T_{theor} = \frac{7.67 \times 2500}{2 \times \pi} = 3050 \text{ in-lbs}$$

Dividing the read-off (measured) torque by the theoretical gives the hydraulic-mechanical efficiency:

$$\eta_{hm} = \frac{T_{mot\ off} \times 100}{T_{theor}} \% = \frac{2700 \times 100}{3050} \% = 88.5\%$$

#### Total efficiency

The total efficiency can now be calculated for the OMS 125 at  $\Delta p = 2500$  psi and  $Q = 14$  gpm (US):

$$\eta_t = \eta_v \times \eta_{hm} = \frac{93 \times 88.5}{100} \% = 82.3\%$$

The same efficiency can be read with fair accuracy from the efficiency curves on the function diagram, page 8.



## Selection of motor size

### Use of the function diagram

The function diagram is used when the right Danfoss motor (and pumps, etc.) has to be selected for an application.

For example, a motor is required with an output:  
- Max. speed: 425 rpm (cont. operation)  
- Max. torque: 2300 in-lbs (cont. operation)

On page 3 of the subcatalogs and in the survey brochure the maximum speed and torque of the different motors can be compared. The smallest motor able to meet the requirements is to be found in the OMR or OMS series. But only OMR 125, OMS 125, and OMS 160 can meet both the required speed and torque.

The function diagrams for OMR 125, OMS 125 and OMS 160 can now be used. Find the operating point concerned, i.e. the torque on the vertical axis ( $T = 2300$  in-lbs), speed on the horizontal axis ( $n = 425$  rpm).

The position of the operating point ( $T, n$ ) in relation to the curves for constant pressure drop  $\Delta p$ , constant oil flow  $Q$ , and constant total efficiency  $\eta_t$ , gives the following associated values:

Motor	Pressure drop $\Delta p$ (psi)	Oil flow $Q$ (gpm, US)	Efficiency $\eta_t$ (%)
OMR 125	2300	15.6	73
OMS 125	2100	14.8	83
OMS 160	1725	18.5	81

Which is now the most important factor in an overall economic and technical assessment: the initial price of the hydraulic system, its efficiency or its operating life?

If the answer is the *price* of the motor, the choice is an OMR 125. The choice between OMR 125 and OMRW 125 N is made according to the required bearing load, see "Selection of motor type".

If the *efficiency* of the motor is all-important, the choice is an OMS 125. The slightly higher initial price of OMS 125 compared with OMR 125 will often be compensated for by a better system design with associated savings in running costs and reduced heat generation. As an additional advantage OMS 125 also requires lesser oil flow.

When it comes to *operating life* being the most important factor, the choice is an OMS 160. It has the least working pressure and thereby gives the longest system operating life.

When the size of motor has been decided, the capacity of the pump can be determined. If, for example, the choice had been an OMS 160, the pump would have had to be able to deliver 18.5 gpm (US) at 1725 psi.

If a hydraulic motor is to be installed in an existing system with a given pump, then the choice of motor is largely predetermined.

### Minimum speed

At very low speeds, the motors may run less smoothly. This is why a min. speed is stated for each type of motor. In borderline cases a motor of the desired type should be tested under the required operating conditions in the system concerned before finally selecting the motor size and type.

To obtain smooth running at very low speed the motor leakage must be constant. Therefore it is recommended that a motor with disc valve (OMS, OMT or OMV) be chosen, but avoid choosing motors with the smaller displacements. The best results are achieved with a constant load, a return pressure of 45-70 psi and an oil viscosity of min. 164 SSU.



## Bearing dimensioning

### Shaft load and bearing life

In many applications the hydraulic motors must absorb both

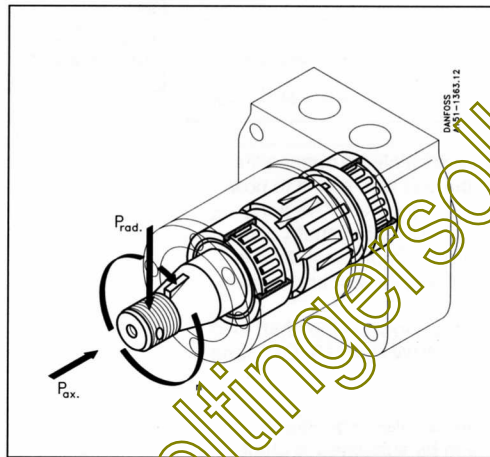
- external radial and axial forces acting directly on the output shaft of the motor (e.g. from the weight of a vehicle) and
- radial forces produced by torque transfer from gearwheels, chainwheels, V-belts, or winch drums.

For such applications hydraulic motors with built-in rolling bearings are particularly suitable. Two different types of bearing are used in Danfoss hydraulic motors:

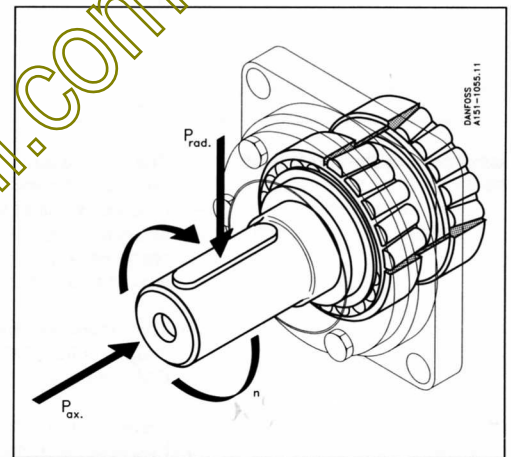
- 1) *Needle bearings in OMPW N and OMRW N*  
The needle bearings are capable of absorbing large radial forces. As the motors have separate axial bearings, the operating life of the needle bearings is not affected by the size of the axial load.
- 2) *Tapered roller bearings in OMS, OMSW, OMT, OMTW, OMV, and OMVW*  
The tapered roller bearings can absorb large radial and axial forces.

The largest possible bearing capacity for the individual motor type is obtained by using OMPW N, OMRW N, OMSW, OMTW, or OMVW because the recessed mounting flange makes it possible to fit for example wheel hubs and winch drums so that the radial load is applied centrally to the two bearings.

Motor with needle bearings



Motor with tapered roller bearings



### Relationship between bearing life and speed

It is a general rule that life and speed are inversely proportional: life is doubled when speed is halved. So life can easily be calculated for other speeds than those given in the sections on shaft load in the individual subcatalogues.

The relation is expressed by the formula:

$$L_{\text{new}} = L_{\text{ref}} \times \frac{n_{\text{ref}}}{n_{\text{new}}}$$

where  $L_{\text{new}}$  is the life at speed  $n_{\text{new}}$ , and  $L_{\text{ref}}$  and  $n_{\text{ref}}$  are the data for the given motor type found in the subcatalogue.

## Bearing dimensioning

### Relationship between shaft load and bearing life

Smaller shaft loads result in longer life of the bearings. The exact relationship is shown by the following formula:

$$\frac{L_{\text{new}}}{L_{\text{ref}}} = \left( \frac{P_{\text{ref}}}{P_{\text{new}}} \right)^{3,3}$$

$L_{\text{new}}$  is the bearing life at a shaft load of  $P_{\text{new}}$ , and  $L_{\text{ref}}$  and  $n_{\text{ref}}$  are data from the subcatalogue.

#### Note:

- The formula applies to OMPW N and OMRW N regardless of the relation between the axial and radial loads.
- To the other motors the formula only applies if there is a constant relation between the axial and radial loads.

### Relationship between permissible shaft load and speed

In certain applications the motor must run at low speeds while the bearings must absorb high loads. This is the case for example when the motors are vehicle support elements. In such cases the following relationship between speed and bearing load (with unchanged bearing life) must be taken into account:

$$\frac{P_{\text{new}}}{P_{\text{ref}}} = \sqrt[3,3]{\frac{n_{\text{ref}}}{n_{\text{new}}}}$$

$P_{\text{new}}$  is the shaft load at  $n_{\text{new}}$ .  $P_{\text{ref}}$  and  $n_{\text{ref}}$  are data from the subcatalogue.

For  $n_{\text{ref}} = 200$  rpm we have the following table for

$$\frac{P_{\text{new}}}{P_{\text{ref}}}$$

$n_{\text{new}}$ rpm	25	50	100	200	300	400	500	600	700
$\frac{P_{\text{new}}}{P_{\text{ref}}}$	1.88	1.52	1.23	1.00	0.88	0.81	0.75	0.72	0.68

### Maximum radial shaft load

The calculations above are solely for bearing life and load capacity. But there is also a limit to how much load the other parts of the motor (bearing housing, mounting flange and output shaft) can carry. For this reason the maximum shaft load is limited to avoid the risk of mechanical breakdown.

The maximum shaft load is shown in the shaft load diagrams for OMPW N, OMPW N, OMS, OMT and OMV motors.

Please contact the Dantoss sales organisation for hydraulics if motors are to be subjected to shaft loads higher than the maximum, or where there are particularly high dynamic effects (shock factor > 3).



## Hydraulic systems

### Max. pressure on the shaft

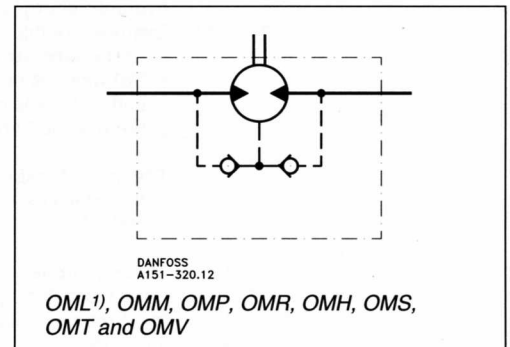
The shaft seal in Danfoss hydraulic motors has a long operating life and retains its excellent sealing properties in demanding conditions. The built-in back-up ring and the optimum design of the lips ensure that the seal will withstand high pressures and speeds. Max. pressure on the shaft seal is graphically illustrated for each motor type in the subcatalogues.

OML<sup>1)</sup>, OMM, OMP, OMR, OMH, OMS, OMT and OMV motors have built-in check valves. This means that the pressure on the shaft seal never exceeds the pressure in the return line. The Max. pressure on the shaft seal is therefore stated in the technical data as "Max. return pressure without drain line or Max. pressure in drain line".

#### Short/ultra short motor

By using these motors, the values of pressure on the shaft seal of the attached component, for example a gear, are valid.

<sup>1)</sup> OML motors have no drain connection



### Sealing materials

#### Characteristics of sealing materials

Material	Temperature °F	Remarks
NBR	-20 to + 210	Swells up on contact with most synthetic fluids. Can be used with Emulsions and Mineral oils.
FPM	-20 to +300	Ideal for mineral oil, synthetic fluids and emulsions

Standard versions of hydraulic motors are fitted with NBR seals (Buna N, Perbunan).

If synthetic fluids are used in hydraulic motors, only the dynamic seals (shaft seals) need to be replaced by FPM seals (Viton). NBR swells up when used with synthetic fluids and therefore static seals will retain their sealing capabilities.

Nevertheless, when a motor has been dismantled, all NBR seals must be replaced.

### Drain line

#### Application

It is possible to fit an external drain line on all Danfoss hydraulic motors except OML. The drain line relieves the pressure on the shaft seal to tank. The following main rules apply to the use of a drain line on Danfoss hydraulic motors:

- A drain line is recommended when the max. pressure on the shaft seal is exceeded. Otherwise shaft seal operating life will be substantially reduced.
- A drain line is always recommended when
  - A short motor is built together with a gear
  - the motor is used in hydrostatic transmissions where there is no separate flushing valve.

#### Oil flow in the drain line

When the size of the charge pump in a closed loop hydraulic system is calculated, the maximum oil flow in the drain line must be known.

The maximum oil flow in the drain line (gpm, US) for Danfoss hydraulic motors is stated in the technical data for each motor type in the subcatalogues.

## Braking

Danfoss hydraulic motors are often used to brake or hold a load. The motor acts as a pump that converts the kinetic energy (mass, speed) of the load to hydraulic energy (oil flow, pressure).

Examples of this kind of application:

- Crane winches on vehicles
- Net winches on fishing vessels
- Luffing booms on cranes and excavators
- Hydrostatic transmissions

The motor braking torque and the opening pressure of the dual shock valve determine how fast the load is braked.

### Braking torque

For a motor the hydraulic-mechanical efficiency ( $\eta_{hm}$ ) means that the effective torque is less than the theoretical.

$$T_{mot\ eff} = T_{theor} \times \eta_{hm} \quad (1)$$

For a pump the hydraulic-mechanical efficiency means that the effective torque which must be applied to the pump to produce a given pressure drop is greater than the theoretical.

$$T_{pump\ eff} = \frac{T_{theor}}{\eta_{hm}} \quad (2)$$

When a hydraulic motor is used as a pump (braking) the relation between braking torque ( $T_{br}$ ) and effective motor torque at a given pressure drop is as follows:

$$T_{br} = \frac{T_{theor}}{\eta_{hm}} \quad (\text{see 2) where}$$

$$T_{theor} = \frac{T_{mot\ eff}}{\eta_{hm}} \quad (\text{see 1)}$$

$$T_{br} = \frac{T_{mot\ eff}}{(\eta_{hm})^2}$$

We recommend the following braking torques be assumed for Danfoss hydraulic motors:

- OMS, OMT, OMV:  $T_{br} \sim 1.2 \times T_{mot\ eff}$
- Other motors:  $T_{br} \sim 1.3 \times T_{mot\ eff}$

$T_{mot\ eff}$  can be read from the function diagram for the individual motor sizes.

The braking torque must not be higher than the maximum operating torque of the motor. The max. torque is stated in the technical data for each type of motor.

### Dual shock valve opening pressure

The braking torque can be regulated by setting the opening pressure of the dual shock valve. The opening pressure should be set at max. oil flow (a rise in the opening pressure of 20-30% can be reckoned on when the oil flow changes from min. to max.)

To avoid pressure peaks being too high, the dual shock valve should be fast acting and located close to the hydraulic motor.

### Replenishment

Effective replenishment is necessary when Danfoss hydraulic motors are used to brake a load. Inadequate replenishment can lead to:

- Cavitation in the gearwheel set (wear and seizing)
- Lack of braking capacity

Therefore there must be positive charge pressure in the motor "suction" port.

The charge pressure ( $p_f$ ) should be higher than the pressure drop in the motor oilways to the gearwheel set.

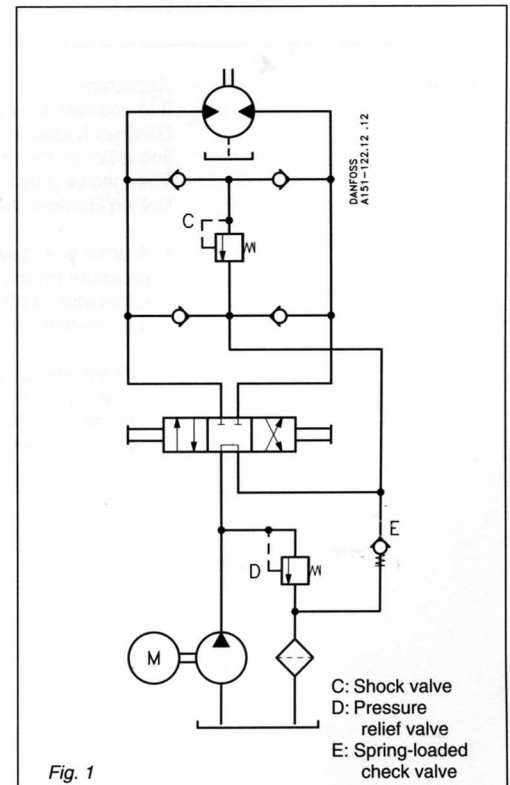
The pressure drop in the oilways depends on type of motor, oil flow and viscosity. Pressure loss curves for each type of motor, can be found in the appropriate subcatalogue. The charge pressure should be half the read pressure loss:

$$p_f = \frac{\Delta p}{2}$$

The charge pressure is always measured at the motor "suction" port.

In closed circuits there will always be a positive charge pressure when the system is fitted with a charge pump ( $p_f \sim 145$  to 220 psi). In open systems, where the hydraulic motor drives a load with high inertia, it is necessary to ensure replenishment as shown in fig. 1.

The opening pressure of the check valve should be higher than the total of the charge pressure ( $p_f$ ) and the pressure drop between the check valve and the motor "suction" port.

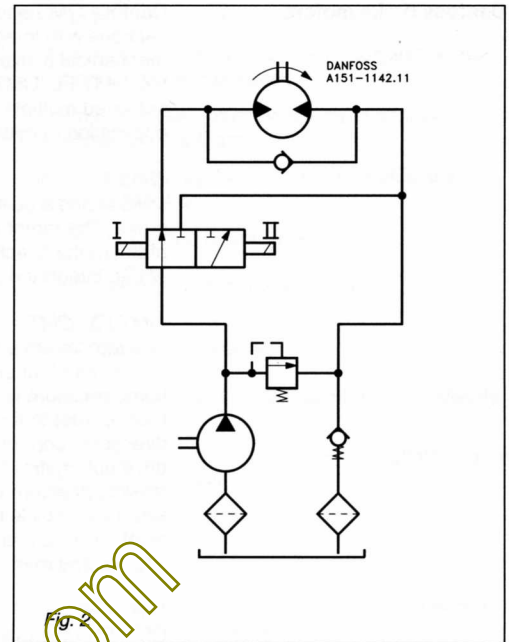




## Braking

Special conditions apply in open loop circuits when the hydraulic motor drives a load with high inertia (see fig. 2)

When the directional valve changes over from I to II the oil flow from the pump to the motor is shut off. The inertia of the load will continue to drive the motor. For this reason a check valve should be fitted to ensure replenishment, otherwise the motor will be emptied of oil.



### Seeping

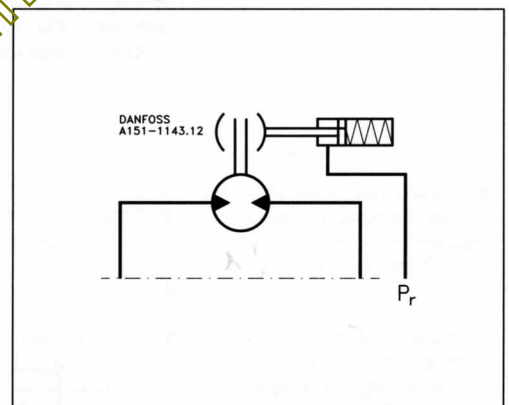
When a load must be prevented from moving for a long time there are two conditions to be aware of:

First, it is necessary to ensure replenishment if the motor has a drain line, otherwise the motor gearwheel set will be gradually emptied of oil and the load will fall freely. The best method is shown in fig. 1.

Second a hydraulic motor cannot completely keep a load in position. The internal motor leakage will cause the load to move (seeping).

So for hydrostatic transmissions, slewing movements of cranes, and for winches with a hanging load a Danfoss motor with integrated holding brake should be used. Otherwise the driving shaft should be supplied with an external holding

### External holding brake



## Danfoss brake motors

Danfoss OMS and OMT motors are available in versions with integral brakes: OMS B has a mechanical activated drum brake, whereas OMT FX, OMT FL, OMT FK and OMT FH has spring-activated multiple disc brakes, released by the application of hydraulic pressure.

### OMS B

OMS B has a built-in mechanically activated drum brake. The motor is braked when the braking arm of the motor is activated. So the braking function is not an integrated part of the hydraulic system.

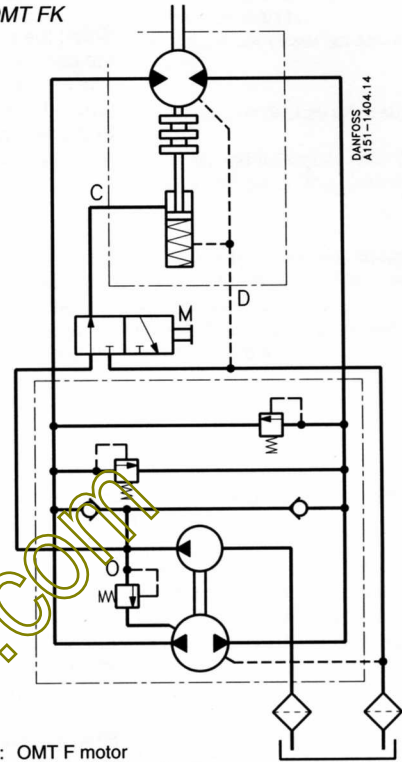
### OMT FX, OMT FL, OMT FK

The motors are suited for hydrostatic transmissions as well as other closed loop circuits, as the charge pump pressure is sufficient for releasing the brakes. Please refer to the diagram to the right. The directional control valve (M) can be connected to the drive automatic of a vehicle so that the brake release pressure is automatically relieved to tank when the vehicle has stopped. The charge pump relief valve (O) must be set at a pressure of min. 175 psi and max. 430 psi.

### OMT FH

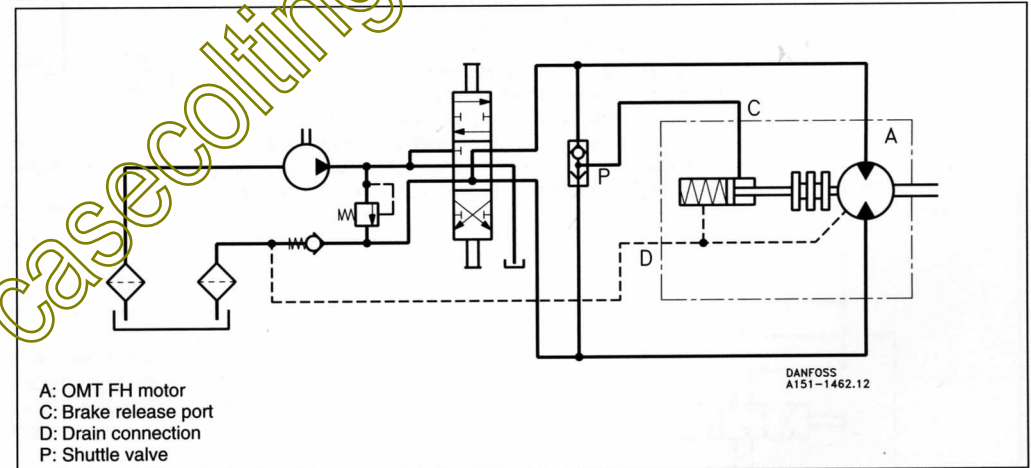
OMT FH motors are designed for open loop circuits, as the max. brake release pressure and max. pressure of the motor are identical. Brake release can be controlled by connecting the release port to the pump line. A shuttle valve for automatical brake release or a directional valve for release control may be used.

OMT FX  
OMT FL  
OMT FK



A: OMT F motor  
C: Brake release port  
D: Drain connection  
M: Directional valve

O: Charge pump relief valve



A: OMT FH motor  
C: Brake release port  
D: Drain connection  
P: Shuttle valve

**Important:**  
As the brake motors do not include integrated check valves, they need a separate drain connection.





## Installation, starting up and oil types

### *Good assembly practices*

- All hydraulic components should be placed so that they are easily accessible.
- There should be a manometer connection in the pump line.
- Mounting surfaces should be flat in order to ensure effective contact.
- Hydraulic signal lines must be fitted in such a way that air pockets are avoided.

### *Installation*

- Install the hydraulic components as stated in their individual installation instructions.
- Installation instructions are enclosed or can be ordered from Danfoss sales organisation for hydraulics.
- The hydraulic motors must not be forced or twisted into alignment by the fixing screws.
- Packing yarn, teflon, and other unsuitable sealing material must not be used. Use bonded seals, O-rings, steel washers, and similar materials.
- Do not remove the plastic plugs until pipes and hoses are to be fitted.
- Never tighten the screwed connections with a torque higher than the max. tightening torques stated in the instructions.
- The oil must have a contamination level better than 20/16 (ISO 4406). Always refill the system through a filter.

### *Starting up and running in*

- Start the prime mover and where possible allow it to run at the lowest speed.

Any bleed screws must be left open until oil emerges without foam.

- In load sensing systems ensure that all signal lines are full of oil.
- Signs of air in the hydraulic system
  - foam in the tank
  - jerky operation of motor and cylinder
  - noise
- Refill again, if necessary.
- The system should not be loaded until completely bled.
- The hydraulic system is checked for tightness and satisfactory function.
- Change the oil filter, if necessary.

### *Maintenance*

- Careful maintenance is essential to the reliability and life of the hydraulic system.
- Oil, oil filters, and air filters must be changed in accordance with the supplier's instructions.
- The condition of the oil must be checked at suitable intervals.
- System tightness and oil level must be checked frequently.

## **Oil types**

The oil in a hydraulic system also lubricates the moving parts of the hydraulic components, protect them against corrosion, and lead dirt particles and heat out of the system. It is therefore important to choose the correct oil with the necessary additives to ensure operation without problems and long operating life for the hydraulic components. For systems with Danfoss hydraulic motors we recommend refined mineral based hydraulic oils with improved properties concerning rust, oxidation and wear.

Mineral oils without anti-wear additives or motor oils may be used provided operating conditions are made to match. If oil types that cannot be classified are to be used, please contact the Danfoss Sales Organisation for Hydraulics.

**Non-flammable or biologically degradable fluids**  
Danfoss hydraulic motors can be used in systems with non-flammable or biologically degradable fluids. Please contact the Danfoss Hydraulics Sales Organisation regarding matching the operation conditions to the properties of the fluid.

## Temperature, viscosity and filtering

### Temperature and viscosity

Ambient temperature should lie between  $-20^{\circ}\text{F}$  and  $+210^{\circ}\text{F}$  to ensure that the shaft seal retains its sealing capacity.

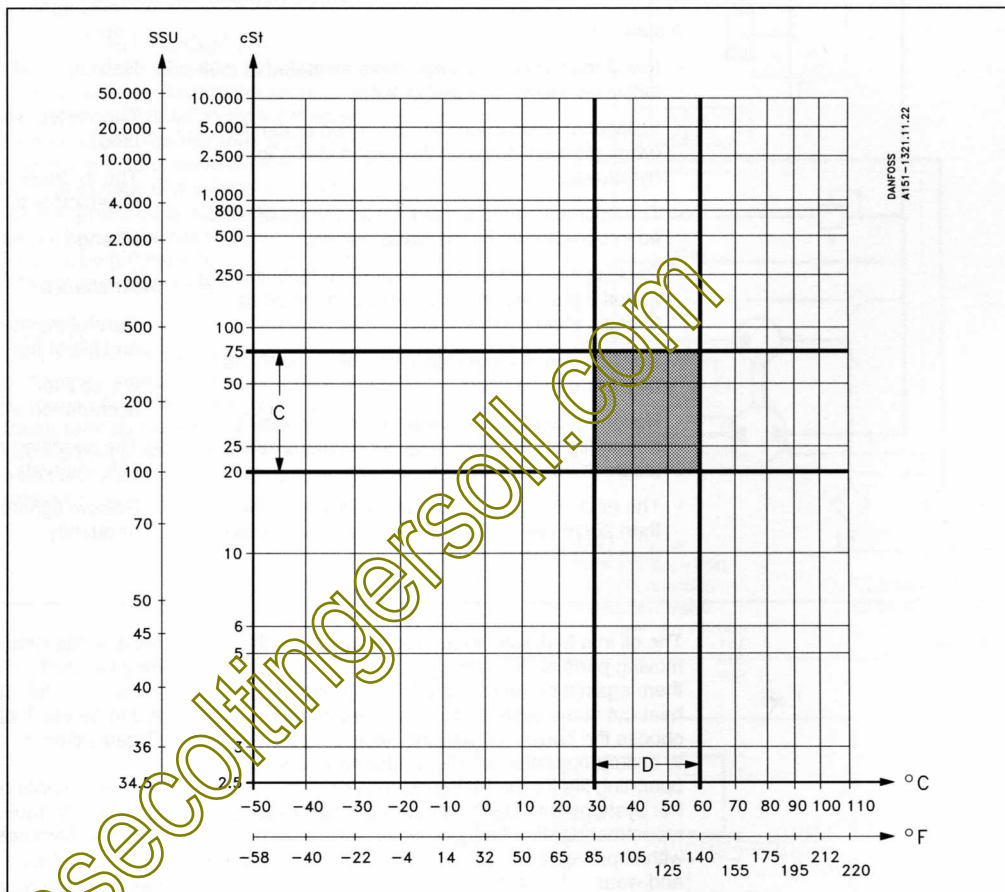
Oil temperature should lie between  $+85^{\circ}\text{F}$  and  $+140^{\circ}\text{F}$  during normal operation. Oil life is greatly reduced if its temperature exceeds  $140^{\circ}\text{F}$ . As a general rule, oil life is halved for each  $15^{\circ}\text{F}$  its temperature exceeds  $140^{\circ}\text{F}$ .

### Viscosity

The viscosity of the oil should lie between 100 and 370 SSU when the operating temperature of the system has become stabilised. We recommend the use of an oil type having a viscosity of 165 SSU at the actual operating temperature.

The diagram below will help in the selection of the correct type of oil.

Viscosity classes (ASTM D 2422-75)



C: Recommended viscosity range  
D: Recommended temperature range

### Filtering

\* Calibrated in accordance with the ACFTD method.

It is necessary to keep the level of oil contamination at an acceptable level to ensure problem-free operation. The recommended maximum level of contamination in systems with Danfoss hydraulic motors is 20/16 (see ISO 4406\*).

In our experience the 20/16 contamination level can be met by using a return filter finer than  $40\text{ }\mu\text{m}$  absolute or  $25\text{ }\mu\text{m}$  nominal. In very dirty environments, in complex systems, and in closed circuits, the recommended filtration level is  $20\text{ }\mu\text{m}$  absolute or  $10\text{ }\mu\text{m}$  nominal. (In systems with quick release couplings a pressure filter having a fineness of  $40\text{ }\mu\text{m}$  absolute should be installed just ahead of the motor).





## Danfoss Hydraulic Organization

Danfoss is an international concern with factories in 10 countries and subsidiaries in 32 countries. In addition to the hydraulic components, the Danfoss range of products includes refrigeration controls, industrial automatics, precision step systems, industrial instrumentations, electrical drives and controls, controls for heating plant, system controls, components for burners and boilers, compressors and thermostats for refrigerators and freezers.

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## Danfoss Hydraulic Organization

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