# Industrial Disc Brakes

**Twiflex**®

*Altra Industrial Motion*

# Twiflex...
# Leaders In Advanced Braking Technology

Twiflex, with headquarters in Twickenham, England, specialises in the design, manufacture and supply of Advanced Braking Technology for industrial applications. With extensive in-house facilities, Twiflex enjoys a global reputation for quality.

Founded in 1946, Twiflex has produced more than half a million brake units, frequently for safety-critical duty, for applications around the world. From textile machines in the north of England to the world's deepest mine shaft in South Africa, Twiflex brakes are specified by engineers and system designers in every type of industry.

From defining complete braking systems to identifying spare components, this catalogue provides useful guidance. An approximate brake selection may be made by assessing the data shown, however, it is always recommended to contact a Twiflex representative for a more detailed proposal.

## Introduction/Selection Guide

# Select the right Twiflex Brake to meet your requirements

The charts below illustrate the range of standard TWIFLEX disc brakes. Model-specific publications and data sheets are available for each caliper shown. To determine which will suit your application compare the braking force required with that generated by the calipers*, noting that other factors (e.g. disc speed, pad material, service factor, etc) should be considered for optimal selection. Twiflex application engineers can provide assistance for your particular application.
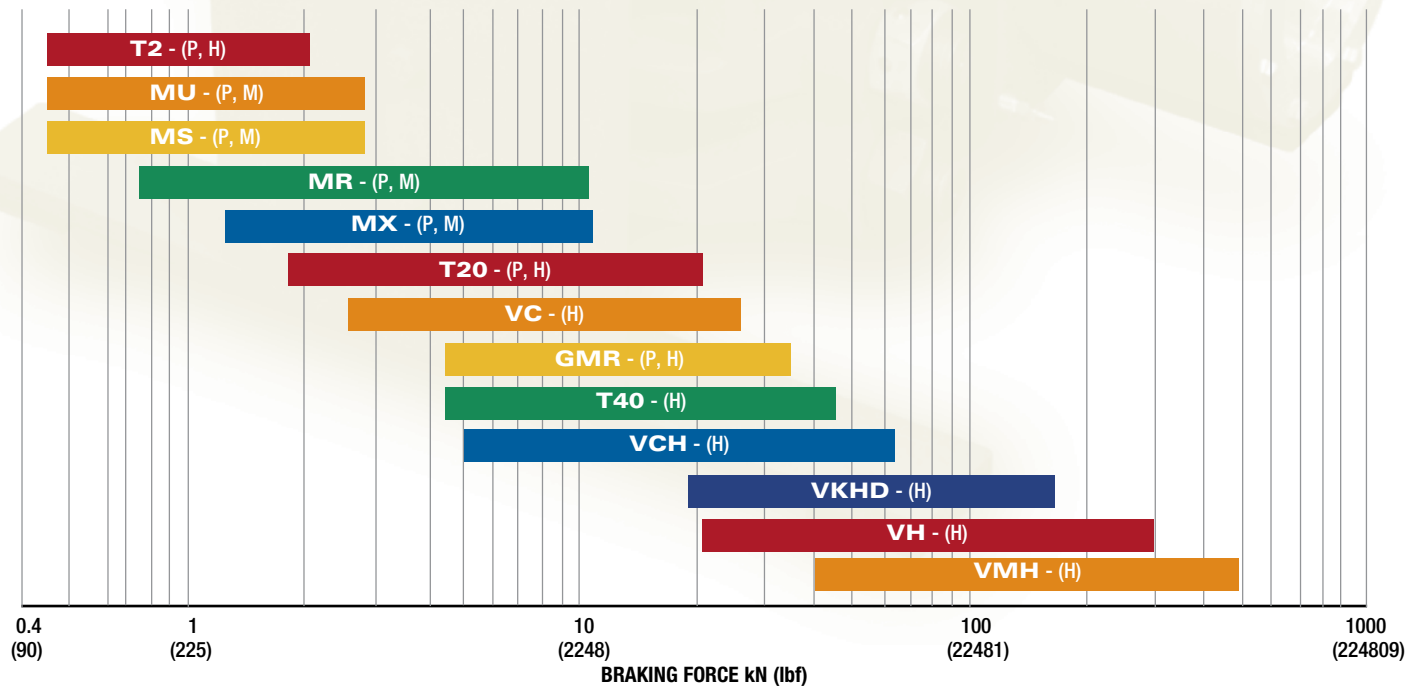
## Spring Applied Calipers[†]

MUS - (P)
MS - (P, H)
MR - (P, H, E)
MX- (P, H, E)
GMR - (P, H)
VCS - (H)
VKSD - (H)
VS - (H)
VMS - (H)

| 0.4 (90) | 1 (225) | 10 (2248) | 100 (22481) | 1000 (224809) |
|---|---|---|---|---|

**BRAKING FORCE kN (lbf)**
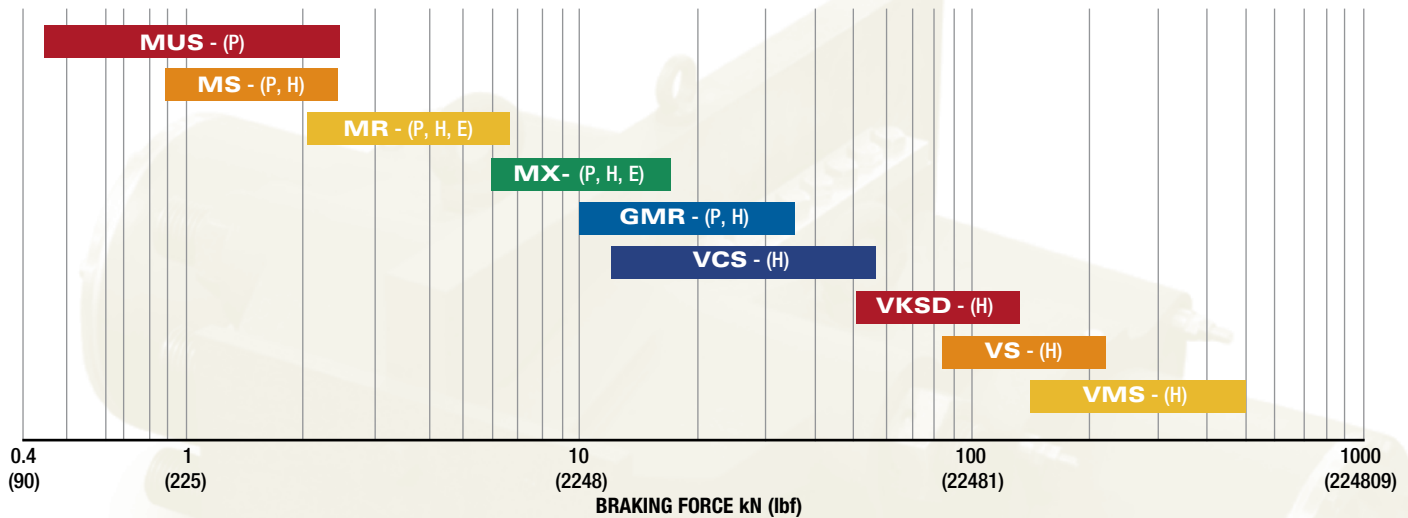
[†] **KEY: (P)** = Pneumatic, **(H)** = Hydraulic, **(E)** = Electrical, **(M)** = Mechanical

## Direct Acting Calipers[†]

T2 - (P, H)
MU - (P, M)
MS - (P, M)
MR - (P, M)
MX - (P, M)
T20 - (P, H)
VC - (H)
GMR - (P, H)
T40 - (H)
VCH - (H)
VKHD - (H)
VH - (H)
VMH - (H)

| 0.4 (90) | 1 (225) | 10 (2248) | 100 (22481) | 1000 (224809) |
|---|---|---|---|---|

**BRAKING FORCE kN (lbf)**

*It should be noted that the braking forces shown are for a single caliper only and multiple calipers may often be used on a disc, with available space being the typical limitation.

# Twiflex disc brakes are found on industrial applications worldwide.

## Metals

Twiflex brakes are used on critical applications throughout the metals processing industry for reliable dynamic, holding and emergency-stop duties. Typical applications include:

- Rolling and slitting
- Finishing and coating
- Cranes and haulage
- Shears and forging

## Mining

For more than 40 years, Twiflex has been specified to provide safety-critical braking control in the mining industry. Typical applications include:

- Winders and hoists
- Conveyors
- Grinding mills
- Drag lines and shovels
- Reclaimers and haulage

## Lifts and Escalators

Disc brake systems are typically used on industrial (freight) elevators and mass transit escalators. They provide safe, controlled braking in the event of power loss or emergency stop situations.

# Energy

Disc brake systems are used on and off-shore in the wind, wave, tidal, and oil and gas industries. Typical applications include:

- Wind and tidal turbine over-speed control
- Draw-works stopping and holding
- Wind turbine yaw motion control





# Entertainment

Twiflex calipers are used to provide speed control, static holding, and emergency braking on a variety of applications, including:

- Theme park rides
- Simulators
- Stage gear, props and scenery
- Monorails

# Marine and Shipping

Twiflex provides specialist solutions for the marine industry ranging from main propulsion shaft and thrusters braking to winch drive and weapon systems brakes.

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# Brake and System Overview



## Brake Calipers

Twiflex offers the largest range of industrial disc brake calipers in the world. Spring applied units may be retracted pneumatically, hydraulically or electrically (depending on caliper design) while most direct acting brakes have some form of positive retraction device.

In general, pneumatically applied brakes are best suited for light to medium stopping duties and for tensioning applications where a high degree of control is required. Hydraulically applied brakes address higher torque requirements, while spring applied calipers are essential where braking must be maintained in the event of supply system failure.

Mechanically applied units are suitable for light tensioning duties or where no external power is available - they may also be specified when designers wish to use their own means of actuation.

## Couplings

Twiflex manufactures a range of torsionally flexible, rubber-element couplings for a range of duties. Sometimes combined with a brake disc, they are a critical interface between components of a transmission system. Twiflex engineers are available to discuss, analyse and advise on coupling suitability for any application, and provide the technical support needed.



## Brake Pads

It is possible to make a realistic assessment of expected pad life based on analytical and test data. Pad life is determined by the area of the brake pad, the energy dissipated during braking and the peak braking path temperature, and must be a consideration whenever the duty includes dynamic braking.
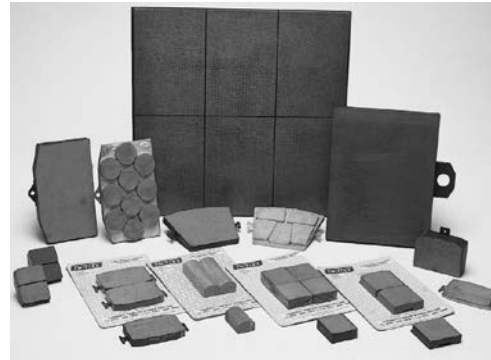


## Discs

Twiflex produces a large range of standard discs and associated mounting hubs. These can be supplied pilot bored or fully machined to suit the particular mounting or shaft arrangement.

Special discs for specific applications may also be supplied on request – contact Twiflex to discuss your requirements.

## Hydraulic Power Units

A number of electro-hydraulic power pack options are available, from standard 'on/off' control units to fully customised closed-loop braking systems. All require careful selection in order to ensure full compatibility with the type and number of brakes being controlled. Consultation with Twiflex engineers is recommended.

• The LC range provides a basic 'on/off' control for a range of Twiflex spring-applied and direct acting hydraulic calipers
• The MP range of modular power units offers flexibility of design and function
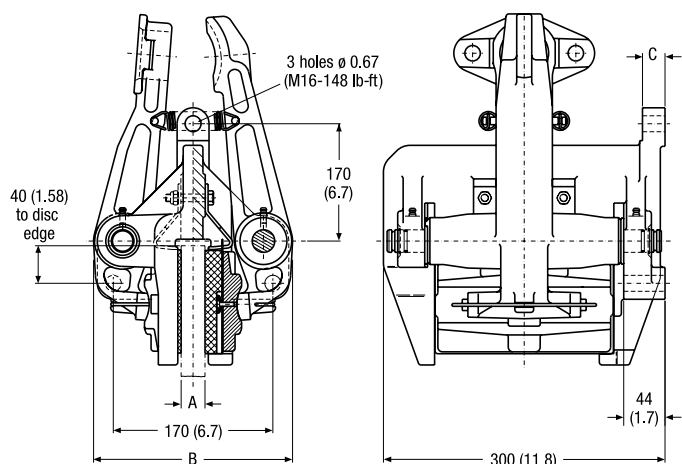• Custom units are available on request

## Monitoring Equipment

Every brake installation requires monitoring visually, mechanically, or electrically; particularly spring applied brakes on safety-critical applications. Twiflex can supply a range of electro-mechanical and electronic monitoring units and limit switches to indicate any combination of brake status or pad condition.

## Materials, Finishes and Traceability

Twiflex is approved to BS EN ISO 9001:2000 and can offer material and dimensional certification by Lloyds Register and other regulatory authorities. All units are supplied with a standard Twiflex finish while special protective coatings to suit particular environments are available on request.

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# GMR Series

## GMR — Disc Brake Caliper



3 holes ø 0.67
(M16-148 lb-ft)

40 (1.58) to disc edge

170 (6.7)

A

170 (6.7)

B

C

44 (1.7)

300 (11.8)

mm (in)

|        | A         | B          | C         |
|--------|-----------|------------|-----------|
| GMR25  | 25 (1.00) | 212 (8.35) | 24 (0.94) |
| GMR40  | 40 (1.57) | 223 (8.78) | 29 (1.14) |

The Twiflex GMR and GMR40 series of disc brake calipers are suitable for use with discs of 25.4mm (1 in), and 40mm (1.57 in) thick respectively. Minimum disc diameter is 610mm (24.02 in).

Normally one or two calipers are used per disc, but the number may be increased depending on disc size. The brakes may be positioned at any angle around the periphery of the disc, but should ideally be mounted horizontally (i.e. at the 3 o'clock or 9 o'clock position). If the caliper mounting angle is greater than 10° from the horizontal, or on vertical shaft applications, it should be fitted with an inclined mounting kit. A range of brake discs is available from Twiflex (see Disc and Hub Assemblies).

For pneumatic operation use dry, filtered and non-lubricated compressed air. Pneumatic brakes require a control valve, operated either manually or by pneumatic or electrical signal.

The ratings shown on the graphs are based on fully bedded in and conditioned brake pads with a nominal friction coefficient μ = 0.4. Twiflex disc brakes must be used with Twiflex asbestos free brake pads.

Effective disc radius = actual radius (m) – 0.06m
(Effective disc radius = actual radius (ft) – 0.19 ft)

## GMRP — Pneumatically Applied – Spring Released



467

A

B

300
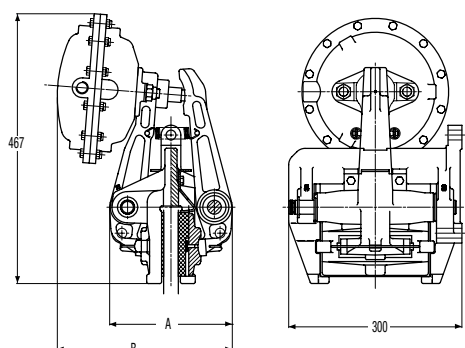
mm (in)

|         | A          | B           |
|---------|------------|-------------|
| GMRP    | 212 (8.35) | 306 (12.05) |
| GMR40P  | 223 (8.78) | 312 (12.28) |
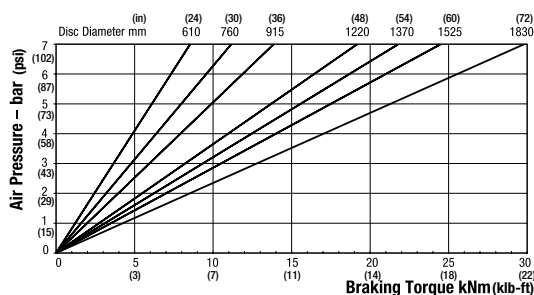


*Maximum Pressure 7 bar (102 psi)*
*Maximum Braking Force = 36kN @ 7 bar (8093.12 lbf @102 psi)*
*Weight of caliper and thruster - 40.8kg (89.95 lb)*
*Weight of thruster only - 6.8kg (14.99 lb)*
*Volume displacement of thruster at full stroke = 1.8 ml (0.06 fl oz)*

## GMRH — Hydraulically Applied – Spring Released



381

A

B

300
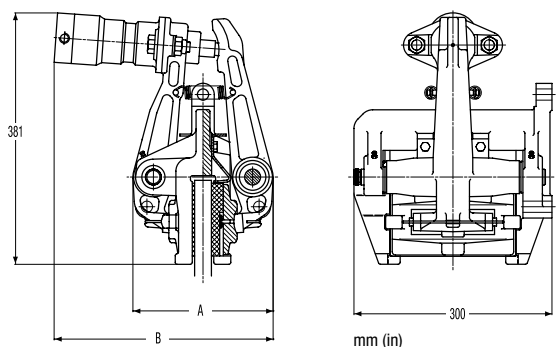
mm (in)

|         | A          | B           |
|---------|------------|-------------|
| GMRH    | 212 (8.35) | 332 (13.07) |
| GMR40H  | 223 (8.78) | 343 (13.50) |
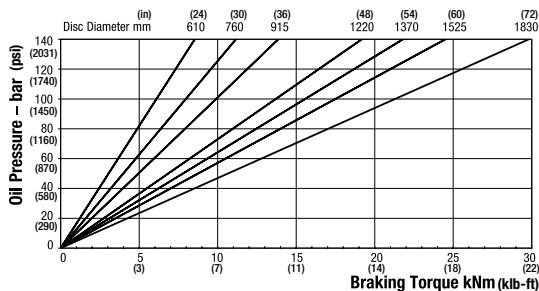


*Maximum Pressure 140 bar (2030.53 psi)*
*Maximum Braking Force = 36kN @ 140 bar (8093.12 lbf @ 2031 psi)*
*Weight of caliper and thruster - 36.9kg (81.35 lb)*
*Weight of thruster only - 2.9kg (6.39 lb)*
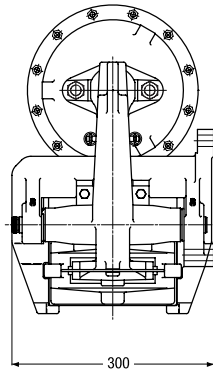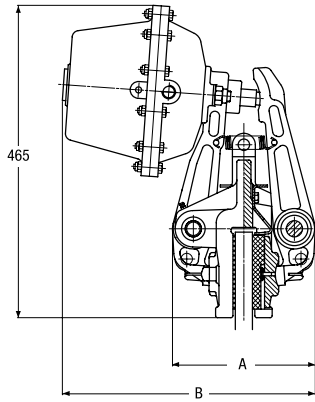*Volume displacement of thruster at full stroke = 40ml (1.35 fl oz)*

*Retraction pressures where shown are calculated and may vary depending on spring tolerance.*
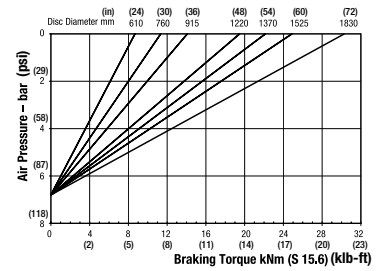
# GMR Series

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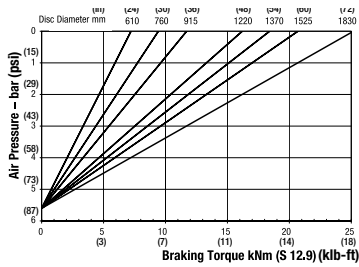
## GMRS — Spring Applied – Pneumatically Released



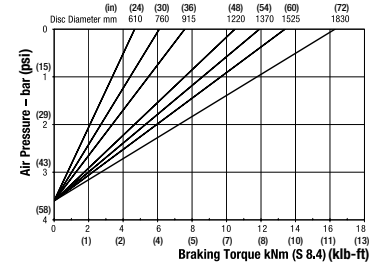| | A | B |
|---|---|---|
| GMRS | 212 (8.35) | 376 (14.80) |
| GMR40S | 223 (8.78) | 382 (15.04) |

*Maximum Braking Force S 15.6: 36kN (8093.12 lbf)*
*Minimum Pressure for full retraction: 8.4 bar (122 psi)*
*Weight of caliper and thruster - 49kg (108.03 lb)*
*Weight of thruster only - 15kg (33.07 lb)*
*Volume displacement of thruster at full retraction =*
*1.31ml (0.04 fl oz)*



*Maximum Braking Force S 12.9: 30kN (6744.27 lbf)*
*Minimum Pressure for full retraction: 7 bar (102 psi)*
*Weight of caliper and thruster - 48kg (105.82 lb)*
*Weight of thruster only - 14kg (30.86 lb)*
*Volume displacement of thruster at full retraction =*
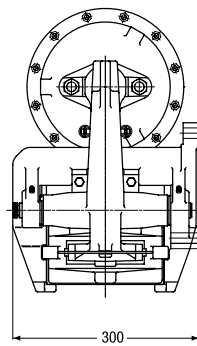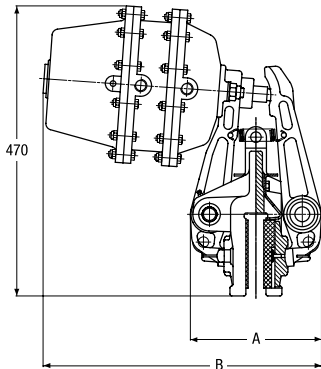*1.31ml (0.04 fl oz)*
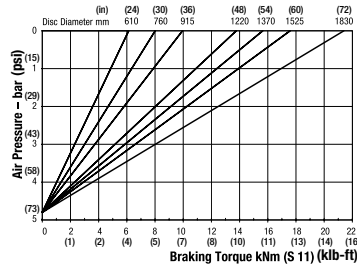


*Maximum Braking Force S 11: 25kN (5620.22 ibf)*
*Minimum Pressure for full retraction: 6 bar (87 psi)*
*Weight of caliper and thruster - 47.2kg (104.06 lb)*
*Weight of thruster only - 13.2kg (29.10 lb)*
*Volume displacement of thruster at full retraction =*
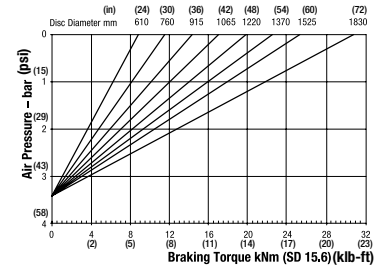*1.31ml (0.04 fl oz)*



*Maximum Braking Force S 8.4: 19.5kN (4383.77 lbf)*
*Minimum Pressure for full retraction: 4.8 bar (70 psi)*
*Weight of caliper and thruster - 46.2kg (101.85 lb)*
*Weight of thruster only - 12.2kg (26.89 lb)*
*Volume displacement of thruster at full retraction =*
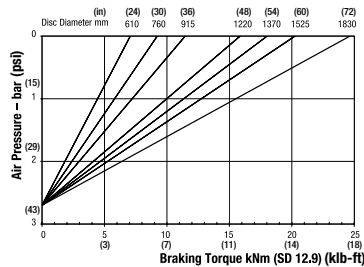*1.31ml  (0.04 fl oz)*

## GMRSD — Spring Applied – Pneumatically Released



| | A | B |
|---|---|---|
| GMRSD | 212 (8.35) | 451 (17.76) |
| GMR40SD | 223 (8.78) | 457 (17.99) |

*Maximum Braking Force SD 15.6: 36kN (8093.12 lbf)*
*Minimum Pressure for full retraction: 4.6 bar (67 psi)*
*Weight of caliper and thruster - 55kg (121.25 lb)*
*Weight of thruster only - 21kg (46.29 lb)*
*Volume displacement of thruster at full retraction =*
*2.51ml (0.08 fl oz)*



*Maximum Braking Force SD 12.9: 30kN (6744.27 lbf)*
*Minimum Pressure for full retraction: 3.8 bar (55 psi)*
*Weight of caliper and thruster - 54kg (119.05 lb)*
*Weight of thruster only - 20kg (44.09 lb)*
*Volume displacement of thruster at full retraction =*
*2.51ml (0.08 fl oz)*
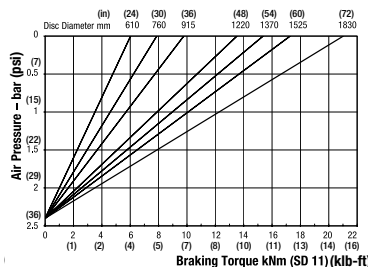


*Maximum Braking Force SD 11: 25kN (5620.22 lbf)*
*Minimum Pressure for full retraction: 3.3 bar (48 psi)*
*Weight of caliper and thruster - 53.2kg (117.29 lb)*
*Weight of thruster only - 19.2kg (42.33 lb)*
*Volume displacement of thruster at full retraction =*
*2.51ml (0.08 fl oz)*



*Maximum Braking Force SD 8.4: 19.5kN (4383.77 lbf)*
*Minimum Pressure for full retraction: 2.4 bar (35 psi)*
*Weight of caliper and thruster - 52.2kg (115.08 lb)*
*Weight of thruster only - 18.2kg (40.12 lb)*
*Volume displacement of thruster at full retraction =*
*2.51ml (0.08 fl oz)*

*Retraction pressures where shown are calculated and may vary depending on spring tolerance.*

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## GMRSH    Spring Applied – Hydraulically Released



*Maximum Braking Force SH 15: 35kN (868.31 lbf)*
*Minimum Pressure for full retraction: 120 bar (1740 psi)*
*Weight of caliper and thruster - 53kg (116.84 lb)*
*Weight of thruster only - 19kg (41.89 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*

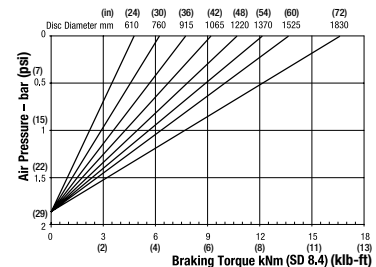| mm (in) | | |
|---|---|---|
| | A | B |
| GMRSH | 212 (8.35) | 380 (14.96) |
| GMR40SH | 223 (8.78) | 387 (15.24) |
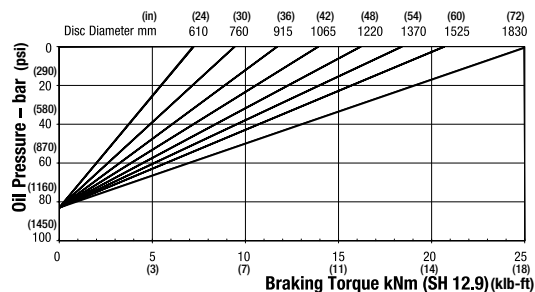


*Maximum Braking Force SH 12.9: 30kN (6744.27 lbf)*
*Minimum Pressure for full retraction: 100 bar (1450 psi)*
*Weight of caliper and thruster - 52kg (114.64 lb)*
*Weight of thruster only - 18kg (39.68 lb)*
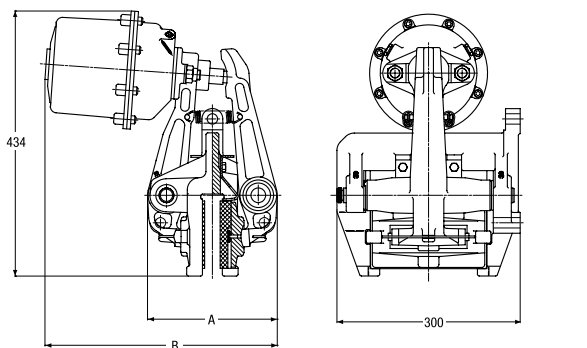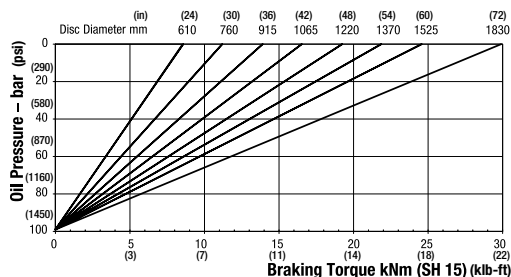*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*
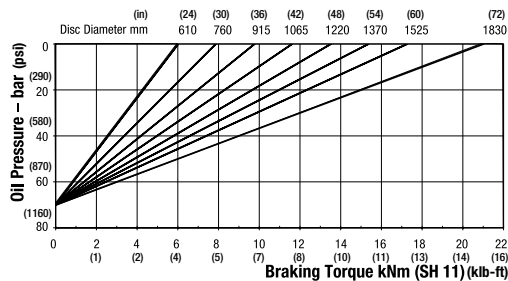


*Maximum Braking Force SH 11: 25kN (5620.22 lbf)*
*Minimum Pressure for full retraction: 92 bar (1334 psi)*
*Weight of caliper and thruster - 51.2kg (112.88 lb)*
*Weight of thruster only - 17.2kg (37.92 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*
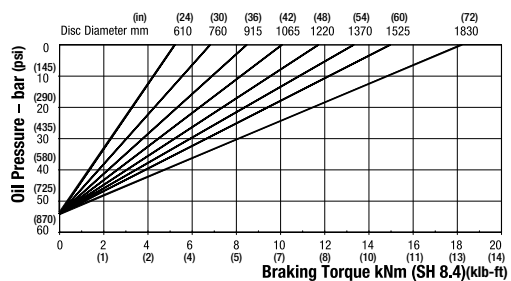


*Maximum Braking Force SH 8.4: 19.5kN (4383.77 lbf)*
*Minimum Pressure for full retraction: 65 bar (943 psi)*
*Weight of caliper and thruster - 50.2kg (110.67 lb)*
*Weight of thruster only - 16.2kg (35.71 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*
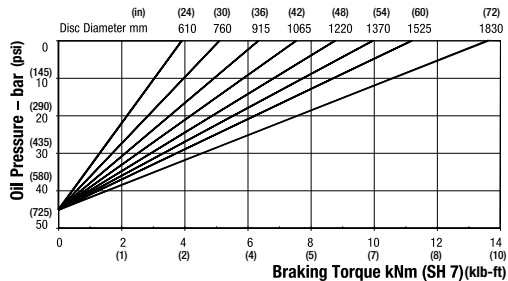


*Maximum Braking Force SH 7: 16.5kN (3709.35 lbf)*
*Minimum Pressure for full retraction: 59 bar (856 psi)*
*Weight of caliper and thruster - 49.7kg (109.57 lb)*
*Weight of thruster only - 15.7kg (34.61 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*
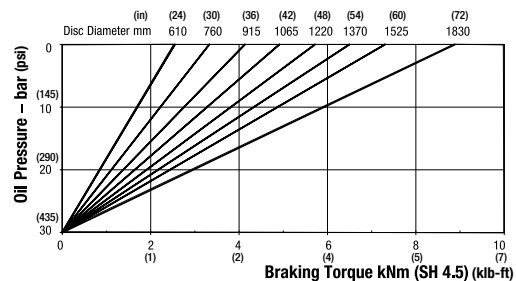


*Maximum Braking Force SH 4.5: 10.5kN (2360.49 lbf)*
*Minimum Pressure for full retraction: 38 bar (551 psi)*
*Weight of caliper and thruster - 48.7kg (107.37 lb)*
*Weight of thruster only - 14.7kg (32.41 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*



*Maximum Braking Force SH 2.5: 6kN (1348.85 lbf)*
*Minimum Pressure for full retraction: 21 bar (305 psi)*
*Weight of caliper and thruster - 47.9kg (105.60 lb)*
*Weight of thruster only - 13.9kg (30.64 lb)*
*Volume displacement of thruster at full retraction = 56ml (1.89 fl oz)*

*Retraction pressures where shown are calculated and may vary depending on spring tolerance.*
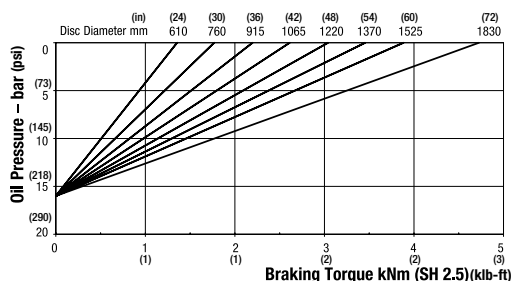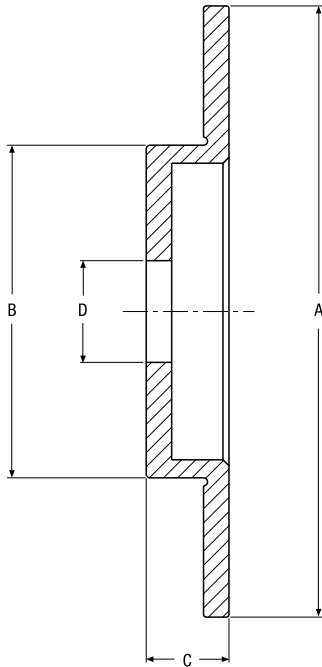
# Disc and Hub Assemblies

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## Brake Discs

### 12.7mm (0.5 in) thick brake discs

| Nominal Diameter | A | B | C | D Min. | Inertia kgm²(psf) | Weight kg (lb) | Max. Safe Disc Speed |
|---|---|---|---|---|---|---|---|
| 250 | 250 (9.84) | 128 (5.03) | 36 (1.42) | 30 (1.18) | 0.04 (0.01) | 4.0 (8.82) | 6500 |
| 300 | 305 (12.01) | 166 (6.54) | 41 (1.61) | 51 (2.01) | 0.09 (0.02) | 7.3 (16.09) | 6000 |
| 350 | 356 (14.02) | 210 (8.27) | 54 (2.13) | 76 (2.99) | 0.17 (0.03) | 10.9 (24.03) | 5100 |
| 400 | 406 (15.98) | 260 (10.24) | 54 (2.13) | 102 (4.02) | 0.28 (0.06) | 14.1 (31.09) | 4400 |
| 460 | 457 (17.99) | 311 (12.24) | 54 (2.13) | 102 (4.02) | 0.48 (0.10) | 19.1 (42.11) | 3900 |
| 515 | 514 (20.24) | 368 (14.49) | 54 (2.13) | 102 (4.02) | 0.75 (0.15) | 22.7 (50.04) | 3500 |
| 610 | 610 (24.02) | 464 (18.27) | 54 (2.13) | 102 (4.02) | 1.57 (0.32) | 33.0 (72.75) | 2900 |
| 710 | 711 (27.99) | 565 (22.24) | 54 (2.13) | 102 (4.02) | 3.20 (0.66) | 52.3 (115.30) | 2500 |
| 810 | 813 (32.01) | 660 (25.98) | 54 (2.13) | 102 (4.02) | 6.57 (1.35) | 85.5 (188.50) | 2200 |
| 915 | 914 (35.98) | 762 (30.00) | 54 (2.13) | 102 (4.02) | 10.80 (2.21) | 110.9 (244.49) | 1900 |

*All dimensions in mm (in)*

### 25.4mm (1 in) thick brake discs

| Nominal Diameter | A | B | C | D Min. | Inertia kgm²(psf) | Weight kg (lb) | Max. Safe Disc Speed |
|---|---|---|---|---|---|---|---|
| 610 | 610 (24.02) | 343 (13.50) | 76 (2.99) | 125 (4.92) | 2.75 (0.56) | 66 (145.51) | 2900 |
| 760 | 762 (30.00) | 495 (19.49) | 76 (2.99) | 125 (4.92) | 7.0 (1.43) | 104 (229.28) | 2300 |
| 915 | 914 (35.98) | 648 (25.51) | 76 (2.99) | 230 (9.06) | 16.0 (3.28) | 150 (330.69) | 1900 |
| 1065 | 1067 (42.01) | 800 (31.50) | 76 (2.99) | 230 (9.06) | 29.1 (5.96) | 220 (485.69) | 1600 |
| 1220 | 1219 (47.99) | 914 (35.98) | 76 (2.99) | 230 (9.06) | 49.1 (10.06) | 273 (601.86) | 1400 |
| 1370 | 1372 (54.02) | 1067 (42.01) | 76 (2.99) | * | 80.1 (16.41) | 346 (762.80) | 1200 |
| 1525 | 1524 (60.00) | 1219 (47.99) | 76 (2.99) | * | 120.5 (24.68) | 393 (866.42) | 1100 |
| 1830 | 1829 (72.01) | 1524 (60.00) | 76 (2.99) | * | 243.5 (49.87) | 522 (1150.81) | 1000 |

*All dimensions in mm (in)*

*\* Bores cast and machined to order*

Twiflex brake discs may be supplied bored and drilled to customer requirements. Non-standard disc sizes, not shown in the tables, can be supplied to order. Brake discs are manufactured from spheroidal graphite iron.
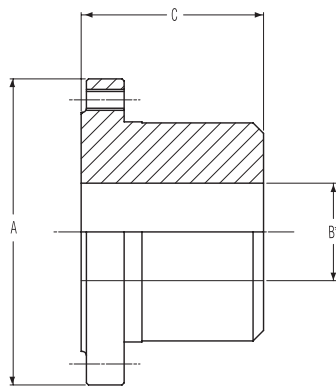
## Hubs

### Range of Hubs used with Twiflex Brake Discs

| Hub Size | A | B* | C | Disc Size | Max. Brake Torque kNm (ft lb) | WR² kgm² (psf) |
|---|---|---|---|---|---|---|
| 112 | 99 (3.90) | 14-42 (0.55-1.65) | 58 (2.28) | 250 (9.84) | 1.1 (811) | 0.00097 (0.0002) |
| 168 | 146 (5.75) | 28-65 (1.10-2.56) | 87 (3.43) | 300 (11.81) | 3.6 (2655) | 0.0088 (0.0018) |
| 240 | 200 (7.87) | 60-95 (2.36-3.74) | 117 (4.61) | 400 (15.75) | 9.5 (7007) | 0.044 (0.009) |
| 330 | 272 (10.71) | 75-130 (2.95-5.12) | 155 (6.10) | 400 (15.75) | 24.0 (17701) | 0.23 (0.05) |
| 370 | 308 (12.13) | 90-150 (3.54-5.91) | 176 (6.93) | 515 (20.28) | 30.0 (22127) | 0.35 (0.07) |

*\* Hubs can be supplied with parallel or taper bores, and keywayed to order, at extra cost.*
*Hubs are manufactured from steel 080M40.*

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# Monitoring Units

Twiflex offers a wide range of monitoring options for both caliper and modular brake types.  This includes a number of IP67-rated inductive and analogue proximity sensors for brake status or pad condition.

In addition, electro-mechanical and limit switches are available as single or multi-function units and may be supplied fully sealed, with positive action safety switches.

Monitoring units are used to indicate:

• Brake on or off, or the fully retracted condition reached

• Adjustment for pad wear required

• Pad replacement needed

• Any combination of the above
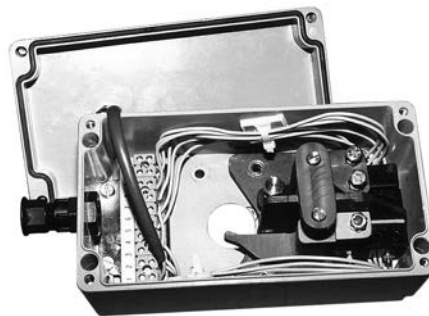
# Materials, Traceability & Finishes

Twiflex Ltd. is approved to BS EN ISO 9001:2000, by Lloyds Registry of Quality Assurance. The scope of Twiflex Ltd Quality System embraces all procedures and controls from quotation to delivery of industrial disc brakes.

### Materials

All materials are obtained from Twiflex approved suppliers. Twiflex discs and brake housings, unless otherwise stated, are made from Spheroidal Graphite Iron and actuator housings from cast aluminium.

### Traceability

We can offer, at customer's request, component traceability through Lloyds. In special circumstances we can also offer traceability through the American Bureau of Shipping (ABS), Det. Norske Veritas (DNV), and other recognized authorities.

### Finishes

Twiflex can offer a range of finishing processes, depending upon the degree of protection required. Disc brake assemblies requiring full environmental protection are built using stainless steel, hard chrome plating and marine paint.

# Hydraulic Power Units

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Twiflex has consolidated decades of development to produce a range of electro-hydraulic power units to meet most application requirements. Each power unit has been designed for reliability, high performance and low maintenance, and is supplied with a comprehensive easy-to-read installation, operation and maintenance manual. The Twiflex datasheets contain user guides giving a step-by-step selection process. Contact Twiflex application engineers to discuss your requirements in detail.

## LC   Electro Hydraulic Power Units

The "LC" range of stand alone power units is designed to operate the Twiflex range MR, MX, GMX, GMR and VCS spring applied hydraulically released brakes, providing a basic brake on/off control. There are various options available including "soft braking", a range of operating and motor voltages, and various add-on accessories including a terminal box.

The "soft braking" option is available as an additional manifold slice to facilitate a fast approach, soft braking system. This enables rapid closing of the pad/disc air gap followed by controlled application of braking force up to full torque. Refer to data sheet DS3001.

## MP   Electro Hydraulic Power Units

The modular "MP" range of electro-hydraulic power packs has been designed to provide a completely flexible means of brake control in the most arduous operating environments.

The units are composed of one of three base modules, dictated by the size and number of calipers to be controlled, comprising motor, pump and reservoir.  The hydraulic circuit is then selected, based on the operation and control logic required by the application and may range from a simple 'on/off' function to full closed loop PLC control.  Finally, auxiliary options are specified (for example, hand pump for manual caliper release; heater for low ambient temperatures; stainless steel components for marine environments, etc.).

The "MP" solution is especially useful when the application requires independent control of multiple brake circuits.

Refer to data sheet DS3002 or contact Twiflex for more details.

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# Braking Calculations

There are many factors to take into account when determining what type of brake to use on any particular machine. For example, what is the function of the brakes? Are there any external loads? Are there any time delays?

The primary consideration should be to answer the question:

**"What do you want the brake to do?"**

The application will often fall into one of three main types:

**• Holding Brakes**
In such static applications a suitable factor should always be used to compensate for the possibility of foreign matter contaminating the disc surface, loss of conditioning of the brake pad surface, and to provide an appropriate safety margin, depending on pad material, statutory or other requirements.

**• Dynamic and Emergency Brakes**
In a dynamic application the brake must stop all of the moving parts of the machine. Often this function is asked for in conjunction with the holding requirements as an emergency braking function. Basic calculations should, in these cases, include an assessment of operating temperature, power dissipation (to ensure that the pads are maintained in good condition), and expected pad life.

**• Tension (Continuous Duty) Brakes**
This application arises when the brake is called upon to provide a continuous torque or tension on material passing through the machine, for example on tension reels. Special considerations are required to ensure adequate pad life.

Braking calculations are fundamental to good brake selection. The following calculations are intended only as a guide for those wishing to make their own selection. For a more detailed analysis of a proposed braking system, Twiflex Application Engineers can assist in providing details of all expected operating characteristics using specialist software.

## Defintion of Braking Terms

**Clamping Force** ($F_n$) is the force pressing each brake pad against the disc.

**Braking Force** ($F_b$) is the tangential friction force acting between the brake pads and disc.

$$F_b = 2 . \mu . F_n$$

Where: $\mu$ is the coefficient of friction between the pad and the disc (a nominal value of 0.4 is assumed for fully conditioned pads of standard material).

**Braking Torque** ($T_b$) is the moment of braking force about the center of rotation.

$$T_b = F_b . r_e$$

Where $r_e$ is the effective disc radius.

Calculated braking torques for the range of Twiflex brake calipers are shown in the brochure for a range of standard disc sizes.

# Braking Calculations

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## Definition of Symbols and Units

It is important, when making calculations, that a consistent set of units is used.

### Symbols and units

| | | | | | |
|---|---|---|---|---|---|
| $\omega_m$ | Maximum disc speed | [rad/sec] | $T_J$ | Inertia Torque | [Nm] |
| $\omega$ | Deceleration during braking | [rad/sec²] | $T_F$ | Friction torque | [Nm] |
| $J$ | Total inertia referred to braked shaft | [kgm²] | $t_b$ | Braking time | [sec] |
| $m$ | External load | [kg] | $t_d$ | Delay time for brake signal | [sec] |
| $T_B$ | Total braking torque | [Nm] | $t_s$ | Overall stopping time | [sec] |
| $T_L$ | Load torque (out-of-balance torque) | [Nm] | $g$ | Acceleration due to gravity | [m/sec²] |

## Basis of Brake Calculation

The fundamentals of braking calculations are to ensure that:

• There is sufficient torque to stop and hold the machine at rest

• For dynamic stops, the power dissipation is acceptable for the area of the brake pads being used

• The operating temperature of the brake disc is controlled, to avoid brake fade and reduced performance

The basic data needed to make an initial calculation are any out-of-balance forces acting on the machine, and the total inertia of the moving parts of the machine.

The total braking torque is defined as follows:

$$T_B = T_J + T_L - T_F$$

Generally the effects of friction can be ignored for a conservative estimate of the required braking torque.

It is important, in all cases of dynamic braking, that the inertia of all of the moving parts is referred to the braked shaft when calculating $T_J$ (see below).

## Brake Calculation

Basic braking calculations are derived from simple mechanics. Both the effects of out of balance loads and the torque needed to stop the inertia in the desired way need to be calculated.

### Load torque $T_L$

Where the machine has any out-of-balance load applied the effective out-of-balance torque must be calculated. In the case of a suspended load, for example this is simply given by

$$T_L = m \cdot g \cdot r \text{ [Nm]}$$

where **r** is the radius at which the load acts (based on drum diameter, reel diameter etc.) The brake will need to overcome this load before it can start to slow down the machine; (it is assumed that the out of balance opposes the action of the brake). If the load is at rest, the static brake torque will prevent the load from moving. In practice a safety factor should be used in the case where the brake is called upon only to hold this load and is only infrequently used in a dynamic manner. In these cases a service factor of 2 is recommended to allow for external environmental conditions, i.e. the brake should be rated to give twice this calculated value.

With some types of machines, such as downhill conveyors or escalators, a component of the load acts in the direction of motion. In these cases the following equation should be used:

$T_L = m . g . r . \sin ø$ [Nm]

Where **ø** is the angle of the motion to the horizontal. In cases where the load does not produce a direct torque on the braked shaft (eg. there is a gearbox between the loaded shaft and the brake) the load torque should be calculated accordingly.

In cases of dynamic braking, where the load torque is not constant, for example on wind turbines where the aerodynamic load varies with the speed of the machine, then the equation for $T_L$ becomes complex and it is recommended that selection should be referred to Twiflex.

### Inertia torque $T_J$ (dynamic braking only)

Having overcome the external forces additional braking torque is required to stop all the moving parts of the machine. This additional torque is calculated as follows:

$T_J = J . \omega$ [Nm]

In this equation the deceleration required can readily be calculated from the braking time.

$\omega = \omega / t_b$

In some special cases more precise calculation of speed and time may be required.

The moment of inertia of the system **(J)** should represent all moving parts. For example, in a hoist calculation allowance should be made to include the motor, brake disc, gearbox, winding drum, ropes, load etc. again with a suitable allowance for any mechanical advantage at various parts of the system.

The effective inertia of the load is given simply as:

$J = m . r2$ [kgm²]

For the winding drum the following well established formula can be used for an initial estimate (can also be used for flat discs):

$J = \pi \rho l ( D^4 - d^4 ) / 32$ [kgm²]

Where **l** is the length of the drum,

**D** is the outside diameter

**d** is the inside diameter and $\rho$ is the density of the material (7840 kg/m³ for steel)

The inertia of the motor should also be included in the calculations. These values can be estimated but should ideally be obtained directly from the manufacturer.

*Note: All inertia must be referred to the brake shaft.*

For example, if the brake is positioned on the low speed shaft of a machine (gearbox output shaft) then all calculated inertia values (motor, couplings, etc.) must be referred to this shaft.

When referring inertia $J_B$ from one shaft with speed $\omega_B$ to another shaft with speed $\omega_A$ use:

$J_A = J_B ( \omega_B / \omega_A )^2$

### Special requirements

In certain cases there are other direct considerations to be applied when making braking calculations.

In mine hoists the service factor for holding is defined, as are allowable levels of deceleration, especially when manriding.

For escalators, allowable stopping distances or even rates of deceleration may be defined in local standards.

Twiflex is able to offer assistance with calculations in such special cases.

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# Braking Calculations

## Other Considerations

To optimise braking performance there are other considerations which must be taken into account.

### Rubbing speed

For high-speed applications a further consideration is the linear speed at which the disc is passing between the pads when the brake operates. This is important and is usually measured at the effective radius.

Thus the rubbing speed is given as:

### Rubbing speed = $\omega_m . r_e$ (m/s)

In general a maximum speed of 30m/s is recommended for standard brake pad materials. Above this value it is likely that the effective coefficient of friction will be reduced leading to a reduction in braking performance. For certain applications where the rubbing speed is particularly high (up to 100m/s) special pads manufactured from sintered materials are available. Refer to Twiflex for details.

### Operating temperatures

During a dynamic application of a brake the energy of the machine will be converted to heat, generated between the pad and the disc. It is the temperature of the disc surface that is normally used to assess the brake performance. Failure to take account of the peak temperature can lead to a reduced braking performance due to the onset of brake fade. With standard brake pads a peak temperature of 250°C has been found to be acceptable, although in certain cases higher temperatures might be permitted. In the case where sintered pads are used peak temperatures in excess of 600°C are possible. The operating temperature also determines pad wear. The higher the temperature, the greater the wear rate of the pads. These calculations require a detailed analysis, carried out by the application engineers at Twiflex, using dedicated software.

### Power dissipation

In order to provide a consistent controlled performance of a brake it is also important to check the power dissipated during a stop. This affects the condition of the brake pads.

To calculate the power dissipation it is necessary to calculate the total energy absorbed during the stop, estimated as follows:

### Kinetic energy (KE) = J . $\omega_m^2$ / 2 (Joules)

In the case of external loads further allowance should also be made for the change in potential energy of the system. For example in the case of a hoist this is determined by how far the load drops during the braking cycle. The mean power dissipated is therefore given by:

### Mean power dissipation = KE / $t_b$ (Watts)

This is usually converted to what is termed the Mean Specific Power Dissipation (kW/cm$^2$) for evaluation of pad performance, i.e. the mean power dissipation is divided by the pad area.

A value of 0.7kW/cm$^2$ has been shown to be acceptable for emergency stops of around 10 seconds duration, providing that the pads have been well bedded in and conditioned. Higher values can be used for shorter stopping times.

For tensioning duties the value of the mean specific power dissipation is more typically around 0.06 kW/cm$^2$. Failure to observe this basic selection criteria may result in poor braking performance and limited pad life.

Twiflex application engineers will be only too happy to assist in the selection process to meet your application requirements.

## Conversion Factors

| To Convert... | Into... | Multiply By... |
|---|---|---|
| kN | lbf | 224.808943 |
| Nm | lb-ft | 0.737562149277 |
| m | ft | 3.2808399 |
| mm | in | 0.0393701 |
| kg | lb | 2.20462 |
| bar | psi | 14.5037738 |
| ml | fl oz | 0.033814 |
| kgm$^2$ | psf | 0.20428571428571 |
| Joules | btu | 0.000948 |
| Watts | hp | 0.001341 |

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# Application Data Form

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Phone: +44 (0) 20 8894 1161

Date _____

Company _____

Address _____

City _____ County _____ Postcode _____

Name _____

Title _____ Phone ( _____ ) _____

Email _____ FAX ( _____ ) _____

☐ Urgent    ☐ For Review    ☐ Please Comment    ☐ Please Reply    ☐ Please Recycle

## Application Description

Type of braking required: (eg: Holding, Dynamic Stopping, Emergency Stopping, Tensioning):

_____

Service Brake:  (Between motor and gearbox):_____

Motor Rating: _____

Safety Braking Required? _____

Brake Torque: _____

## Comments

_____
_____
_____
_____
_____
_____
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_____
_____
_____
_____
_____
_____

## Drawing of Application

## Twiflex Facilities

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