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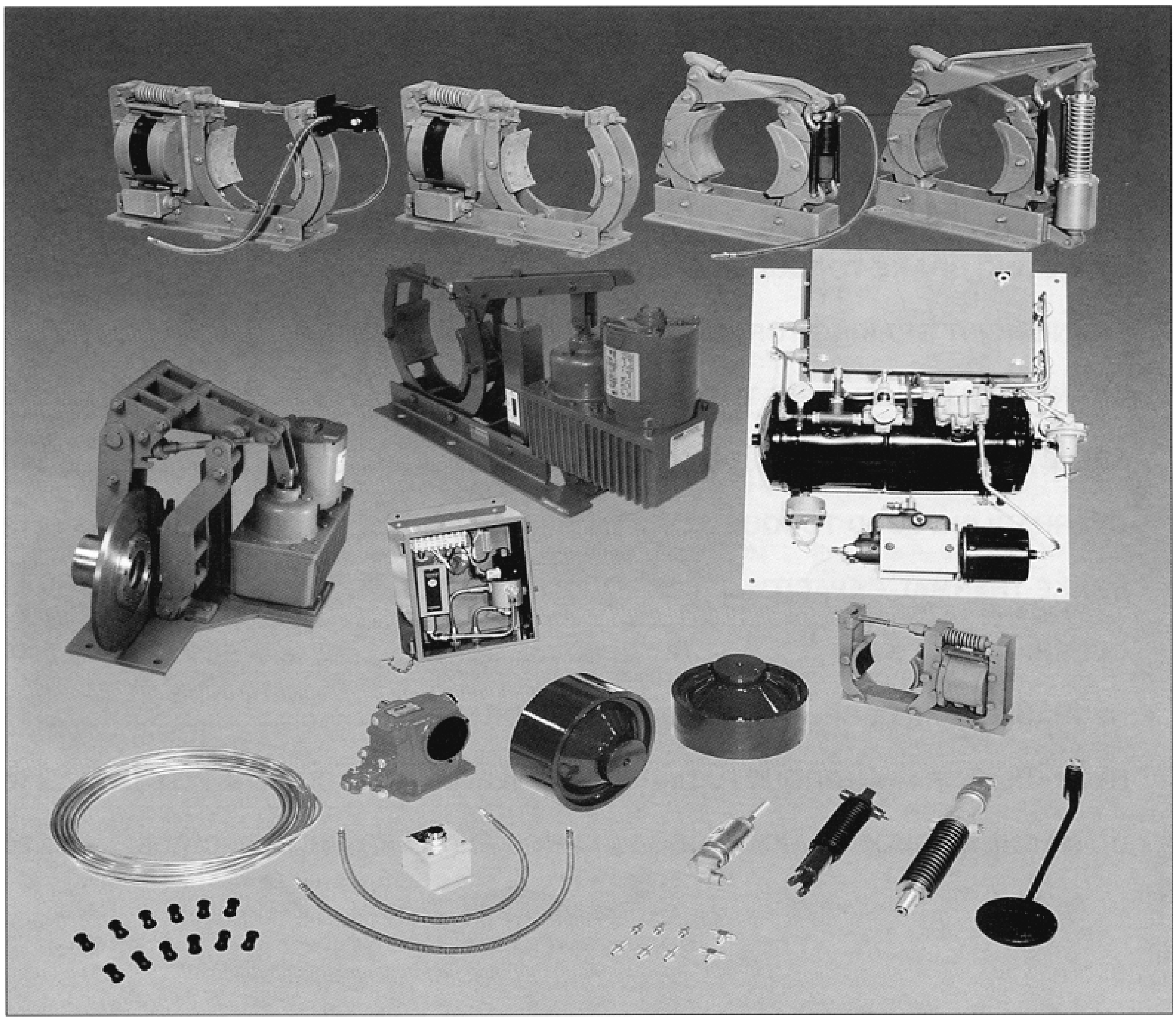
Industrial Brakes

Gemco™

Brake Systems Application Guide



Brake Systems Application Guide

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INTRODUCTION

BRAKE CALCULATIONS

NOTE: Pages 9 through 14 describe brake calculations that in general apply to all style Gemco brakes. The hydraulic brake selection, pages 15 through 19 are specifically for hydraulic brakes used as bridge brakes for overhead cranes.

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BRAKE SUMMARY AND KEY FEATURES

HYDRAULIC, MAGNETIC, AND ELECTRO-THRUST BRAKE SYSTEMS

Gemco Industrial Brakes stop virtually any type of industrial machine. Applications such as indoor and outdoor bridge cranes, gantries, heavy-duty cranes, high duty cycle cranes, lock and dam projects, stacker reclaimers, commercial laundry equipment, and heavy-duty industrial transfer equipment are just some of the uses for Gemco Industrial Brakes.

These field-proven, high performance brake systems are tough and reliable, and they provide extended, trouble-free service. That's because they are designed and built to exacting specifications by Gemco. For more than 40 years, Gemco has been an acknowledged leader in brake systems technology for heavy-duty industrial applications.

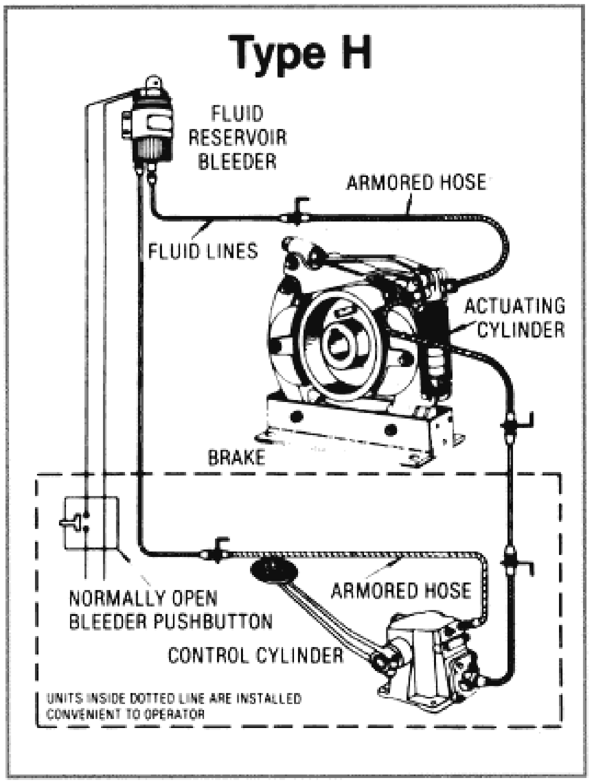
BRAKE SYSTEM KEY FEATURES SUMMARY

	H	HM	AH	AHM	CB	TM	ET	S	DB
Hydraulically Applied	•	•	•	•					
Spring Applied					•	•	•	•	•
Controlled Stopping	•	•	•	•					
Parking		•		•	•	•	•	•	•
AISE Rated						•	•		•

H - Manual Hydraulic Applied Brake System
HM - Manual Hydraulic Brake with Parking
AH - Air-Over-Hydraulic Brake System, for remote control
AHM - Air-Over-Hydraulic Brake with Parking
CB - AC Brake, Spring Set
TM - DC Brake, Spring Set (Auxiliary Hydraulic Cyl. available)
ET - Electro-Thrust, Spring Set Release by Electro-Hydraulic Actuator (Auxiliary Hydraulic Cylinder Available)
DB - Electro-Thrust, Spring Set Release by Electro-Hydraulic Actuator (Auxiliary Hydraulic Cylinder Available)

Note: Custom design and special brake assemblies are available; please consult factory for application assistance.

TYPICAL DESCRIPTION AND APPLICATIONS HYDRAULIC BRAKES

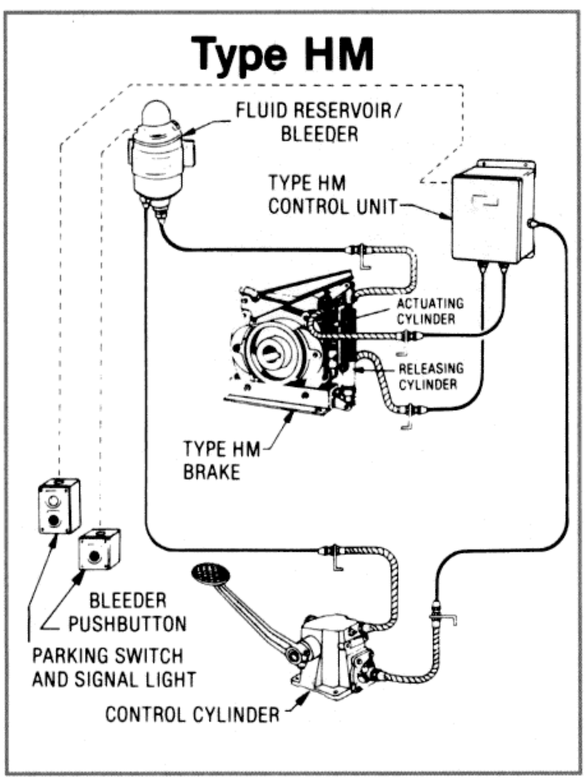


DESCRIPTION:

Type H manually operated hydraulic brakes for smooth controlled service stops. Sizes are 6” through 18” with torque ratings 150 to 900 ft-lbs.; one and two brake systems.

TYPICAL APPLICATIONS:

Bridge brakes for overhead, gantries and heavy duty cranes. The hydraulic brakes described in the following pages have been utilized for many years in steel mill cranes, shipyards and other applications where an “operator” control stop is desirable.



DESCRIPTION:

Type HM brakes not only provide smooth controlled stopping but are also equipped with a spring applied parking actuator. Sizes for single brake systems 6” through 18”, two brake systems 6” and 8”.

TYPICAL APPLICATIONS:

Bridge brakes for “outdoor” cranes that require parking feature due to wind loads.

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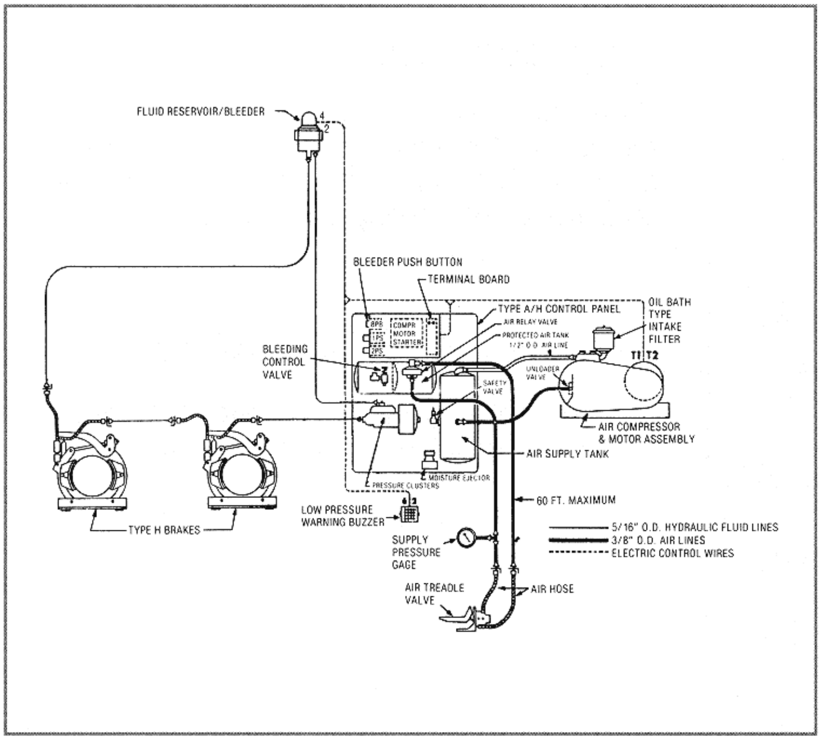
TYPE AH-ARC

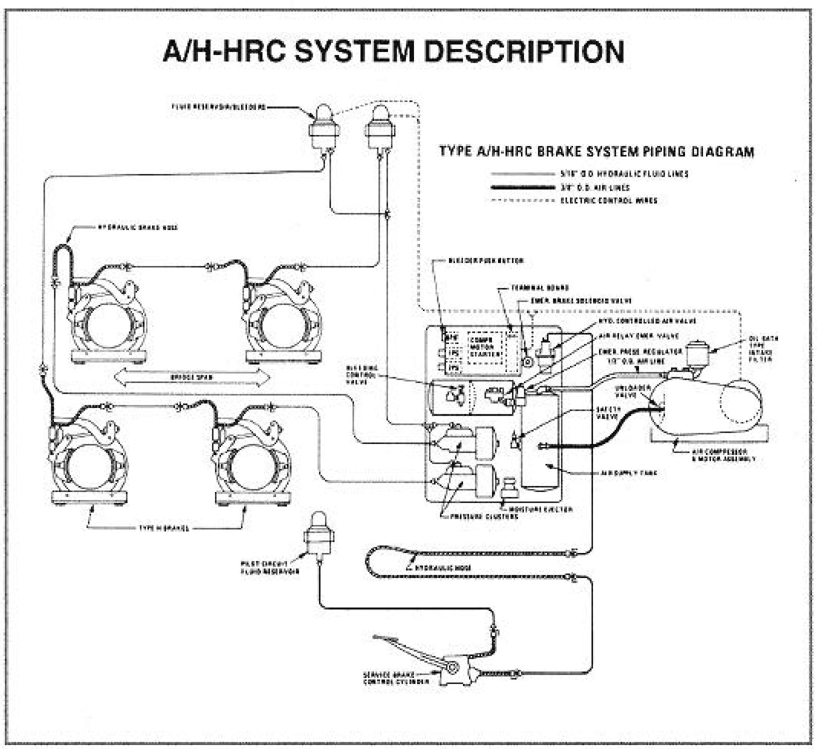


DESCRIPTION:

Type AH-ARC (Air/Hydraulic Air Remote Control) brake system for stopping large loads. Sizes one, two and four brake systems - 6” through 18”.

TYPICAL APPLICATIONS:

Large overhead crane brakes for ladle cranes and other hot metal cranes, usually four brakes systems.



DESCRIPTION:

Type AH-H RC (Air/Hydraulic-Hydraulic Remote Control) brake systems with operator hydraulic control. Sizes one, two and four brake systems - 6” through 18”.

TYPICAL APPLICATIONS:

Bridge brakes for overhead crane with moving trolley cabs that require more than 60 feet travel.

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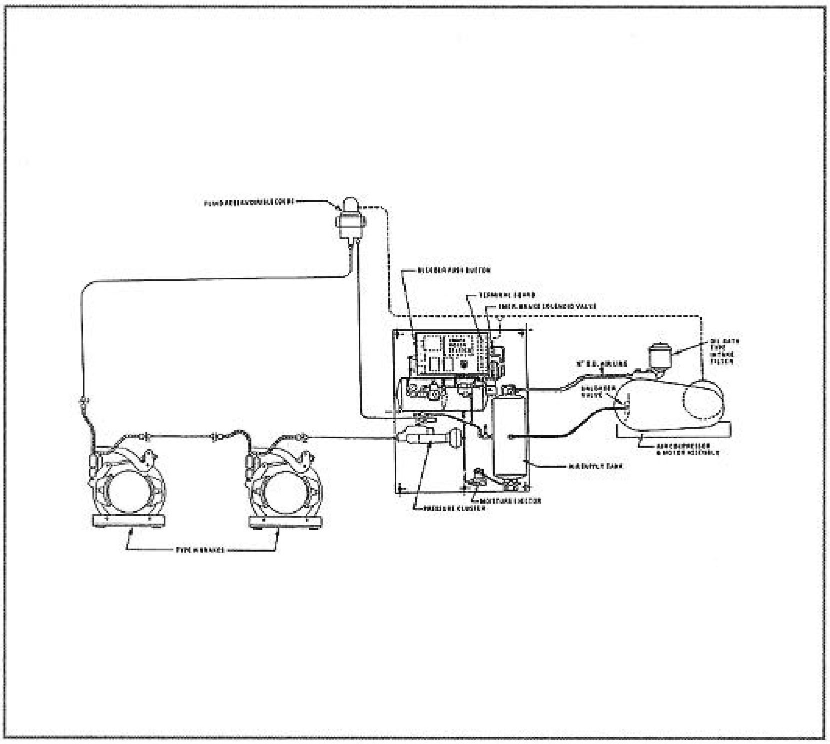
TYPE AH-ERC



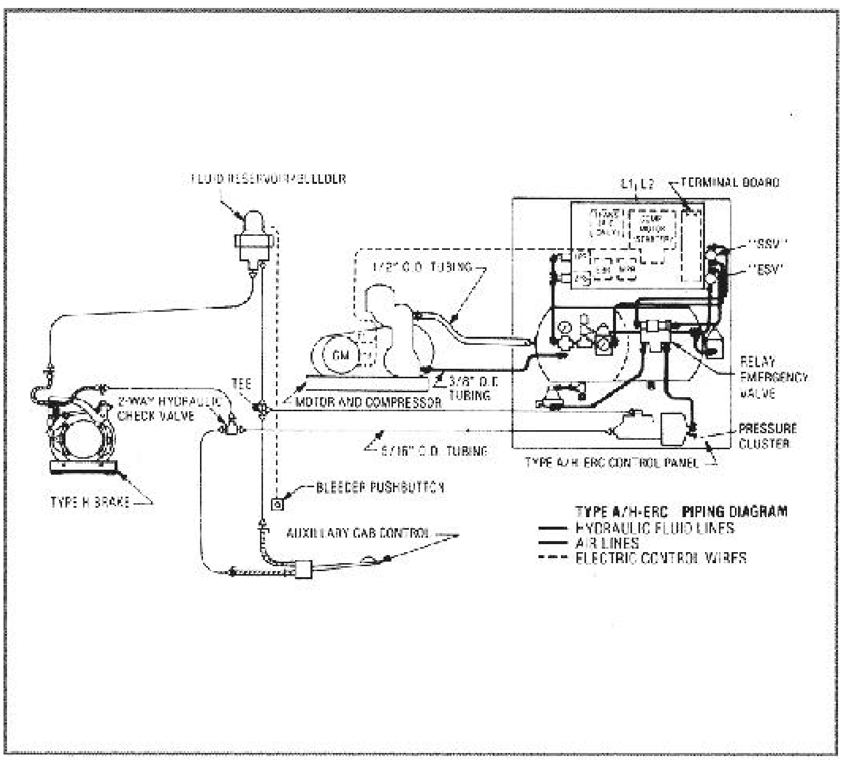
DESCRIPTION:

Type AH-ERC systems for operating hydraulic brakes by radio or pendent control. Size one, two and four brake systems - 6” through 8” brake.

TYPICAL APPLICATIONS:

Any remote radio or pendent control brake requirement for bridge brakes.

TYPE AH-ERC CONVERSION



DESCRIPTION:

Type AH-ERC Conversion package adds remote control capability to existing H brake systems. Size one and two brake systems.

TYPICAL APPLICATIONS:

Field modification for remote control capabilities on existing manual system.

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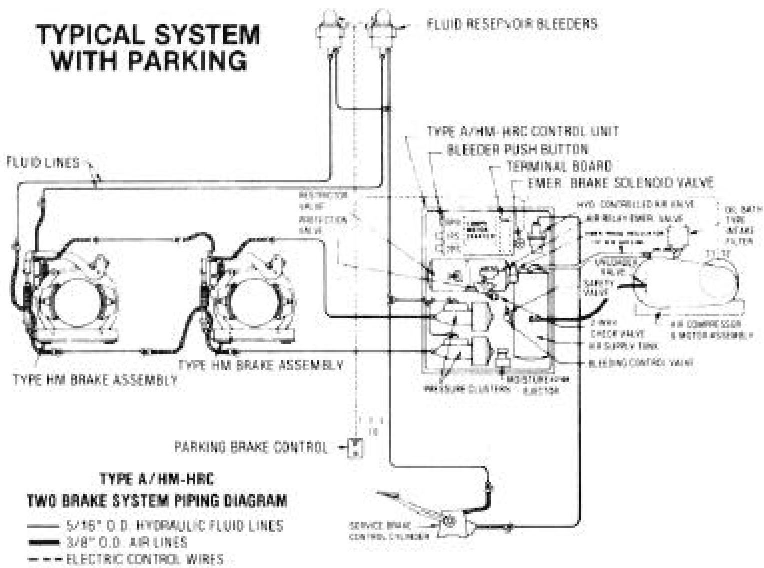
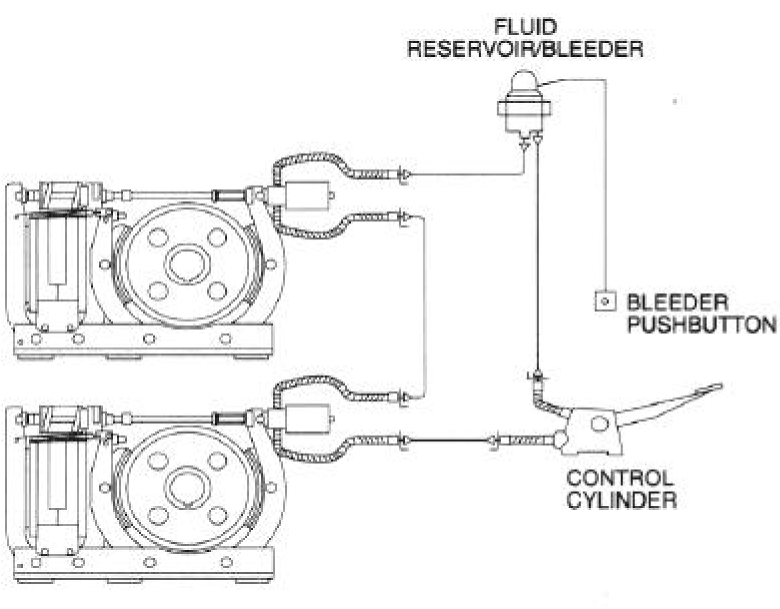


DESCRIPTION:
Type AHM System. All three of the previously described air over hydraulic systems can be provided with parking. (AHM-ARC, AHM-HRC, and AHM-ERC).

TYPICAL APPLICATIONS:
As previously described but with parking for “outdoor crane” applications.



DESCRIPTION:
Type TMH System for remote operation of D.C. Electric Brake assemblies. Auxiliary cab control also allows hydraulic operation for controlled braking. sizes are 4’ to 23”, one and two brake systems.

TYPICAL APPLICATIONS:
Bridge brakes for overhead cranes. Since electric brake is spring set, parking feature is also present.

Note: Auxiliary cab control is also available for EH style electro-thrust brakes.

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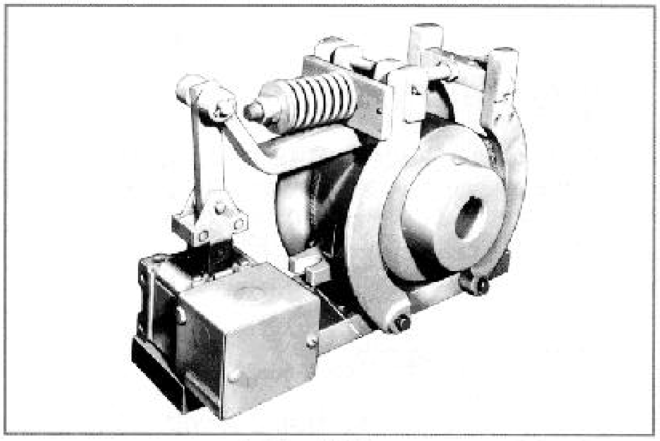
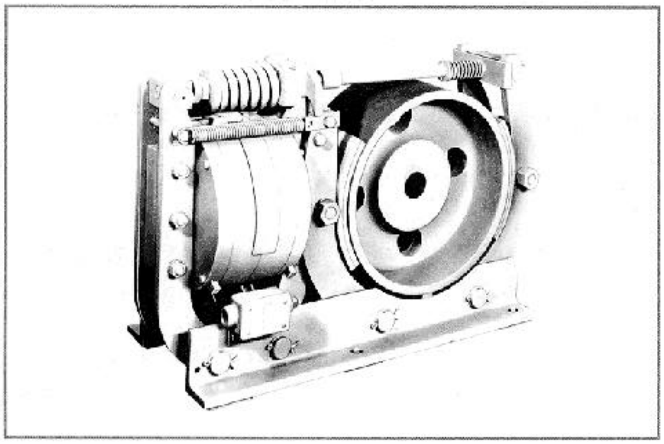


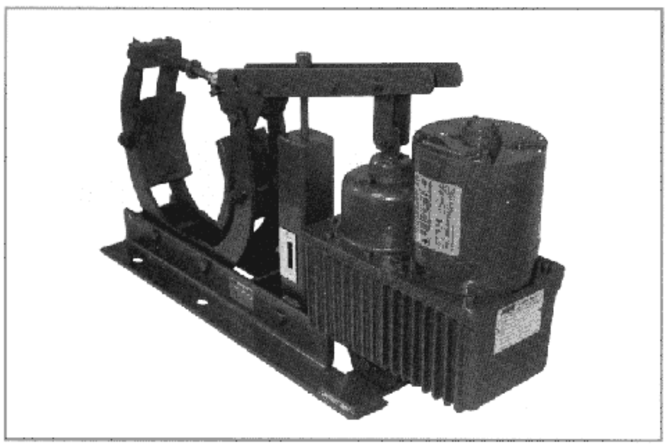
***DESCRIPTION*:**
Type CB brakes spring applied electrically released via solenoid. Sizes, 4 ½ to 10', general duty.

TYPICAL APPLICATIONS:
Light duty crane bridge brakes and holding brakes.



***DESCRIPTION*:**
Type TM brakes spring applied electrically released via D.C. magnet coils. AISE sizes, Mill Duty.

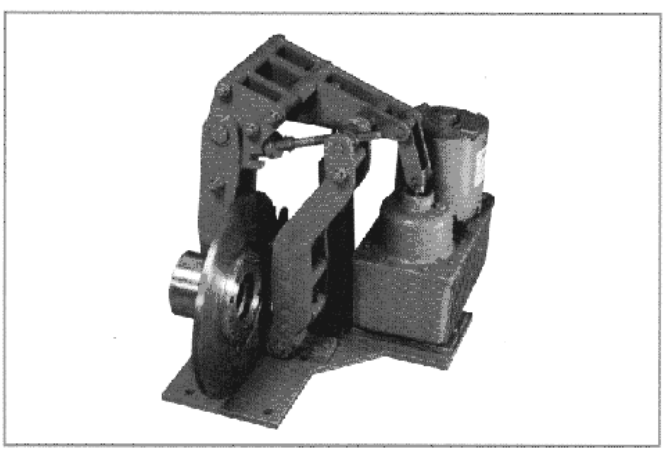
TYPICAL APPLICATIONS:
Crane hoist, stationary hoist, drive roller brakes, and lock and dam motor brakes.



DESCRIPTION:
Type ET brake spring applied electrical release by A.C. or D.C. electro-thrust mechanism.

TYPICAL APPLICATIONS:
Bridge brakes, lock and dam project,
stacker reclaimers, container cranes.

Note: Auxiliary hydraulic cylinder is also available for manual cab control.



***DESCRIPTION*:**
Type DB brake spring applied electrical release by A.C. or D.C. electro-thrust mechanism.

TYPICAL APPLICATIONS:
Bridge brakes, lock and dam project, stacker reclaimers, container cranes.

Note: Auxiliary hydraulic cylinder is also available for manual cab control.

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INTRODUCTION

When selecting the proper brake for a specific application, there are several factors to consider; a few that need to be reviewed are brake torque, stopping time and/or deceleration rates, brake mounting, brake location, thermal rating, environment, and brake style.

The brake systems manufactured by Gemco Industrial Brake Products are external friction brakes. Applications for which these brakes are suited can be classified into two general categories: non-overhauling and overhauling.

A) Non-overhauling loads are typically horizontally moving masses such as crane bridges, crane trolleys, and horizontal conveyors.

B) Overhauling loads tend to “run up” in speed if a brake is not present, examples of which are crane hoists, winches, lifts, and downhill conveyors.

Type A (non-overhauling) loads require brake torque only to stop the load and will remain at rest due to friction. Type B (overhauling) loads have two torque requirements; the first is braking torque required to stop the load, and the second is the torque required to hold the load at rest.

SELECTING BRAKE TORQUE BASED ON MOTOR DATA

The full -load torque of a motor is a function of horsepower and speed and is commonly used to determine a brake torque rating. The brake torque rating is to equal or exceed the full load torque of a motor. The formula to calculate the full load motor torque is as follows:

$$T = \frac{5250 \text{ x HP x S.F.}}{\text{RPM}}$$

where:
- 5250 = constant
- HP = motor horsepower
- RPM = speed of motor shaft
- S.F. = application service factor
- T = static brake torque

CRANE HOIST BRAKING TORQUE

Sizing of crane hoist brakes is typically based upon full load hoisting torque. The following is a brief summary of guidelines for hoist brakes.

Each hoist on a crane should be equipped with at least one spring-set magnetic brake; hoists handling hot metal should be equipped with more than one brake. Brake rating expressed as a percent of hoisting torque at the point of brake application should be no less than the following:

1) 150% when only one brake is used.

2) 150% when multiple brakes are used and the hoist is not used to handle hot metal. Failure of any one brake shall not reduce braking torque below 100%.

3) 175% for hoists handling hot metal. Failure of any one brake shall not reduce brake torque below 125%.

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CRANE TROLLEY BRAKING TORQUE

Crane trolley brakes are typically sized with a torque rating less than the motor's full load torque (service factor less than 1.0) to provide a longer stopping time or a "soft stop." Overhead crane trolley brakes are minimized to prevent sway of the hook and load. Typical service factor is 50% for "soft stopping."

SELECTING BRAKE SIZE BASED ON LOAD DATA

For applications where high inertial loads exist or where a specific stopping time or distance is required, the brake should be selected based on the total inertia of the load. Total system inertia reflected to the brake shaft can be expressed as follows:

$$WK_T^2 = WK_B^2 + WK_M^2 + WK_L^2$$

where:
- WK_T^2 = Total reflected inertia to brake (lb-ft^2)
- WK_B^2 = Inertia of brake wheel (lb-ft^2)
- WK_M^2 = Inertia of motor rotor (lb-ft^2)
- WK_L^2 = Equivalent inertia of load reflected to shaft (lb-ft^2) brake

The following formulas apply when calculating inertia of systems with different rotational speeds or linear moving loads to brake shaft speeds.

Rotary Motion:

$$WK_b^2 = WK_L^2 \, \mathbf{(}N_L / N_B\mathbf{)}^2$$

where:
- WK_b^2 = Inertia of rotation load reflected to brake shaft (lb-ft^2)
- WK_L^2 = Inertia of rotating load (lb-ft^2)
- N_L = Shaft speed at load (RPM)
- N_B = Shaft speed at brake (RPM)

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Horizontal Linear Motion:

$$WK_W^2 = W\ (V / 2pN_B)^2$$

where: WK_W^2 = Equivalent inertia of moving load reflected to brake shaft (lb-ft^2)

W = Weight of linear load (lb)

V = Linear velocity of load (ft/mm)

N_B = Shaft speed at brake (RPM)

With the total system inertia calculated, the required average dynamic torque for a desired stopping time can be calculated using the following formula:

$$T_d = \frac{WK_T^2 \ x\ N_B}{308 \ x\ t}$$

where: T_d = Average dynamic braking torque (lb-ft)

WK_T^2 = Total inertia reflected to brake (lb-ft^2)

N_B = Shaft speed at brake (RPM)

t = Desired stopping time (sec.)

308 = Constant

To determine stopping time for a given brake torque this formula can be rewritten as follows:

$$t = \frac{WK_T^2 * N_B}{308 \ x\ Td}$$

For some brake styles the time required until the brake lining makes contact with the wheel may be significant. Time required to stop is then as follows:

$$t = t_1 + \frac{WK_T^2 x N_B}{308 \ x\ Td}$$

where: t_1 = Time between signal and moment when brake torque is actually applied (sec.)

For linear applications, the dynamic braking torque can be calculated directly using the following formula:

$$T_d = \frac{W \times V \times r}{g \times t}$$

where:

T_d	=	Average dynamic braking torque (lb-ft)
W	=	Total weight of linear moving load (lb.)
V	=	Linear velocity of load (ft/sec.)
g	=	Gravitational acceleration constant (32.2 ft/sec2)
t	=	Desired stopping time (sec.)
r	=	Length of movement arm or wheel radius (ft.)

This formula is applicable on crane trolley or crane bridge brakes.

OVERHAULING LOAD TORQUE

Applications with a descending load, such as crane hoists, elevators, etc., require a brake with sufficient torque both to stop the load and to hold it at rest. The total system inertia reflected to the brake shaft speed should be calculated using the previous formulas. Next, the average dynamic torque should be calculated with the previous formula:

$$T_d = \frac{WK_T^2 * N_B}{308 * t}$$

Next, the overhauling torque reflected to the brake shaft can be determined by the following formula:

$$T_o = \frac{0.159 * W * V}{N_B}$$

where:

T_o	=	Overhauling dynamic torque of load reflected to brake shaft (lb-ft)
W	=	Weight of overhauling load (lb.)
V	=	Linear velocity of descending load (ft/min.)
N_B	=	Shaft speed at brake (RPM)
0.159	=	Constant (1/2 p)

The total dynamic torque required for an overhauling load is the sum of T_d and T_0, as follows:

$$T_t = T_d + T_o$$

where: T_t = Total dynamic torque for descending load

BRAKE THERMAL CAPACITY

When a brake stops a load, the energy required to stop is converted to heat. This heat is absorbed by the brake and the wheel. The ability to absorb and dissipate heat without exceeding temperature limitations is known as thermal capacity.

There are two types of thermal capacity. The first is referred to as the maximum energy the brake can absorb in one stop, or emergency stop. The second is the heat dissipation capability of the brake if it is for frequent stopping.

The kinetic energy that must be absorbed and dissipated by the brake can be determined as follows:

<u>Rotational Loads</u>:

$$KE_r = \frac{WK_T^2 \text{ X } N_B^2}{5875}$$

where: KE_r = Kinetic energy of rotating load (ft-lb)

WK_T^2 = Inertia of the rotating load reflected to brake shaft (lb-ft^2)

N_B = Shaft speed at brake (RPM)

5875 = Constant

$$KE_L = \frac{W \text{ x } V^2}{2g}$$

where: KE_L = Kinetic energy (ft-lb)

W = Weight of load (lb.)

V = Linear velocity of load, (ft/sec.)

g = Gravitational constant (32.2 ft/sec^2)

OVERHAULING LOADS

In the case of overhauling loads, both the kinetic energy of the linear and rotating loads and the potential energy transformed into kinetic energy by the change in height must be considered. The potential energy transformed to kinetic energy is determined as follows:

$$PE = WS$$

Where: PE = Change in potential energy, (ft-lb)

W = Weight of overhauling load (lb)

S = Distance load travels (ft.)

Therefore, the total energy to be absorbed by the brake in stopping an overhauling load is:

$$ET = KE_L + KE_r + PE$$

In general, a brake will repetitively stop a load at the duty cycle that the electric motor can repetitively start the load.

For rotating or linear loads, the rate at which a brake is required to absorb and dissipate heat when frequently cycled is determined as follows:

$$T_C = \frac{WK_T^2 \times N_B^2 \times N_O}{3,220,000}$$

where: TC = Thermal capacity (HP - sec/min)

WK_T^2 = Total system inertia (lb-ft^2)

N_B = Shaft speed at brake (RPM)

N_0 = Number of stops per minute

3,220,000 = Constant

For overhauling loads the rate at which the brake is required to absorb and dissipate heat when frequently cycled is determined as follows:

$$TC = \frac{E_T \times N_O}{550}$$

where: TC = Thermal capacity (HP-sec/min)

E_T = Total energy brake absorbs (ft-lbs)

550 = Constant

N_0 = Number of stops per minute

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BRAKE SELECTION FOR BRIDGE BRAKES

The following formulas apply for calculating linear loads such as bridge brake applications:

$$KE_L = \frac{W \times V^2}{2 \times g} \qquad T_d = \frac{W \times V \times r}{g \times t}$$

where:

where:	KE_L	=	Kinetic energy (ft-lb)
	W	=	Weight (lb.)
	V	=	Linear velocity (ft/sec)
	G	=	Gravitational constant (32.2 ft/sec^2)
	R	=	Wheel radius (ft)
	T	=	Stopping time
	T_d	=	Average dynamic torque (lb-ft)

Given in terms of tons, wheel diameter, gear ratios, etc., the specifications necessary to calculate crane bridge brakes include the following:

Empty crane weight — WE	_____Tons
Full load crane weight — WL	_____Tons
Max. bridge speed — FPM	_____Ft/Min.
Stops per hour — N	_____Number value
Track wheel diameter — DIA	_____Inches
*Gear ratio brake shaft to track wheel — R	_____(To 1)
Number of brakes — NB	_____Number value
Acceleration rate — A	_____Ft/Sec^2.
Min. deceleration rate — d_{MN}	_____Ft/Sec^2.
Max. deceleration rate — d_{MX}	_____Ft/Sec^2.
Drive motor inertia — WK_M^2	_____(Lb-Ft^2)

* Drive motor RPM can be used to verify gear ratios, etc., for a maximum speed and track diameter.

In general, service bridge brakes should have sufficient thermal and torque range to stop the bridge within a distance of 10% of the full load speed with full load, or at a deceleration rate as specified by the original manufacturer.

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The kinetic energy and torque calculations can be stated in terms of crane specifications as follows:

<u>Kinetic energy absorption rate, per brake per hour</u>:

$$KE = \frac{N \times (FPM)^2 \times (WE + WL)}{232 \times NB}$$

<u>Minimum stopping torque (to stop empty crane at minimum deceleration rate)</u>:

$$T_{MN} = \frac{2.59 \times WE \times d_{MN} \times DIA}{NB \times R}$$

<u>Maximum stopping torque (to stop fully loaded crane at maximum deceleration rate)</u>:

$$T_{MX} = \frac{2.59 \times WL \times d_{MX} \times DIA}{NB \times R}$$

HYDRAULIC BRAKE TORQUE RATINGS AND THERMAL CAPACITIES

Using the table below, select the smallest brake size that will exceed KE and TMX calculations listed above. TMN calculations for air powered systems should be above "Minimum" torque limits below:

Brake Size	**Max. KE per Brake per Hour (ft.-lb)**	Max. Dynamic Torque per Brake (lb-ft.)**			Min. Dynamic Torque, All Air Powered Systems (lb-ft.)
		Type H 1-Brake	**Type H 2-Brake or Type HM**	**All Air Powered**	
6 x 3	1.0×10^6	150	150	350	25
8 x 3	1.25×10^6	200	200	450	50
10 x 4	2.5 x 10	425	250	1000	75
14 x 6	5.0×10^6	600	350	1400	125
18 x 8	9.0×10^6	900	550	1800	175

**Based on 70 lb. pedal force, 8" max. pedal travel on Type H or HM manual systems.

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Maximum stops per hour can be calculated using the following:

$$\text{Max. stops/hr.} = \frac{N \times (\text{Max. KE per brake per hour})}{KE}$$

where: (Max. KE per brake per hour) = Value for brake size as shown in table above.

The additional torque required to stop the drive rotor and the brake wheel inertia is normally insignificant and is ignored when the gear ratio (R) is less than about 10 x 1. If the gear ratio, and thus the drive rotor inertia is abnormally high, considerable torque may be needed just to stop the drive rotor.

To calculate the additional torque needed to stop the drive rotor and brake wheel inertia, proceed as follows:

1. Complete the previous calculations to establish the prelimary brake size.

BRAKE SIZE	BRAKE WHEEL INERTIA
6 x 3	.55 lb-Ft^2.
8 x 3	1.41 Lb-Ft^2.
10 x 4	4.25 Lb-Ft^2.
14 x 6	24.20 Lb-Ft^2.
18 x 8	75.73 Lb-Ft^2.

2. Record the following data from brake wheel inertia table above and additional data from previous calculations.

WK^2	Brake wheel Inertia	________	Lb-Ft^2.
WK^2	Drive Rotor Inertia	+ ________	Lb-Ft^2.
WK^2	Total (Drive Motor and Wheel)	________	Lb-Ft^2.
R,	Gear Ratio	________	x1
d_{MN}	Deceleration Rate	________	ft/sec^2.
d_{MX}	Deceleration Rate @ Full Load	________	ft/sec^2.
DIA,	Track Wheel	________	inches

3. Calculate No Load Drive Torque, T_{NLD}:

$$\frac{\mathbf{WK^2}\text{Total} \times \mathbf{R} \times \mathbf{d_{MN}}}{1.34 \times \mathbf{DIA.}} = \frac{\_\_\_\_\_ \times \_\_\_\_\_ \times \_\_\_\_\_}{1.34 \times \_\_\_\_\_} = \_\_\_\_\_ \text{Lb-Ft.}$$

4. Calculate Full Load Drive Torque, T_{FLD}:

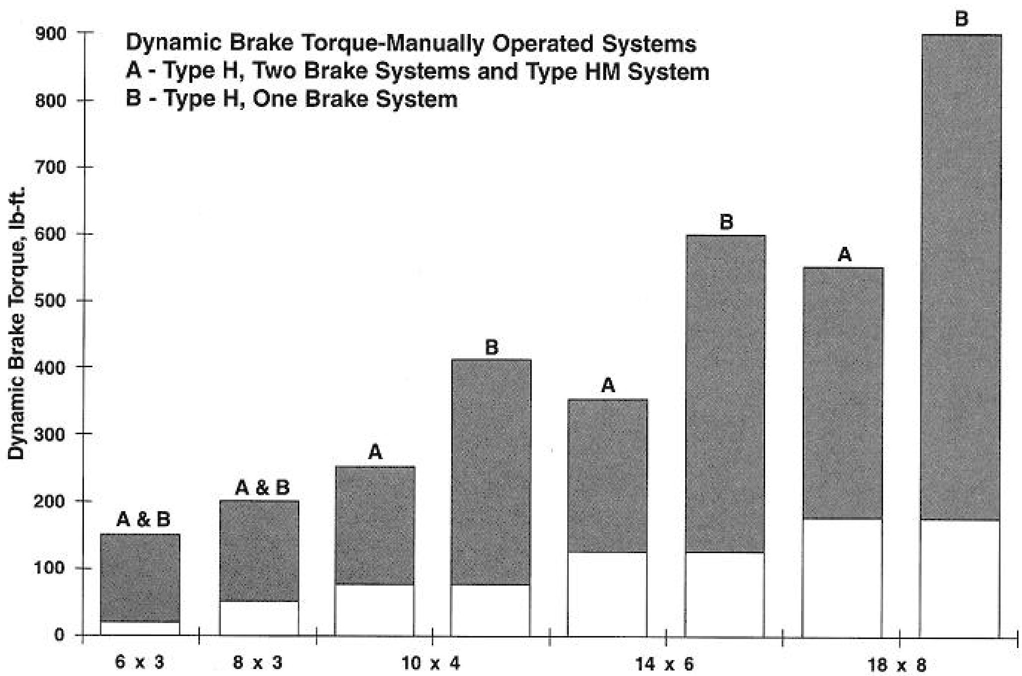
$$\frac{\mathbf{TNLD \ X \ d_{MX}}}{\mathbf{d_{MN}}} = \_\_\_\_\_ \times \frac{\_\_\_\_\_}{\_\_\_\_\_} = \_\_\_\_\_ \text{ Lb-Ft.}$$

5.Calculate Total Minimum and Maximum Torques:

T_{MN} (previous)		____________ Lb-Ft.	T_{MX} (previous)		____________ Lb-Ft.
T_{NLD}	+	____________ Lb-Ft.	T_{FLD}	+	____________ Lb-Ft.
T_{MNT}		____________ Lb-Ft.	T_{MxT}		____________ Lb-Ft.

6.Check to determine that T_{MxT} is still within the torque limits of the brake size selected. If necessary, recalculate the problem based on alternate brake size and brakewheel inertia.

The chart below shows the dynamic torque values developed by manually operated brake systems. Maximum torques tabulated are developed at 70 lb. pedal force, the limit indicated by AISE and OSHA. Two maximum values are shown for 10 x 4, 14 x 6, and 18 x 8 brakes, as follows:



Torques below the minimum value shown require careful application.

The chart below shows the dynamic torque ranges developed by air powered hydraulic systems.

The maximum torques shown are developed by a 70 lb. force applied on the air treadle on Type A/H systems or applied on the pedal of the control cylinder on Type NHM-HRC systems. Air powered hydraulic systems include either a 1 x 5 or a 1 x 8 air hydraulic pressure cluster to apply the service brake. In addition, 10”, 14”, and 18” brakes include either a 7/8” diameter or a 1-1/8” diameter service brake actuator. Hence, 6” and 8” brakes have two possible maximum torque limits, while 10”, 14”, and 18” have four possible maximum torque limits.

The minimum torque limits shown are developed by light application of the treadle or pedal. Because of hysteresis and friction in the power system valves, it is not practical to consistently control less torque than the minimum calculated.

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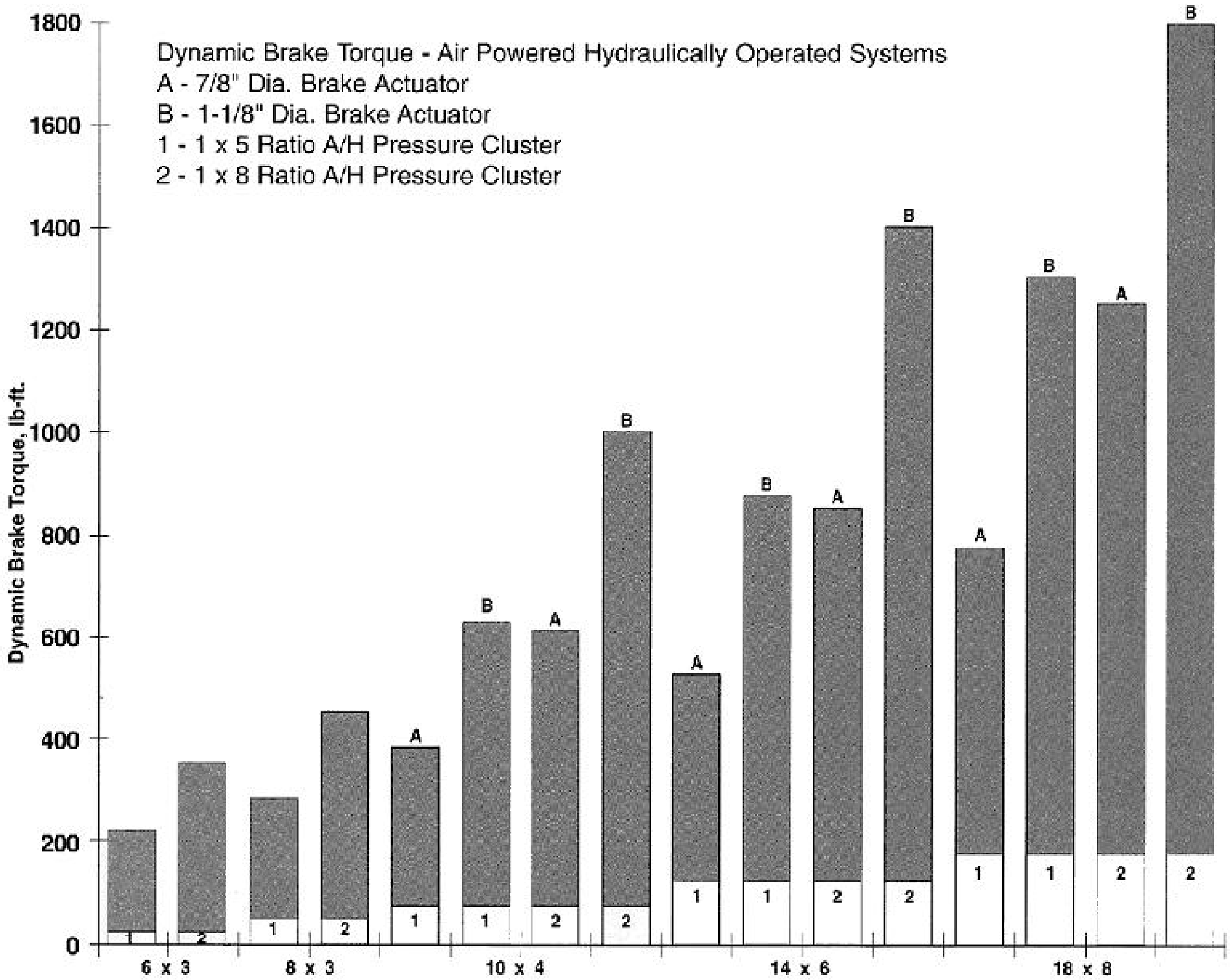

Static holding torque values tabulated below are those developed by the parking spring on the Type HM brakes. The brake must be correctly adjusted in order to get the holding torque tabulated.

Brake Size	6 x 3	8 x 3	10 x 4	14 x 6	18 x 8
Holding Torque, lb-ft.	35	50	450	550	700

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TM, ET and DB SHOE BRAKE TORQUE RATINGS AND THERMAL CAPACITIES

TM Torque Ratings

	Maximum Torque in Lbs.-Ft (Max.)			
	Series Brake		Shunt Brake	
	1/2 HR	1 HR	1 HR	8 HR
TM 43	25	15	25	15
TM 63	50	40	50	40
TM 83	100	65	100	75
TM 1035	200	130	200	150
TM 1355	550	365	550	400
TM 1655	1000	650	1000	750
TM 1985	2000	1300	2000	1500
TM 2311	4000	2600	4000	3000
TM 3014	9000	6000	9000	6750

ET Torque Ratings

BRAKE STYLE	WHEEL DIAMETER (inches)	TORQUE LB.FT. (Max.)
ET8	8	100
ET10	10	200
ET13	13	550
ET16	16	1000
ET19	19	2000
ET23	23	4000
ET30	30	9000

Allowable Heat Absorption for Brake Wheels

Wheel Size	Ft.-Lb. per Hour
4.5”	396,000
6.0”	660,000
8.0”	990,000
10”	1,716,000
13”	3,300,000
16”	5,016,000
19”	7,425,000
23”	10,890,000
30”	18,150,000

DB Torque Ratings

BRAKE STYLE	DISC DIAMETER (Inches)	TORQUE LB.FT. (Max.)
DB12	12	100
DB14	14	200
DB17	17	550

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