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AIRFRAME AND SYSTEMS
CHAPTER 10: WHEEL BRAKING SYSTEMS

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INTRODUCTION

Aircraft braking systems vary from simple single disc brake units fitted to light aircraft and operated by pedal pressure only, to very complex power operated multi-disc units incorporating computer controlled sub-systems such as autobrake and anti-skid.

This Chapter will describe the normal brake systems used on small and large aircraft including the following brake sub-systems found on large transport aircraft;

- alternate, reserve and emergency brake systems,
- anti-skid system,
- autobrake system,
- in-flight brake system,
- park brake system, and
- brake cooling methods and temperature management.

A brake unit is designed to decrease the rotational velocity of the wheel by friction between two surfaces, one rotating and one stationary. This converts the kinetic energy of the rotating wheel into heat energy, which is absorbed by the brake unit.

The ability of the brake unit to dissipate the absorbed heat determines the overall efficiency, and stopping capability, of the brakes. As more and more heat energy is absorbed and retained by the brake unit the braking efficiency decreases and brake wear increases.

For interest note the relative difference in heat dissipation and wear between older steel brakes and newer carbon brakes. Refer to Figure 10-1.

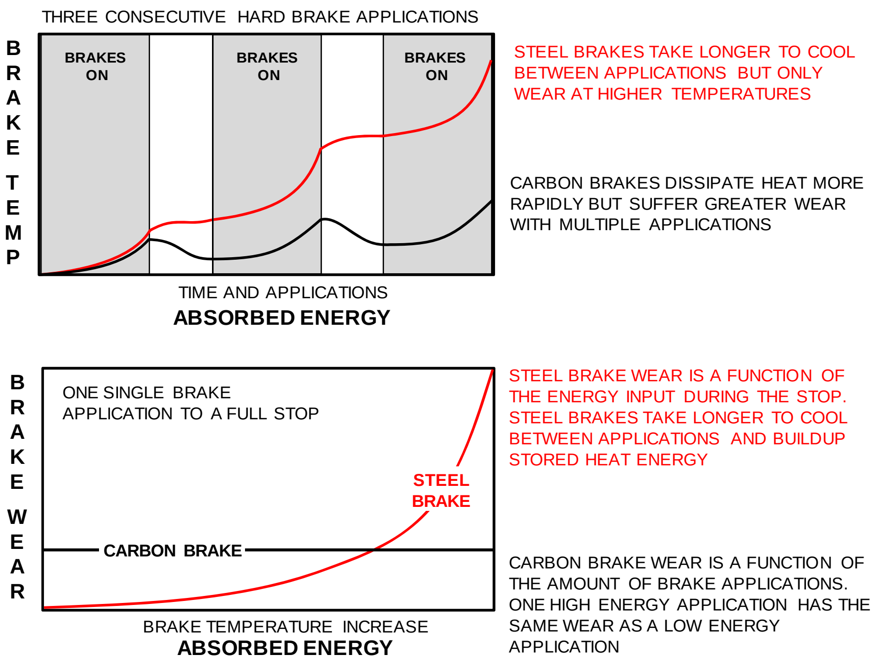


Figure 10-1 Heat Dissipation and Wear for Steel and Carbon Brakes

BRAKE UNITS

Brake units are fitted to the axles of the main wheels of the aircraft. Large commercial aircraft will have a brake unit on every main wheel axle and some aircraft fit brake units to the nose wheel axles although this is rare.

There are two types of brake units used on aircraft. They are;

- Single Disc brake units, and
- Multi-Disc Brake Units.

SINGLE DISC BRAKE UNITS

Single disc brake units are used on small aircraft that only have to dissipate small amounts of heat.

The unit consists of a single steel disc which is mounted to the wheel assembly and allowed to rotate with the wheel. This disc runs between two brake pads which exert the friction against the rotating disc.

The operating pad is moved by a brake piston which is actuated by hydraulic pressure, supplied from master cylinders which are operated by the pilot.

Light aircraft fitted with simple systems such as this will not have the additional features found on large aircraft such as autobrake and anti-skid. Refer to Figure 10-2.

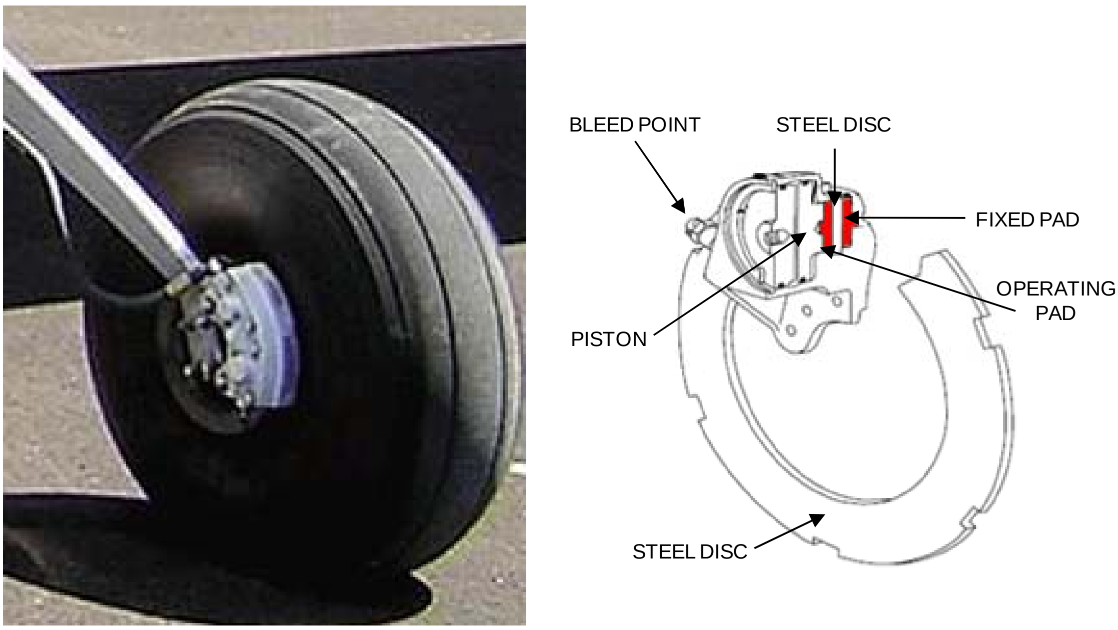


Figure 10-2 Single Disc Brake Unit

Brake pads are made from a compound of hard fibrous material which when applied to the steel disc results in wear of the pads producing a fine “brake dust” as wear occurs. Brake pads are also referred to as brake linings.

MULTIPLE DISC BRAKE UNITS

Multiple disc brakes units are used on all large aircraft and require a much greater hydraulic pressure than that applied by the pilot to operate effectively.

Instead of a single rotating disc as described previously, a disc pack of rotating and stationary discs is compressed together to create the friction required. Refer to Figure 10-3.

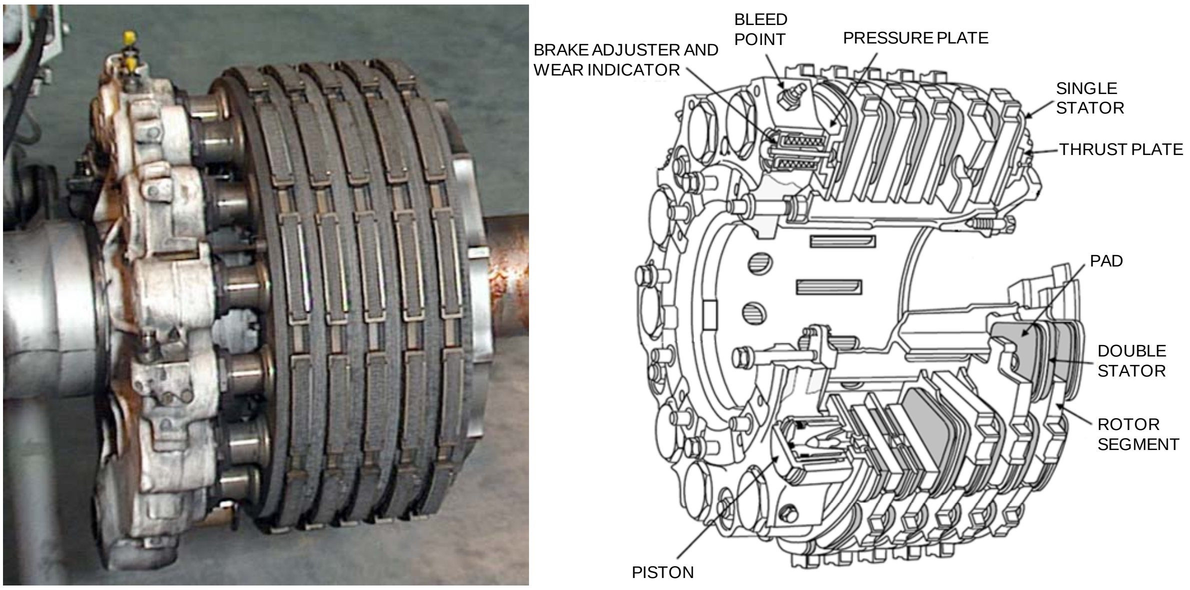


Figure 10-3 Multi Disc Brake Unit

The stationary discs are called STATORS and they carry the brake pads or linings. The rotating discs are called ROTORS and of course rotate with the wheel. When the brakes are applied a set of pistons compress the disc pack between a pressure plate and a thrust plate.

Older brake units used one piece ROTORS similar to single disc brake units. Compression of the disc pack was achieved either by a single annular piston or two pistons only.

More modern brake units use SEGMENTED ROTORS to help dissipate heat and the compression of the disc pack is achieved by multiple individual pistons. Both these types use brake pads or linings mounted on the STATORS to produce friction against the ROTORS.

Very modern brake units made from carbon composites still use STATORS and ROTORS but have no pads or linings. Friction occurs directly between the two carbon discs. Refer to Figure 10-4.

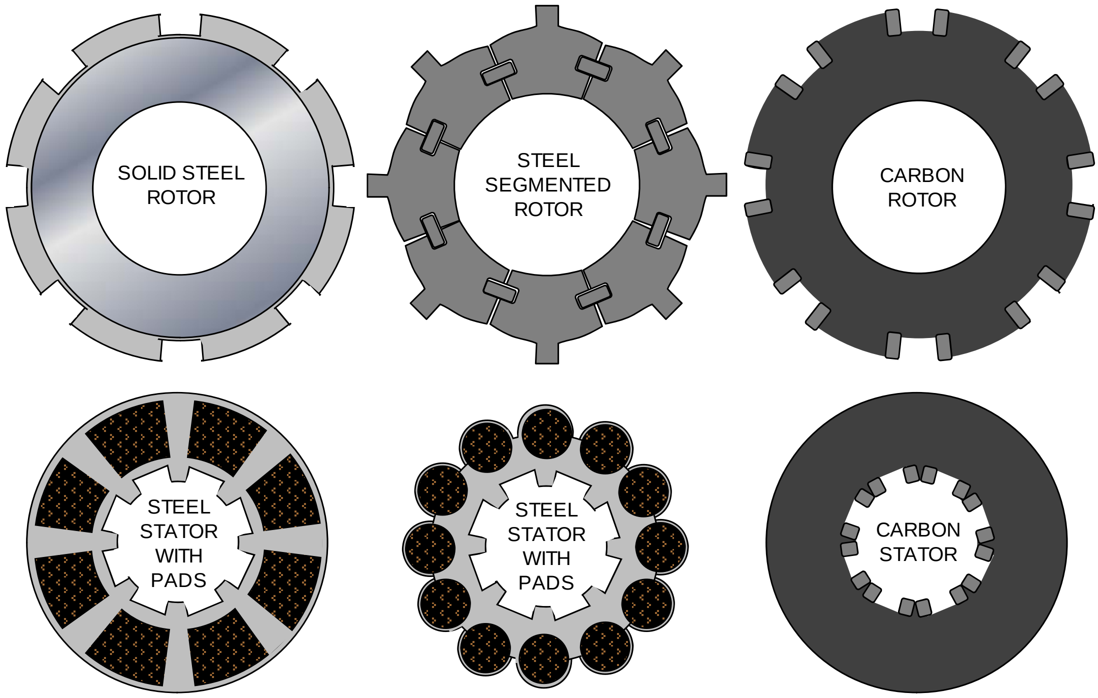


Figure 10-4 Rotor and Stator Types

When multi-disc brakes are off (released) a small gap exists between the stationary discs (STATORS) and the rotating discs (ROTORS) allowing the wheel to rotate.

As hydraulic pressure is applied the multiple pistons compress the disc pack causing friction between the discs and braking action occurs.

The stators can move laterally guided by keyways in the disc carrier and the rotors can move laterally in keyways or bosses located on the underside of the wheel rim. Refer to Figure 10-5.

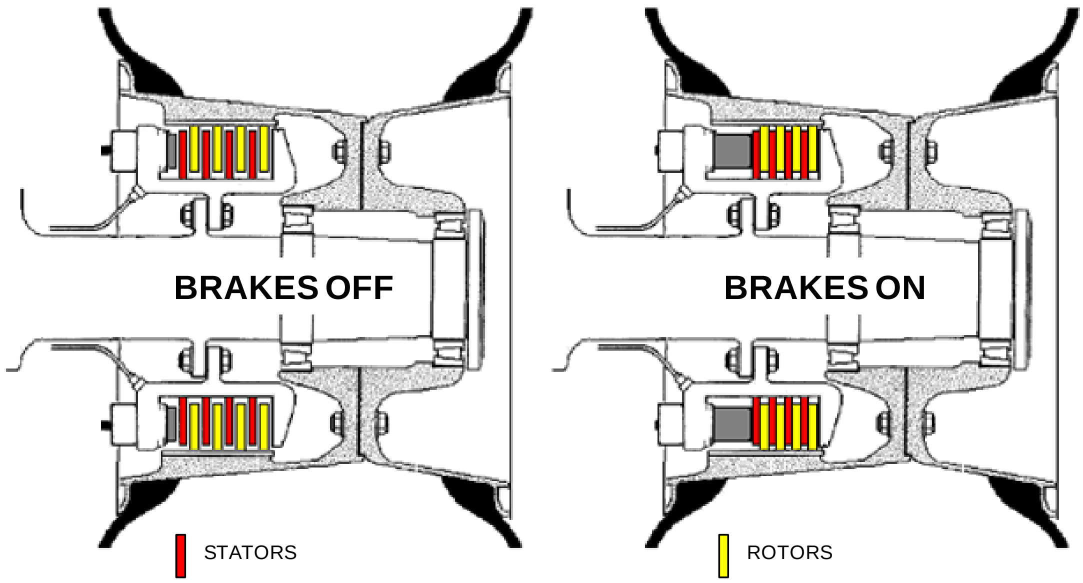


Figure 10-5 Multi Disc Brake Operation

AUTOMATIC BRAKE ADJUSTMENT

As the brakes wear the disc pack becomes smaller and smaller and the pistons have to extend further to compress the disc pack during brake application. When brakes are released the pistons only need to be retracted just enough to allow a running clearance between the discs.

If the pistons were to retract fully, subsequent brake application would be delayed slightly as the pistons move out to contact the disc pack. Automatic adjustment each time the brakes are operated ensures minimum piston travel at subsequent applications. Automatic Brake Adjusters perform this function and may be integrated into the pistons or fitted next to each piston assembly. Refer to Figure 10-6.

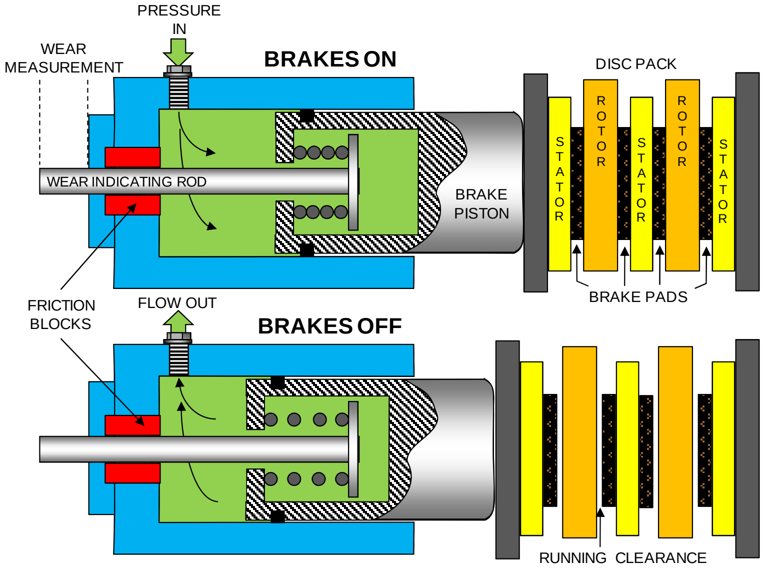


Figure 10-6 Brake Adjuster Operation

When brakes are applied the piston compresses the spring fully and then drags the wear indicating rod with it. The rod is dragged through tight friction blocks which trap and hold the rod at the applied position. The rod is now held in position by the friction blocks and when brakes are released the spring retracts the piston just enough to provide a running clearance.

As the brake unit wears the rod will get closer and closer towards the piston housing thus providing a method of wear measurement. Refer to Figure 10-7.

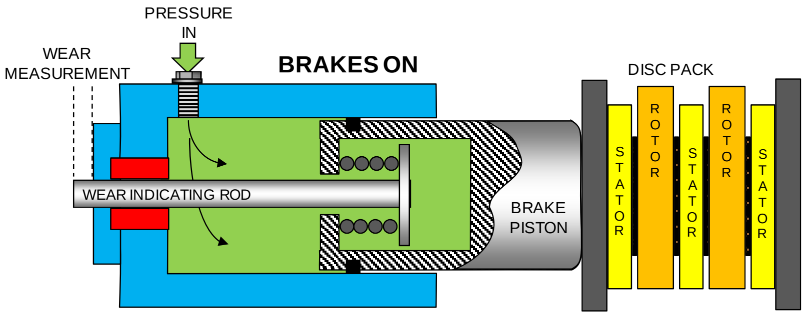


Figure 10-7 Brake Wear Measurement

BRAKE WEAR INDICATION

When brakes are applied and the disc pack is compressed the wear indicator pins or rods may be observed protruding from the back of the piston/cylinder assembly or the back of the brake adjuster or separately from the brake unit itself.

The measurement of pin protrusion determines the extent of brake wear and the Aircraft Operating Manual will specify the minimum measurement allowed.

Due to the design of the brake unit **brake wear can only be checked with brakes applied**. Refer to Figure 10-8.

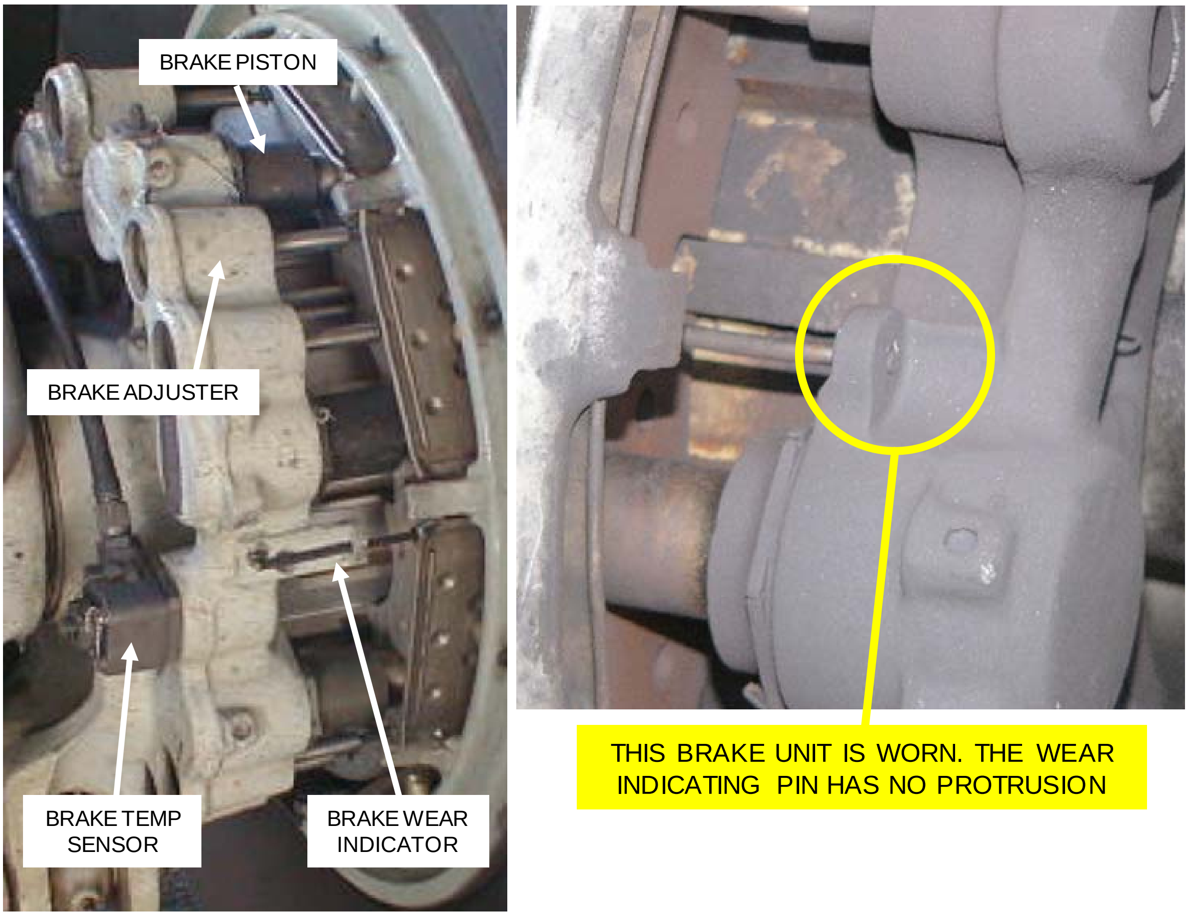


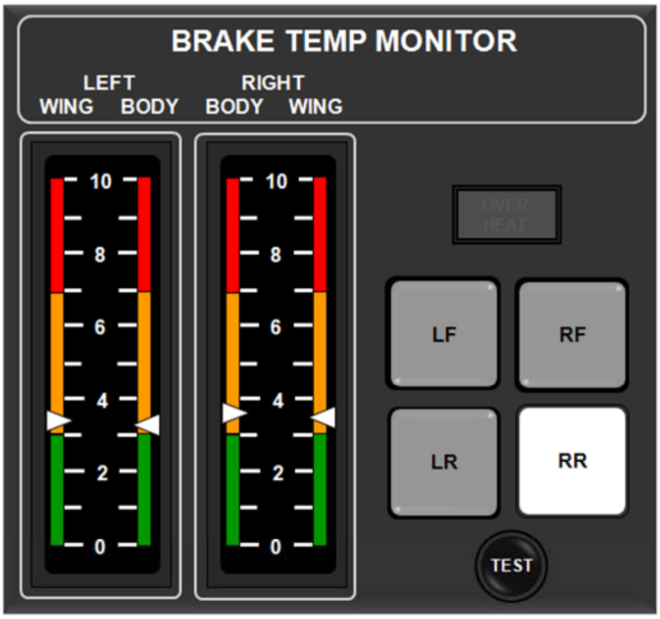
Figure 10-8 Brake Wear Indication

BRAKE TEMPERATURE MEASUREMENT AND INDICATION

Braking action converts kinetic energy into heat which is absorbed by the brake unit. The more heat that is absorbed increasingly reduces the stopping capability of the brake unit.

Individual brake units on large aircraft are monitored for temperature so that crews can determine if brakes are capable of safely performing an aborted take-off or if brakes are dangerously overheated.

Temperature sensors are located on each brake unit (Refer to Figure 10-8) and temperatures are displayed in the cockpit. Refer to Figure 10-9.



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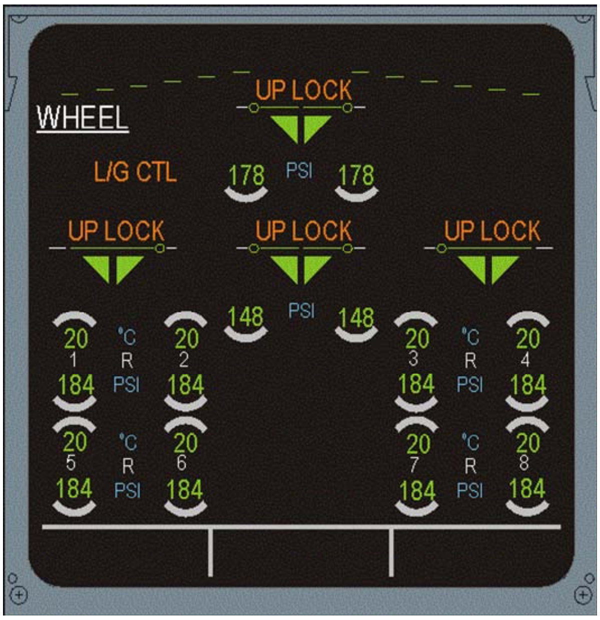

AIRBUS A330

Figure 10-9 Brake Temperature Indication

BRAKE UNIT LEAKS

As a general rule all types of brake units (on all types of aircraft) are to be considered unserviceable when any evidence of hydraulic fluid leakage is observed.

Hydraulic fluid which has lubricating properties will quickly reduce the braking efficiency of brake units if allowed to get into the disc pack. Additionally, some hydraulic fluids are flammable and may cause fires on very hot brakes.

BRAKE UNIT DEACTIVATION

For interest on large multi-wheel aircraft when brake units are worn beyond limits or leaking, it is possible to dispatch with individual brake units deactivated in accordance with the MEL.

Brake unit deactivation is carried out by maintenance when no spare brake units are available and the aircraft needs to be dispatched. The brake unit is hydraulically and electrically disconnected from the aircraft's braking system and performance penalties applied in accordance with the MEL.

BRAKE HYDRAULIC SYSTEMS

Aircraft braking systems vary from simple to complex depending on the size and weight of the aircraft. They are generally divided into two types;

- Unpowered brakes used on light aircraft, and
- Powered brakes used on medium to large aircraft.

Unpowered brakes rely on sufficient brake pressure being produced by the pilot pushing on the brake/rudder pedals to stop the aircraft. Pushing down on the top of these pedals, causes hydraulic fluid to be pressurised in the brake lines and pistons which applies the brakes.

The amount of foot pressure determines the braking force. Refer to Figure 10-10.

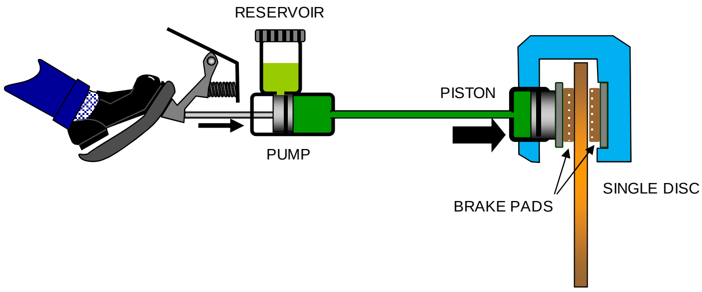

Figure 10-10 Simple Unpowered Brake System

Powered brakes on larger aircraft use main hydraulic system pressure to provide adequate pressure in the brake lines to apply the brakes. Main hydraulic system pressure, typically 3000 PSI, is difficult to control for braking and is usually reduced down to a more usable pressure on medium sized aircraft.

There is also a need for the pilot to be able to hold the brakes partially applied without there being a build-up of pressure in the brake lines, causing a lock-up of the wheels. The brake control or modulating valve allows the pilot to apply a consistent brake pressure within the pressure range of zero to maximum PSI.

The pilot schedules the amount of braking required by varying the amount of toe pressure he applies on the pedal which operates the brake modulating valve. The modulating valve maintains the scheduled brake pressure by releasing excess fluid to return. Refer to Figure 10-11.

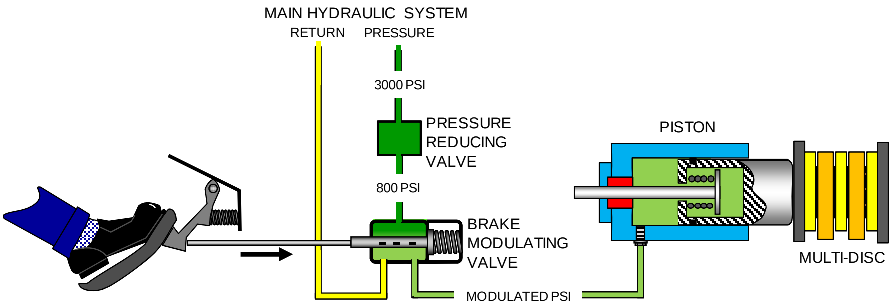

Figure 10-11 Powered Brake System

One problem with all hydraulically operated brake systems is there is little or no feedback to the pilot as to how hard he is applying the brakes, so great care must be taken when applying power brakes. Powered brake systems normally incorporate an anti-skid system which reduces the risk of wheel lock-up and consequent tyre blow-out due to over-braking.

POWERED BRAKE SYSTEM CONFIGURATIONS

Large transport aircraft normally have triple redundancy for wheel brakes and on older aircraft the brake systems were configured and named as follows;

- Normal brakes (using one hydraulic system)
- Alternate brakes (using another hydraulic system), and
- Emergency brakes (using a compressed air bottle).

Modern large transport aircraft use the following configuration and terminology;

- Normal brakes (using one hydraulic system)
- Alternate brakes (using another hydraulic system), and
- Reserve brakes (using another hydraulic system or reconfiguring the Alternate System)

POWERED BRAKE SYSTEM OPERATION

The brake system receives system pressure from at least two of the aircraft hydraulic systems. On some aircraft system pressure is reduced as full pressure makes braking control difficult on lighter aircraft.

The two system pressure sources are called **NORMAL** and **ALTERNATE** brakes. A third hydraulic source may be added which is called **RESERVE** brakes. Refer to Figure 10-12.

Some older aircraft use a pneumatic air bottle as the third source and this is referred to as **EMERGENCY** brakes.

Typically the normal and alternate brakes have the Brake Accumulator available as a limited source of hydraulic power should either source system fail.

The heart of the brake system is the Brake Control Valve. These valves are actually pressure modulating valves, which proportion the amount of fluid sent to the brake units. They are connected to the pilot's rudder control pedals either electrically or mechanically. There are always two brake control valves, one connected to the left rudder pedal and one connected to the right. This allows the pilot to steer the aircraft using differential braking should nose wheel steering fail. Some aircraft have additional brake control valves (left and right) to operate the reserve brake system.

On aircraft fitted with autobrakes an additional valve replaces the function of the brake control valves. This valve is called the Autobrake Control Valve and will be described later in this Chapter.

Downstream of the brake control valves are the Anti-Skid Control Valves which control the flow of fluid to the brake units. They reduce pressure slightly when an impending skid is detected. Anti-skid systems will be described later in this Chapter.

Downstream of the anti-skid control valves, Fuse Valves are typically incorporated to protect from total fluid loss if a brake hydraulic line fails. Fuse valves are described in Chapter 3 Hydraulic Systems.

Lastly and just before the brake units, Shuttle Valves are fitted to allow an automatic changeover of pressure sources from normal/alternate system to a reserve or emergency system. Shuttle valves are described in Chapter 3 Hydraulic Systems.

Typically included within a large aircraft brake system is the capability to stop the main wheels before retraction and to apply a park brake when the aircraft is at rest. These sub-systems are described later in this Chapter.

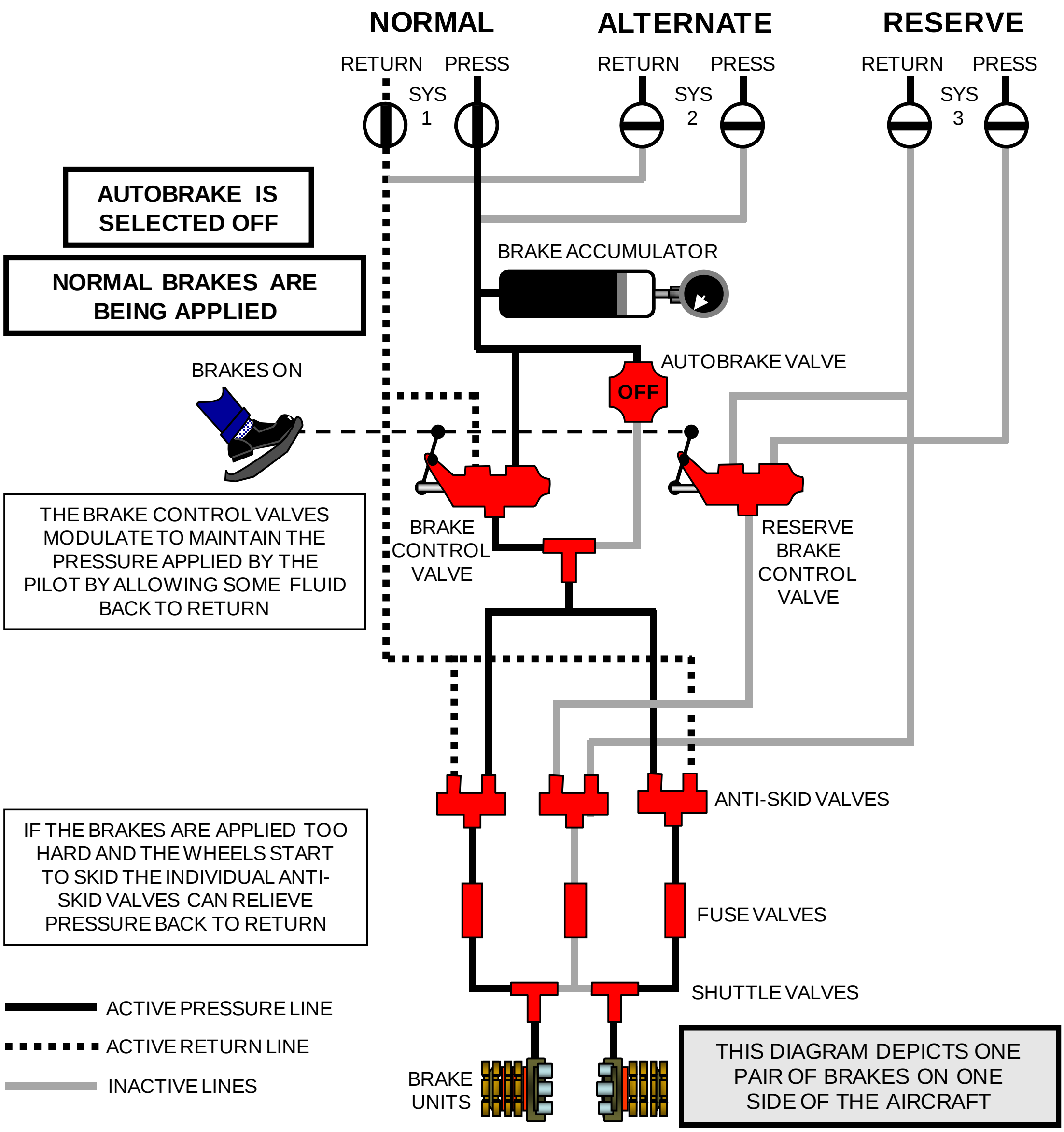

Figure 10-12 Normal Brakes Operation

NOTE

For simplicity the schematic diagram above and subsequent schematics do not show the full brake system. The source hydraulic systems, the brake accumulator and the autobrake valve are common to both sides of the aircraft. One pedal is shown and the other pedal will obviously operate another two brake control valves for the opposite side of the aircraft. Only one pair of the many pairs of brake units is shown.

If the hydraulic system that supplies pressure for NORMAL brakes fails the crew can select the ALTERNATE brake source. On very modern aircraft this will occur automatically when the normal system fails.

The alternate hydraulic source simply replaces the normal source and the braking system retains full capability including brake accumulator, anti-skid and autobrake functions. Refer to Figure 10-13.

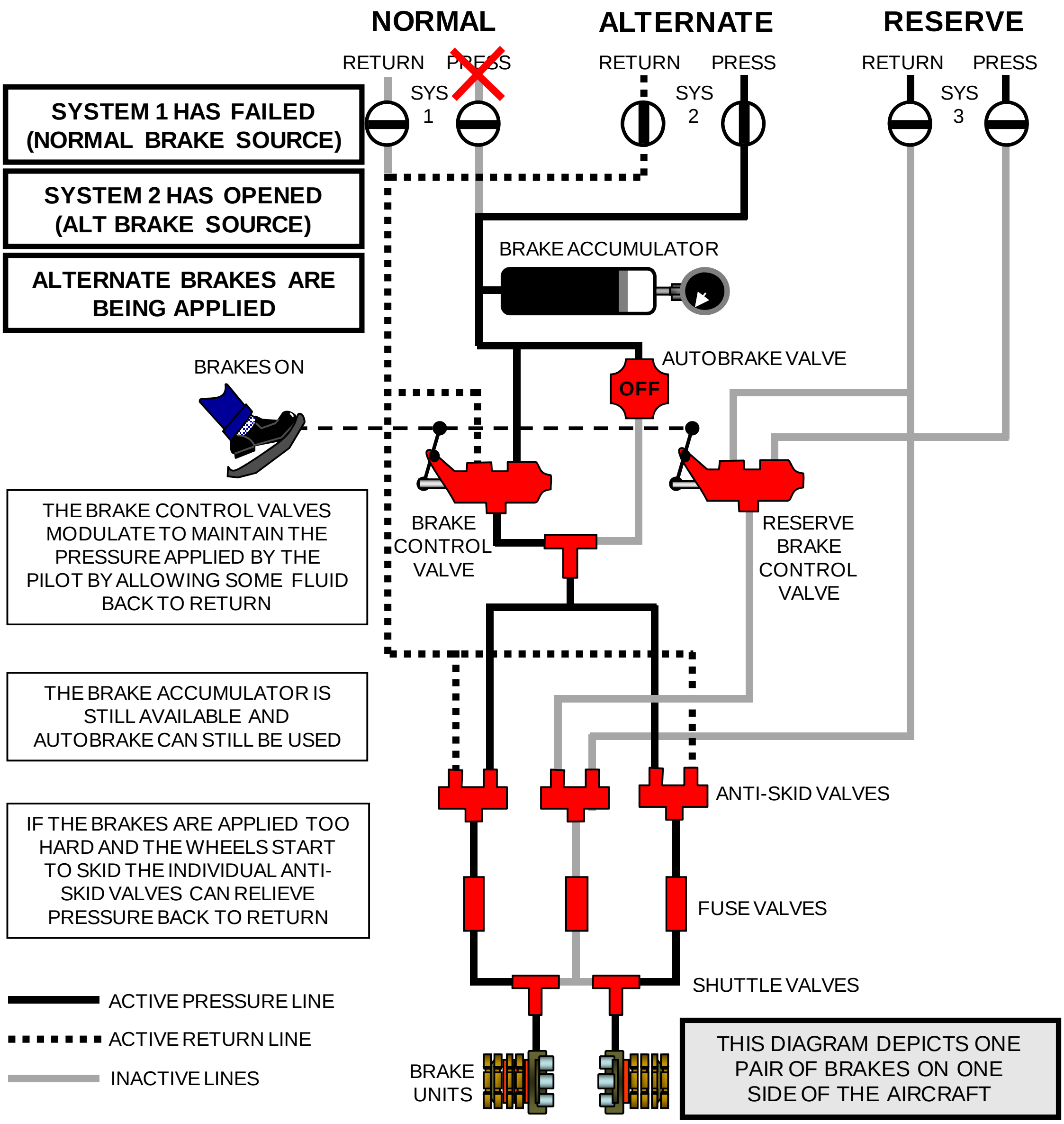

Figure 10-13 Alternate Brakes Operation

If both the hydraulic systems that supply pressure for NORMAL and ALTERNATE brakes fail the crew can select a third source, reserve brakes. On very modern aircraft this will occur automatically when the normal and alternate systems fail.

The reserve system, which is the last option available to bring the aircraft to a stop, has a degraded capability in comparison with the previous systems.

The brake accumulator and autobrake functions are lost and anti-skid protection is not provided for individual wheels, but pairs of wheels (bogies). Refer to Figure 10-14.

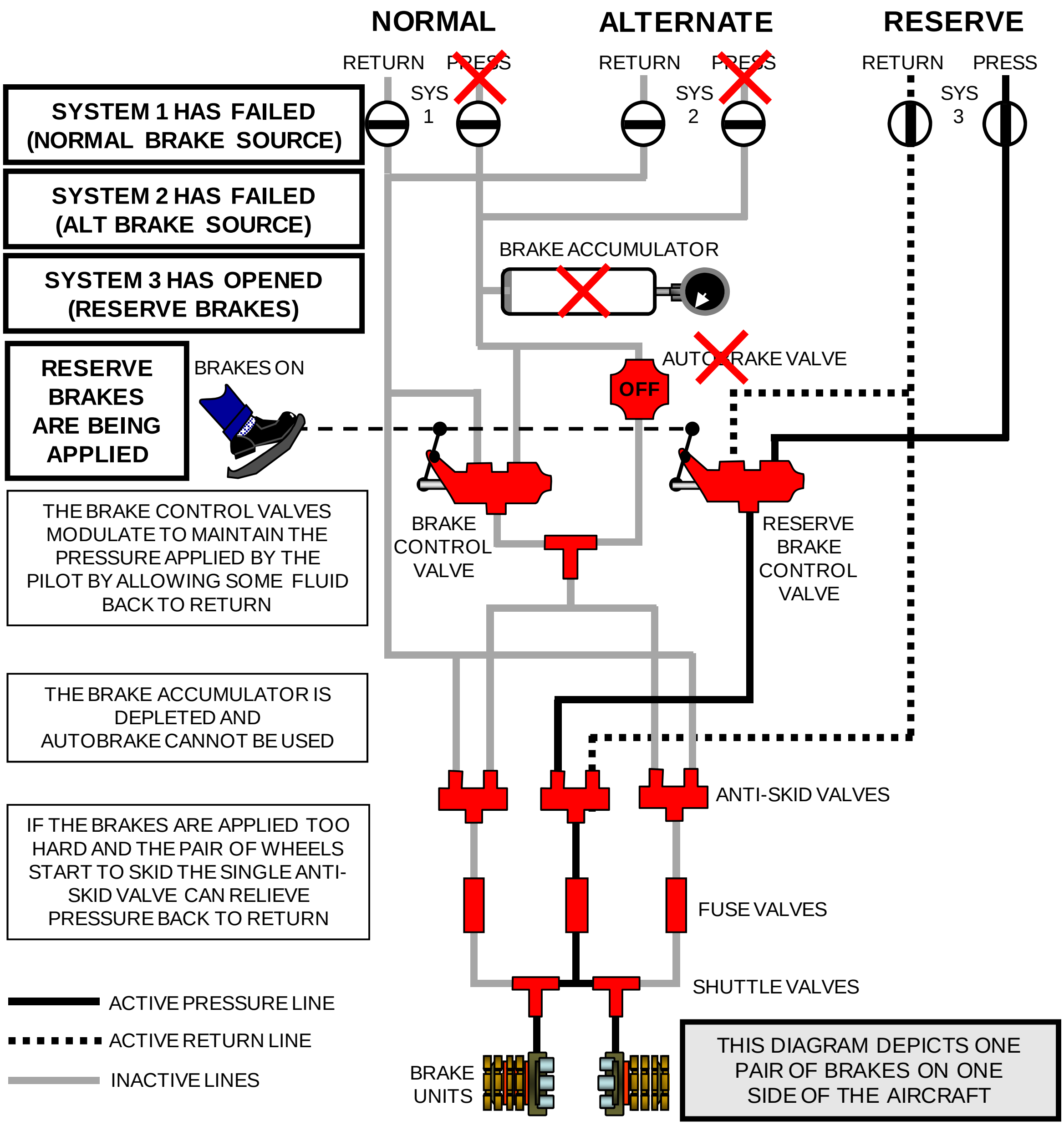

Figure 10-14 Reserve Brakes Operation

Older aircraft with only two main hydraulic systems utilise a stored bottle of compressed air instead of the reserve hydraulic system.

Normally referred to as EMERGENCY brakes a hand operated control is actuated in the cockpit which allows compressed air to apply the brakes via the shuttle valves located just before the brake units.

Emergency brake systems like this cannot differentially steer the aircraft and of course have no autobrake or anti- skid capability. Additionally, only a limited number of brake applications are available before the compressed air is exhausted.

Refer to Chapter 4, Pneumatic Systems, Page 2, Figure 4-2 for information regarding an Emergency Brake Valve.

Emergency brake systems require maintenance action after use to replenish the stored air bottle and bleed the brake units of the introduced air.

ANTI-SKID SYSTEM

On large multi wheel aircraft equipped with power brakes the pilot has little or no feedback during brake application which could lead to wheel lockup and tyre skid resulting in tyre blowout.

To assist the pilot to attain maximum braking effectiveness during adverse weather or runway conditions without blowing tyres due to over-braking, an anti-skid system is fitted.

This system prevents the aircraft main wheels from skidding by monitoring the speed of each wheel and modulating the hydraulic pressure to individual wheel brake units thereby achieving maximum braking capability.

The main components of the anti-skid system are;

- speed transducers in each main wheel axle which measure wheel speed,
- anti-skid valves, one for each wheel, which control the pressure to the brake units,
- the system control unit which monitors and controls the operation of the anti-skid valves,
- control switches in the cockpit which allow testing and ON or OFF selection, and
- annunciator lights to alert the crew of anti-skid malfunction.

When the pilot applies heavy braking, each wheel's rate of deceleration is compared to a programmed rate of deceleration. If the rate is excessive and the wheel is about to skid, the control unit will send a release signal to the respective anti-skid valve.

The anti-skid valve releases some of the applied braking pressure by returning fluid back to the reservoir, thus slightly reducing the brake pressure to that applicable wheel, preventing the wheel from coming to a full stop and skidding. Refer to Figure 10-15.

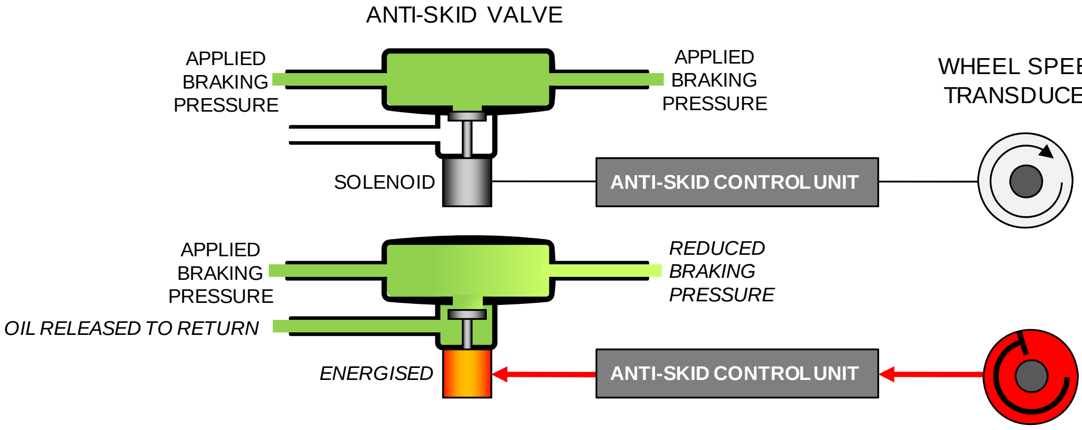

Figure 10-15 Anti-skid Operation

This then allows that wheel to spin back up and the correction signal is removed when the wheel returns to an on speed condition during the deceleration phase of the aircraft.

Under maximum braking or in adverse runway conditions the anti-skid system continuously seeks a level of correction which produces maximum braking efficiency which is just short of skidding.

During low speed taxy and particularly when the aircraft is approaching the parking position the anti-skid system must be disabled otherwise the aircraft cannot be braked to a full stop.

Most aircraft incorporate a low speed lockout which automatically disables anti-skid whenever the aircraft speed falls below approximately 15 kts.

Anti-skid may be also turned OFF at any time by the pilot.

The anti-skid system normally provides protection for the Normal, Alternate and Reserve brake systems and incorporates the following three features;

- touchdown protection
- normal skid protection, and
- locked wheel protection.

Touchdown protection, which provides a full release signal to all wheel brakes ensuring the brakes are in the released state at touchdown. This protection is overridden to allow normal skid protection as soon as wheel spin-up has occurred.

Normal skid protection becomes operational after wheel spin-up (approximately 35 kts) and protects each individual wheel from skidding by reducing the brake pressure acting on the individual brake unit fitted to that wheel.

Locked wheel protection is always operational and will release pressure to any wheel that enters a deep skid or fails to spin-up after touchdown.

AUTOBRAKE SYSTEM

The autobrake system is designed to relieve pilot workload by eliminating the need to manually operate the brake pedals.

For landing the autobrake automatically applies brakes after touchdown and maintains a selected deceleration rate during the landing roll to bring the aircraft to a complete stop.

For take-off, if a rejected take-off is conducted, to automatically apply brakes at a maximum effort rate to bring the aircraft to a complete stop.

The pilot can override the autobrake system at any time and revert to manual brake pedal use.

In large aircraft that are fitted with autobrake, the system is normally available with either the normal or alternate brake systems but not available using reserve or emergency brakes.

Although the anti-skid is a separate system its correct functioning is vital to the operation of the autobrake to ensure that wheels do not skid when autobrake is in use.

Autobrake is disabled if the anti-skid system is switched OFF or is inoperative.

The main components of the autobrake system are;

- speed transducers in each main wheel axle which measure wheel speed, or an inertial ground speed input to the control unit
- an autobrake valve, which controls the pressure to the brake units,
- the system control unit which monitors and controls the operation of the autobrake valve,
- switches in the cockpit which allow programming of the deceleration rate and OFF selection, and
- annunciator lights to alert the crew of autobrake malfunction.

Prior to landing or take-off the pilot ARMS the autobrake system by selecting the desired deceleration rate on the control panel in the cockpit.

For landing, the switch is set to a selection between 1 and MAX AUTO or LO, MED or MAX. For take-off the switch is set to RTO or MAX. Refer to Figure 10-16.

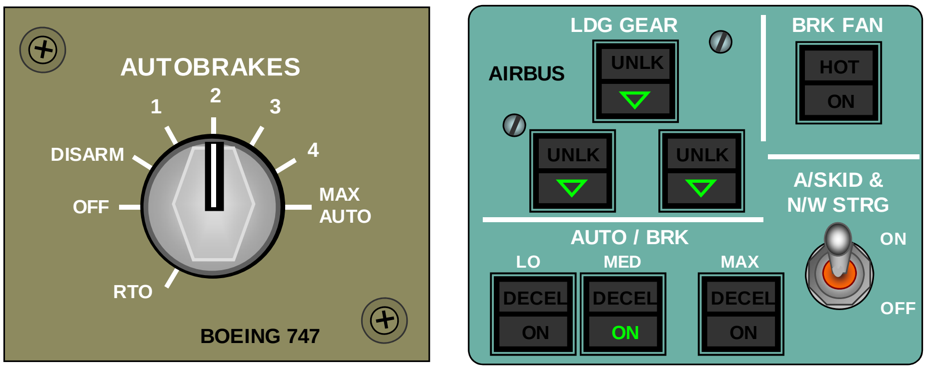

Figure 10-16 Autobrake Selection

After touchdown or when a take-off is aborted the brakes will apply automatically and maintain the selected deceleration rate. The system uses wheel speed signals from the anti-skid system and compares the speed to the selected rate to compute the correct hydraulic pressure to the brake units. The autobrake hydraulic control module then modulates brake pressure equally to all brake units.

Modern aircraft are designed so that as engine reverse thrust is applied, autobrake pressure reduces to maintain the selected deceleration rate. Refer to Figure 10-17.

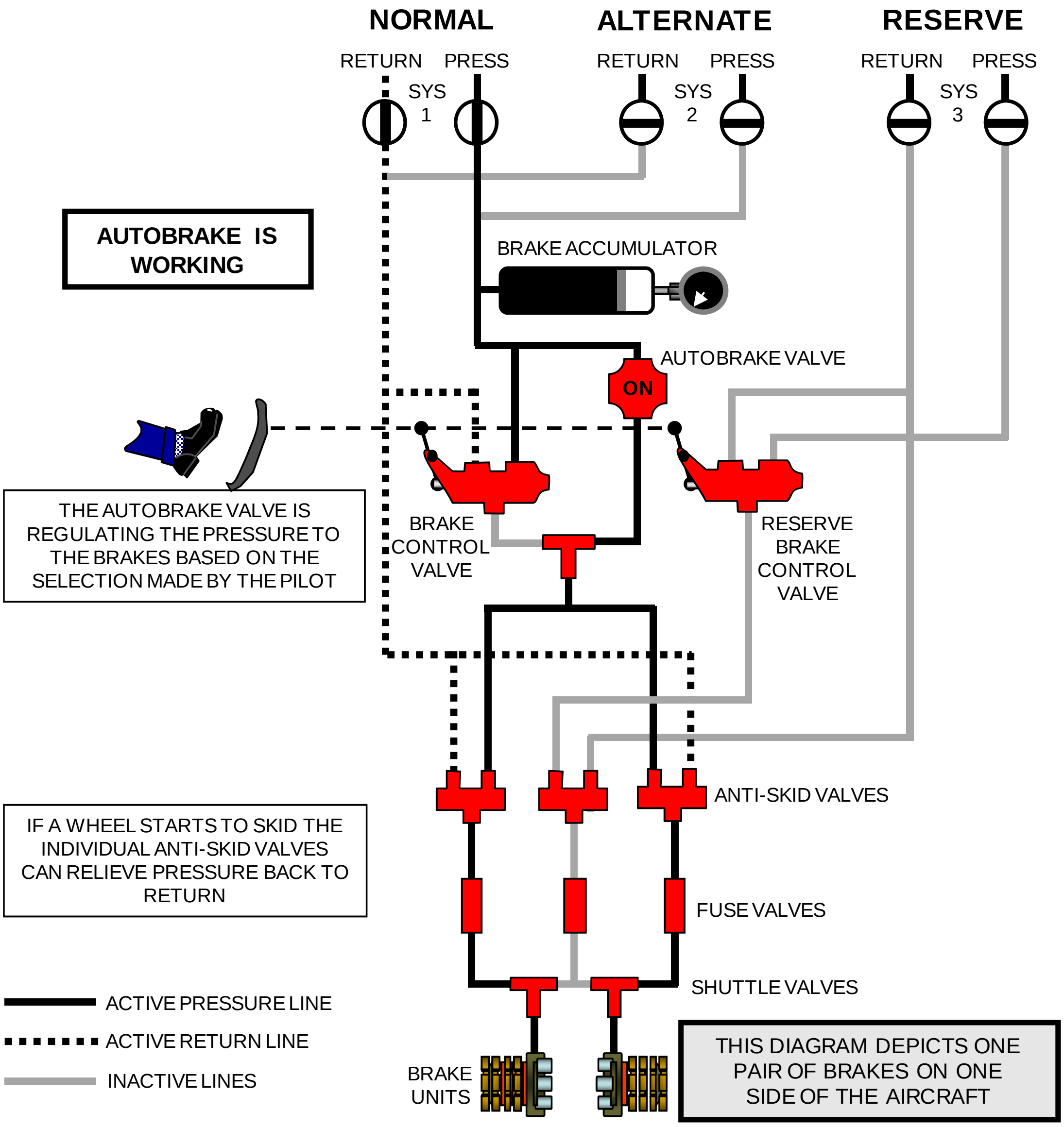

Figure 10-17 Autobrake Operation

The autobrake system operates in the following way;

For take-off, the autobrake is ARMED by selecting RTO or MAX before thrust is advanced for take-off. Autobrake will begin working when;

- the aircraft has achieved a speed of approximately 70 to 80 kts, and
- the thrust levers are retarded to idle.

For landing, the autobrake is ARMED by selecting 1 thru MAX AUTO or LO or MED before touchdown. Autobrake will begin working when;

- the aircraft main wheels are on the ground (WoW logic),
- the main wheels have spun up, and
- the thrust levers are closed.

As the aircraft reduces to taxi speed the pilot ceases autobrake operation and reverts to manual braking. This is normally done by manually operating the brake pedals which causes an automatic DISARM. The autobrake is then selected OFF.

For safe operation and contingency the autobrake will automatically DISARM whenever;

- either brake pedal is applied,
- any thrust lever is advanced after landing,
- if the spoiler lever is moved to the DOWN position after they have been deployed on the ground,
- an anti-skid fault is detected or anti-skid selected OFF,
- an autobrake fault is detected or autobrake selected OFF or DISARM, or
- there is a loss of hydraulic system pressure.

When a DISARM occurs an autobrake caution light will ‘flash’ to alert the crew of this condition.

PARK BRAKE SYSTEM

Most aircraft are fitted with a parking brake system. This is used to prevent the aircraft from moving when parked and particularly during engine start when idle thrust may be enough to move the aircraft forward.

Large transport aircraft will have an associated annunciation indicating when the park brake is ON and a gauge showing the park brake pressure available from the brake accumulator. The park brake ON is also typically part of the aircraft’s configuration warning system for take-off.

The system generally consists of a handle or lever in the cockpit, usually on the Captains side, which operates the normal braking system in one of the following ways.

- mechanically locking the same linkages (brakes applied) that are normally operated by the pilot when he pushes on the top of the pedals.
- a cable system that is connected to a park brake control valve which locks brake pressure in the brake lines in a similar manner to the normal system.

Park brake pressure is maintained by the brake accumulator after engines are shut down and the normal system pressures have depleted.

To apply parking brake, both pedals are fully depressed then the parking brake lever is selected and the pedals are released while the lever is held. With the pedals now locked in the brakes applied position the park brake handle can be released.

To release the park brake, depress the pedals firmly to release the lock. Refer to Figure 10-18.

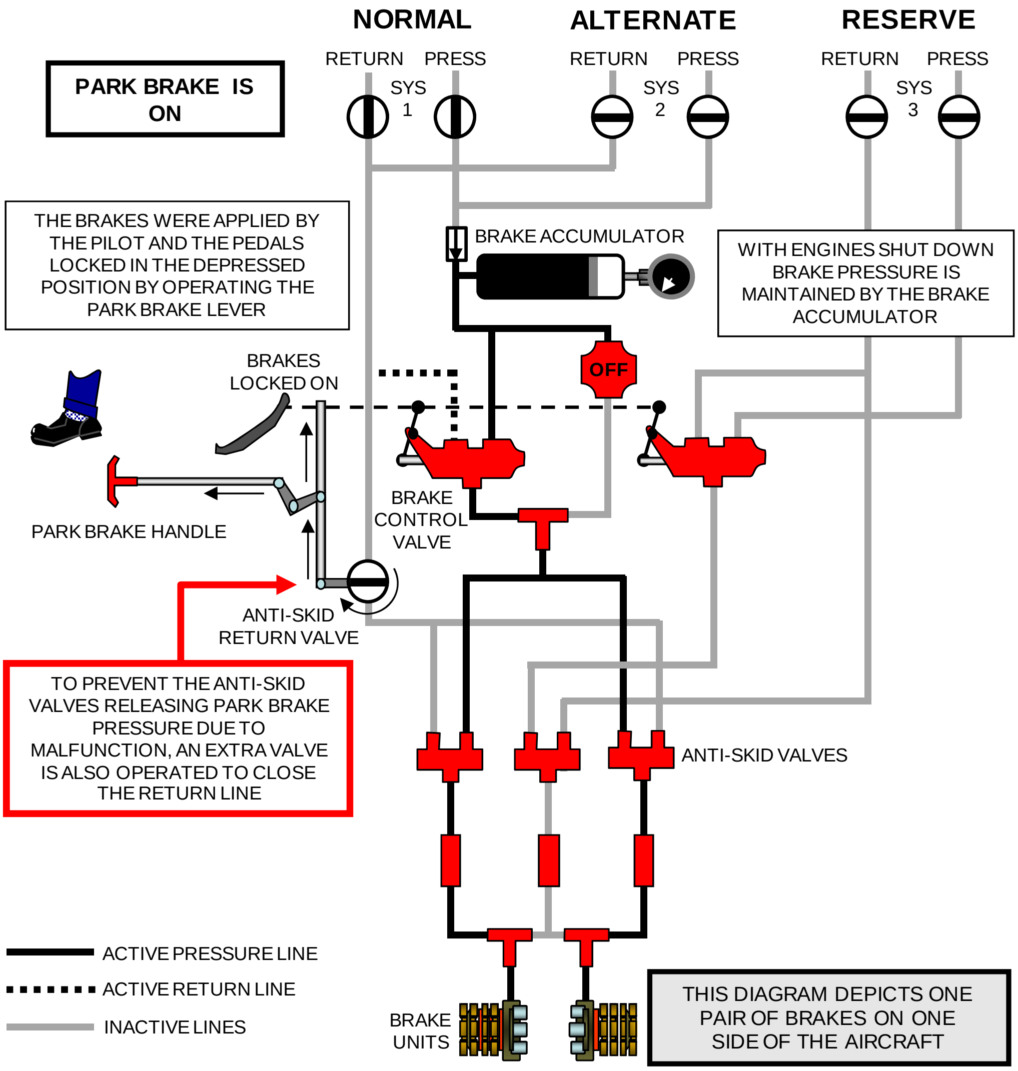

Figure 10-18 Park Brake Operation

When the park brake is applied the possibility exists that the anti-skid valves may inadvertently sense a stopped wheel and release brake pressure. This should not occur due to the low speed lockout function of the anti-skid, however, an additional shut-off valve is provided to close the anti-skid return line to ensure park brake pressure is maintained.

The brake accumulator on most aircraft will maintain brake pressure for up to approximately 24 hrs, however, it is normal practice to fit wheel chocks and then release park brakes when an aircraft is parked.

INFLIGHT BRAKE SYSTEM

Large jet transport aircraft normally retract the main gears laterally toward the fuselage and the gyroscopic effect of the rapidly spinning wheels can exert a highly resistive force to retraction. To overcome this main gear wheels have to be braked to a stop before lateral retraction begins.

If the pilot was to apply the brakes after take-off and prior to retraction, the wheels would stop very rapidly from around 130 kts, with the likely result being the wheels separating from the axles. This is due to the fact that the wheels are unloaded from the weight of the aircraft, the lack of feel in the brake system and full system pressure being used.

An automatic retraction braking sub-system is built into the brake system to apply a reduced hydraulic pressure to the brake units to stop the spinning wheels before retraction begins.

Automatic retraction braking occurs when the landing gear lever is selected to the UP position. Whilst the large main gear doors are opening, landing gear up hydraulic pressure is also directed to the Brake Control Valve which applies a reduced brake pressure to stop wheel rotation.

When all gears are up and locked, retraction braking is terminated either automatically or by positioning the gear lever to OFF.

As nose gears typically retract longitudinally and are not normally fitted with brake units, retraction braking does not apply. Nose gear wheels are typically brought to a stop by friction pads contacting the tyres as the gear locks up.

BRAKE SYSTEM INDICATIONS AND WARNINGS

The normal and abnormal indications associated with braking systems fall into the following groups;

- the brake hydraulic system(s),
- the anti-skid, autobrake and park brake,
- the brake unit temperatures,
- the brake unit wear, and
- the main gear wheel well fire detection on some aircraft.

Brake hydraulic system pressure may be depicted on a gauge along with the hydraulic pressure available from the brake accumulator. Some aircraft also depict the brake accumulator gas (nitrogen) pressure as well. Refer to Figure 10-19. Obviously the hydraulic systems that supply brakes will have their own pressure indications and failure alerts.

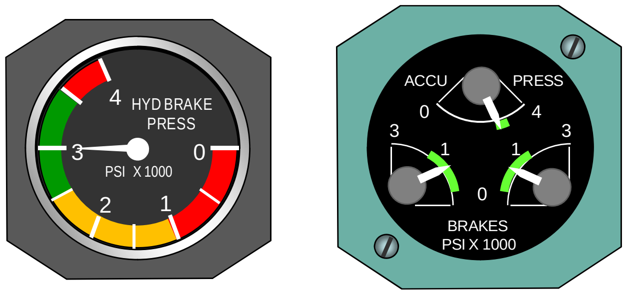

Figure 10-19 Brake Pressure Indication

Anti-skid, autobrake and park brake sub-systems will have annunciators or alerts to warn of failure, disarmament or configuration.

Brake unit temperatures are displayed as well and are used by the crew to predict possible tyre deflation and to determine required cooling times for the next departure. Brake temperature management and cooling procedures will be described later in this Chapter.

Brake unit wear is checked visually using the brake wear indicator pins described earlier.

Wheel well fire detection is provided on some large transport aircraft and will be described later in this textbook in Fire Detection Systems.

BRAKE TEMPERATURE MANAGEMENT

Already mentioned several times, the efficiency of the brake system is relative to the temperature of the brake units, and their ability to dissipate heat.

Most commercial aircraft have a brake temperature indicator to allow the pilots to observe the current temperature of the brakes. This will usually consist of a set of indicators calibrated into three colour coded zones, SAFE (green), MARGINAL (amber) and UNSAFE (red). Additionally it is usual for an annunciator light to illuminate when any brake unit has reached an overheat condition. Refer to Figure 10-20.

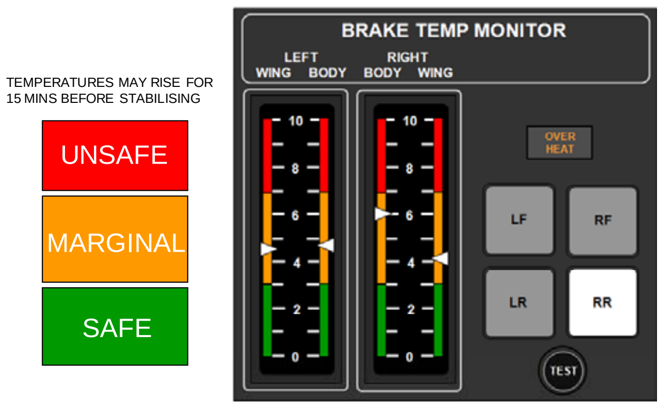

Figure 10-20 Brake Temperature Indicators

To prevent the possibility of brake overheat, the pilot should adhere to the recommended braking techniques and ensure cooling procedures are considered.

Brakes units may overheat due to the following reasons;

- high energy stops,
- prolonged taxying, and
- short flight sectors without adequate in-flight cooling time.

Overheated brakes can impact on turn-around times as take-offs should not be attempted with hot brakes. The Aircraft Operating manual will provide guidance for cooling times and maximum allowable brake temperatures for take-off. Refer to Figure 10-21.

BRAKE COOLING GUIDANCE

PROVIDED THE HOTTEST BRAKE IS LESS THAN THE TEMPERATURE LISTED, THE BRAKES WILL BE LESS THAN 300°C AT PUSHBACK.

MINS TO PUSHBACK	5	10	15	20	25	30	35	40	45	50	55	60	65
MAX TEMP°C	300	315	330	345	360	380	400	420	440	465	490	520	550

IF TEMPERATURES ARE GREATER THAN 500°C USE COOLING.

Figure 10-21 Airbus Brake Cooling Guidance

For more accurate measurement of absorbed heat energy and predictions for cooling times some aircraft provide comprehensive brake energy graphs or tables to calculate the heat energy absorbed after landing or a rejected take-off. Refer to Figure 10-22.

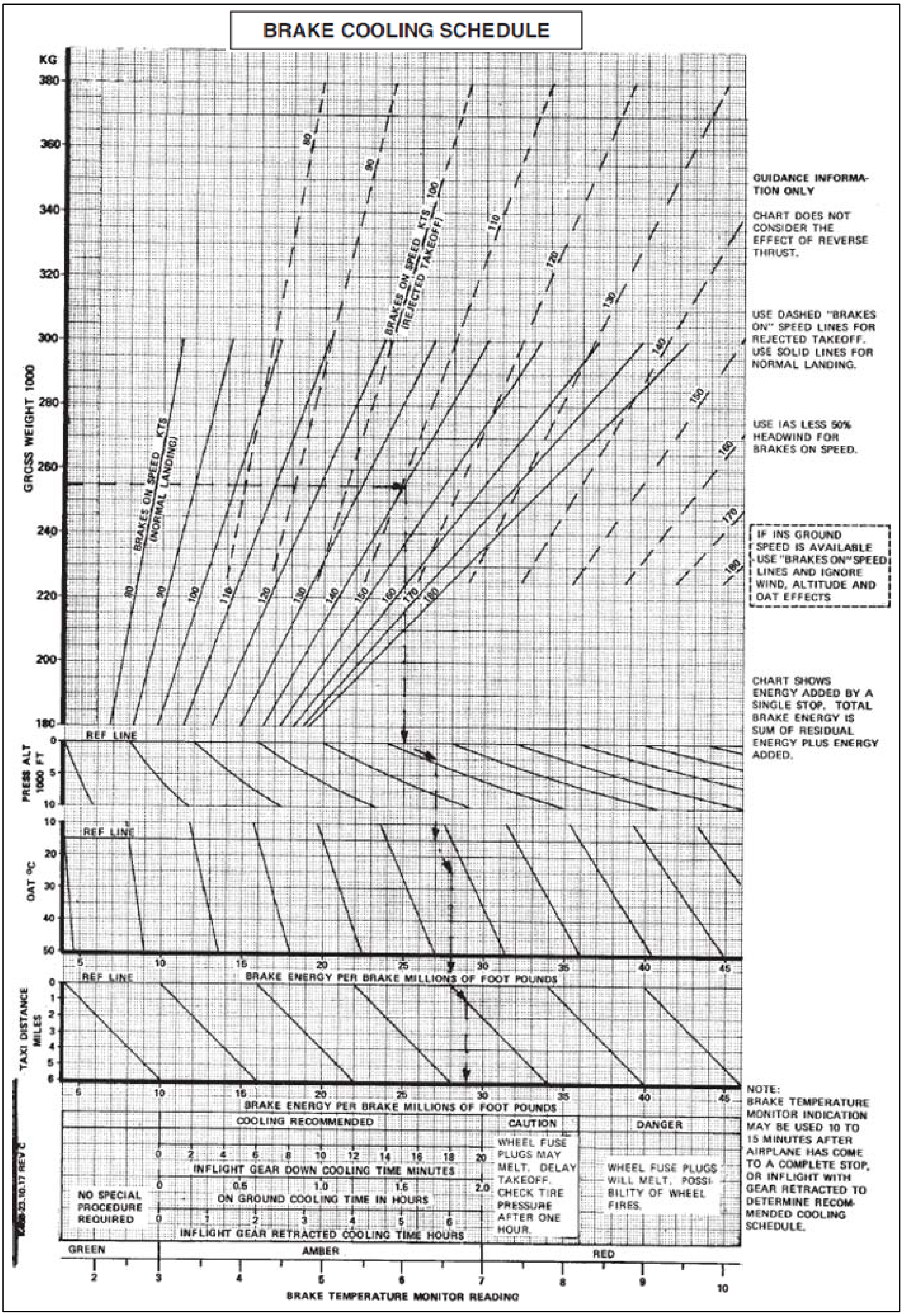

Figure 10-22 Brake Energy Chart

The brake energy chart provides a means to approximate the heat energy levels in the brakes. The chart covers both a normal landing with normal braking effort (solid weight lines) and a rejected take-off (dashed weight lines) which represent maximum braking effort. The use of reverse thrust will substantially reduce the resultant brake energy levels.

The bottom of the chart aligns with the colour codes of the brake temperature indicator and is used to determine brake capability, cooling times and overheat procedures.

- The **GREEN range** indicates that a maximum effort stop could be made and the wheel fuse plugs should not melt.
- The **AMBER range** indicates that a maximum effort stop may melt the wheel fuse plugs and that cooling is recommended.
- The **RED range** indicates the next stop will melt the wheel fuse plugs and wheel fires are possible.

Take-offs should not be commenced until the indicator is below the top amber limit (7.0 Units) with the BRAKE OVHT caution light extinguished.

BRAKE COOLING PROCEDURES

Brake cooling time with the aircraft parked or in flight with the gear retracted, is relatively long. Cooling time can be substantially reduced by leaving the gear extended in flight. If more than one stop is being made without allowing time for brake cooling, the brake heat levels will be cumulative. The use of excessive braking during taxi operations will increase the level of brake heat. The brake temperatures will continue to rise after a braking stop, for as much as 15 minutes.

Brake cooling on the ground with the aircraft parked should be conducted with park brakes released and the aircraft chocked. If faster brake cooling is required some airlines may fit specially shaped containers over the gear trucks and force cold air over the brake units.

For interest very modern aircraft such as the Airbus have brake cooling fans integrally mounted in the main wheels. Under no circumstances should liquid coolants (water) be used to cool brakes as undetected cracking may occur within the brake assemblies.

BRAKE FIRES

Generally speaking overheated brakes produce large amounts of smoke before a fire begins and if observed in time fires can be prevented.

If brakes are smoking or on fire and there is a necessity to approach the wheel, this should be done from the front or rear of the wheel only, as wheel explosions due to excess wheel temperatures will cause metal and rubber to be displaced to both sides of the wheel assembly. Normally this risk is reduced as wheel fuse plugs should have deflated the tyres.

No attempt should be made to extinguish a wheel fire by using any cooling type extinguishing agent, as shattering of the wheel is likely to result. If an attempt to put the wheel fire out must be made, a dry powder agent extinguisher should be used.

This normally applies to smaller aircraft as airport fire services are responsible to extinguish brake fires on large transport aircraft.

WHEEL BRAKING TERMINOLOGIES AND DEFINITIONS

The following table defines old and/or common terms that you may encounter with reference to brakes and the associated sub-systems. Refer to Figure 10-23.

TERM REFERRED	DEFINITION
Brake linings	Is the common term used to describe the pads of fibrous friction material that contact the steel disc(s) when the brakes are applied.
Brake puck	Another common name used to describe the brake adjusters
Brake Fuse	A hydraulic Fuse Valve which closes off hydraulic oil flow to the brakes if a serious leak occurs. Each Brake Unit has its own Fuse Valve.
Brake De-boosters	Brake De-boosters are used on some brake systems to reduce the amount of pressure used to apply the brakes. If the normal operating system pressure was 3,000 psi it would be very difficult to control the braking effect on a lightweight aircraft.
Brake deactivated	When a brake unit is hydraulically disconnected and sealed off from the aircraft braking system, usually because it is worn or leaking. Aircraft may be operated with some brakes deactivated in accordance with the MEL.
Brake drag	Also known as a “dragging brake”. Brake units that have not correctly released causing smaller aircraft to tend to steer away from centre due to the extra friction on one side. On large aircraft will be detected by a higher temperature indication than the other units
Brake fade	As the heat energy caused by braking is absorbed into the brake units the efficiency of braking action diminishes or fades. When the brake unit can absorb no more heat energy the brakes will become inoperative.
Brakes spongy	On some aircraft one brake pedal may feel softer than the other when depressed or both pedals feel softer than normal to an experienced operator. This normally means that the brake lines have air in them and need “bleeding”.
Drum Brakes	Are a type of brake used on some cars. This type is not used on aircraft.
In Flight Brakes	Another name for automatic retraction braking.

Figure 10-23 Wheel Braking Systems Terms and Definitions

WHEEL BRAKING SYSTEM QUESTIONS

The following questions will examine your understanding of the wheel braking systems. The answers may be found in the text or diagrams of this Handbook.

1. The most common type of brake units used on small light aircraft are;

a. single disc carbon brake units.
b. multi-disc steel brake units.
c. single disc steel brake units.

2. The brake adjusters are fitted;

a. in the pressure hydraulic lines to the brake unit.
b. in the return hydraulic line from the brake unit.
c. on the brake unit adjacent to the pistons.

3. Autobrake will begin applying the brake when;

a. it is selected to the required deceleration rate.
b. the wheels have begun rotating.
c. when reverse thrust is selected.

4. On large commercial aircraft inflight or retraction braking is applied;

a. automatically when gear is up.
b. automatically when gear is selected up.
c. by the pilot after take-off when gear is up.

5. Indicated brake temperatures in the amber range means;

a. brakes are warm but still safe.
b. no special procedures are required unless at the top of the amber range.
c. brake cooling is recommended.

6. Brake deactivation means;

a. a brake unit has been disabled from use.
b. taxi speed is below brake lockout speed.
c. anti-skid has been selected OFF.

7. A brake De-booster is;

a. a valve to reduce brake return pressure.
b. a valve to increase brake application pressure.
c. a valve to reduce brake application pressure.

8. Protection against exploding wheels with overheated brakes is due to;

a. awl vents in the tyres.
b. fuse plugs fitted to the wheels.
c. stainless steel heat shields insulating the tyre.

9. Anti-skid systems normally cease operation when;

a. autobrake disarms.
b. the aircraft is almost at a stop.
c. the aircraft has come to a stop.

10. The brake accumulator gauge in the flight deck is used to indicate;

a. the brake pressure available from the accumulator.
b. the pressure of the brake source hydraulic system.
c. the pressure of the nitrogen charge in the accumulator .

11. With the park brake applied;

a. brake wear cannot be checked.
b. brake wear can be checked.
c. brake temperature is not valid.

12. The rotating elements of a multi disc brake are the;

a. brake adjusters.
b. stator discs.
c. rotor discs.

13. In order to prevent the wheels locking on touchdown;

a. the anti-skid system is inoperative during the landing approach.
b. the anti-skid is active on touchdown.
c. the wheels are spun up prior to touchdown.

14. When the parking brake is applied;

a. the brake accumulator maintains brake pressure.
b. the system accumulator maintains brake pressure.
c. the in-flight brake system is used to apply the brakes.

15. Emergency brake pressure is normally supplied by;

a. the standby hydraulic system.
b. pumping the brake pedals.
c. a pneumatic bottle.

16. Brake wear is indicated by;

a. a pin which protrudes further as wear increases.
b. a pin which protrudes less as wear increases.
c. a pin which only protrudes when wear reaches a preset limit.

17. Flight deck brake caution indications are;

a. high temperature and anti-skid failure.
b. EDP and/or ADP pressure failure.
c. all of the above.

18. Autobraking will operate;

a. at any engine power, provided aircraft weight is on the wheels.
b. at any engine power, provided the anti-skid system is operative.
c. only when the engine thrust levers are at IDLE.

19. The autobrake RTO option;

a. can only be selected on the ground.
b. can only be selected in conjunction with landing flap.
c. can be selected at any time provided the engine thrust levers are at IDLE.

20. The maximum braking action on a dry runway surface is achieved by;

a. autobrake selection of MAX AUTO with anti-skid operable.
b. pilot operation of the pedals with anti-skid operable.
c. autobrake selection of RTO with or without anti-skid operable