DASS Information Paper

JORDAN CIVIL AVIATION REGULATORY COMMISSION

DEPARTMENT OF AIRPORT SAFETY & STANDARDS

Rubber Removal Techniques

Technical Information Paper

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INTRODUCTION

The most significant reason to be concerned about the buildup of rubber deposits is SAFETY. If you operate an airport with large jet aircraft, you will eventually have a deterioration of the pavement skid-resistance, or a reduction in friction coefficients, which is a problem for aircraft tires to grab and safely stop the aircraft. One of the main causes of ground based accidents is a runoff event. When an aircraft skids off of the runway, whether the pilot is unable to brake soon enough upon landing or when having to abort a takeoff, the pavement surface will be carefully examined as a contributing factor. There are several factors that contribute to surface deterioration, but the one that is easy to recognize, simple to correct and relatively inexpensive to do is AIRFIELD RUBBER REMOVAL.

MICROTEXTURE *and* MACROTEXTURE, of pavement surfaces. **FRICTION COEFFICIENTS and FRICTION TESTING** will be discussed, along with a few methods that can be used to restore acceptable levels of friction to the pavement surface to give pilots safe conditions in which to land the airplane.

MICROTEXTURE

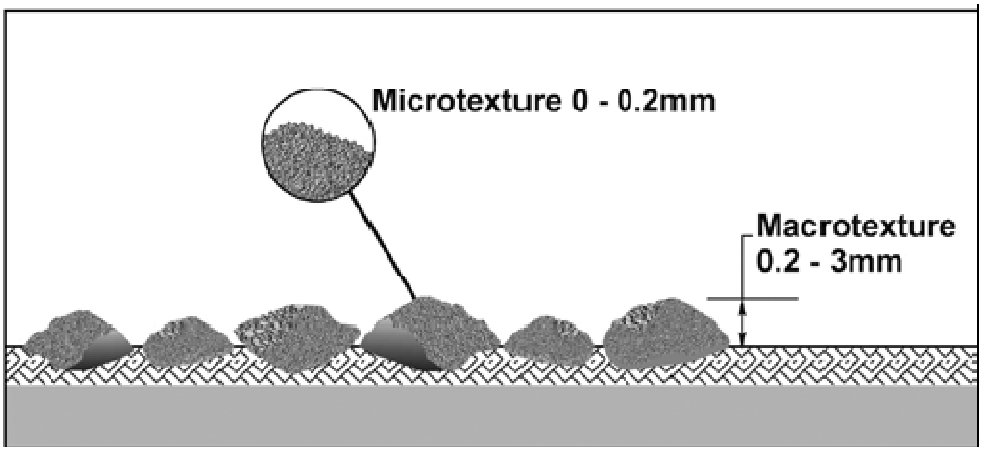
Microtexture is the roughness of the surface of the pavement. The fine scale particles on the pavement surface are not readily discernible to the eye, but are apparent to the touch, like the feel of fine sandpaper. In asphalt surfaces, the type of aggregate used will help increase and maintain the microtexture of the pavement. Specifically, the presence of course grain sizes and rocks high in silica are the most effective in providing long wear of the pavement and a constantly renewed abrasive surface.

MACROTEXTURE

Macrotexture refers to the **visible** roughness of the pavement surface as a whole. The primary function of the pavement’s macrotexture is to provide paths for water to escape so that the landing traffic does not hydroplane.

The **MICROTEXTURE** of the pavement provides frictional properties for aircraft operating at low speeds. **MACROTEXTURE** provides frictional properties for aircraft operating at high speeds. Together they provide adequate frictional properties for aircraft throughout their landing/takeoff speed range these two factors are particularly important on airports, which accommodate large commercial or military aircraft. But even on smaller, general aviation airports, as well as on roads and highways, these friction-enhancing properties can prevent many accidents.

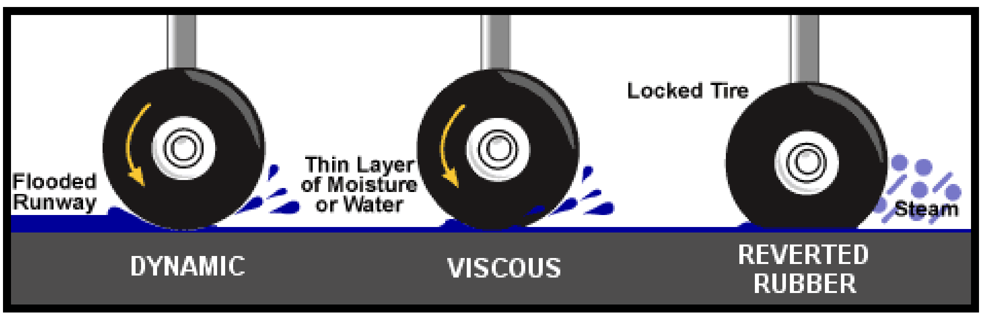
FIGURE 1: RUNWAY PAVEMENT SURFACE MICROTEXTURE AND MACROTEXTURE.



HYDROPLANING

Hydroplaning can occur when landing on a runway surface contaminated with standing water, slush, and/or wet snow. It can seriously affect ground controllability and braking. The three basic types of hydroplaning are dynamic hydroplaning, reverted rubber hydroplaning , and viscous hydroplaning. Any one of the three can render an airplane partially or totally uncontrollable anytime during the landing roll.

FIGURE 2: BASIC TYPES OF HYDROPLANING



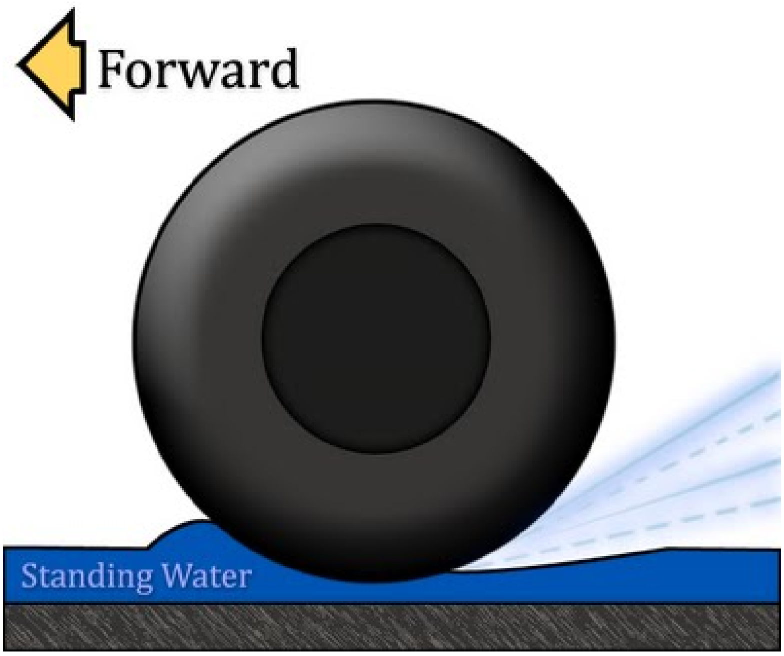
DYNAMIC HYDROPLANING

Dynamic hydroplaning is a relatively high-speed phenomenon that occurs when there is a film of water on the runway that is at least one-tenth inch deep.

As the speed of the airplane and the depth of the water increase, the water layer builds up an increasing resistance to displacement, resulting in the formation of a wedge of water beneath the tire.

When the water pressure equals the weight of the airplane, the tire is lifted off the runway surface and stops rotating. Directional control and braking is lost.

FIGURE 3: DYNAMIC HYDROPLANING



REVERTED RUBBER HYDROPLANING

Reverted rubber (steam) hydroplaning occurs during heavy braking that results in a prolonged locked-wheel skid. Only a thin film of water on the runway is required to facilitate this type of hydroplaning.

The tire skidding generates enough heat to cause the rubber in contact with the runway to revert to its original uncured state. The reverted rubber acts as a seal between the tire and the runway, and delays water exit from the tire footprint area. The water heats and is converted to steam which supports the tire off the runway.

FIGURE 4: REVERTED RUBBER HYDROPLANING DAMAGED TIRE.

FIGURE 5: CLOSE-UP OF REVERTED RUBBER TIRE DAMAGE.

Reverted rubber hydroplaning frequently follows dynamic hydroplaning, during which time the pilot may have the brakes locked in an attempt to slow the airplane. Eventually the airplane slow enough to where the tires make contact with the runway surface and the airplane begins to skid.

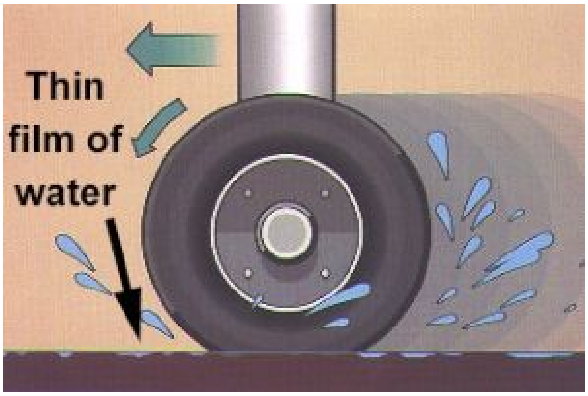
Reverted rubber hydroplaning is insidious in that the pilot may not know when it begins, and it can persist to very slow ground speeds (20 knots or less).

VISCOUS HYDROPLANING

Viscous hydroplaning is due to the viscous properties of water. A thin film of fluid no more than one thousandth of an inch in depth is all that is needed.

The tire cannot penetrate the fluid and the tire rolls on top of the film. This can occur at a much lower speed than dynamic hydroplane, but requires a smooth or smooth acting surface such as asphalt or a touchdown area coated with the accumulated rubber of past landings. **Such a surface can have the same friction coefficient as wet ice.**

FIGURE 6: VISCOUS HYDROPLANING



HOW RUBBER DEPOSITS ACCUMULATE

The material that accumulates on the runway surface is no longer rubber like that on the tires of the airplane that put it there; that rubber is relatively soft and flexible and designed to absorb some of the shock of the landing aircraft. The aircraft tires are stationary just before they touch the ground, but at the moment they touch, literally where the rubber meets the runway, and for about 1000 feet or 300 meters, that tire is gaining rotation speed. During that time, the tires are under thousands of pounds of pressure between the tire and the surface, right at the interface, that causes considerable friction and heat. This time is referred to as *"spin up speed".* The heat created causes a polymerization of the rubber, or a chemical reaction, turning it into a very hard material that is spread on that 300 meters of runway surface in a thin layer. Seven hundred grams of rubber, or about 1.4 pounds, are deposited per tire per landing of each large aircraft, such as a 747 or an L-1011. With repeated landings of aircraft, this hardened rubber fills the microtexture of the pavement giving it a smooth, almost glass like surface that can make landing the aircraft and stopping difficult, or even dangerous, particularly when the pavement is wet. It will also begin to fill the macrotexture of the pavement surface, which will diminish the ability of the grooves to adequately drain the water during a rain event, increasing the likelihood of hydroplaning.

FRICTION DETERIORATION

Over time, the skid-resistance of runway pavement deteriorates due to a number of factors, the primary ones being mechanical wear and polishing action from aircraft tires rolling or braking on the surface and accumulation of contaminants, mainly rubber, on the pavement surface. Other factors such as structural pavement failure contribute to friction deterioration.

FRICTION EVALUATIONS

The operator of any airport with heavy aircraft traffic should schedule periodic friction evaluations of each runway depending upon the number of daily landings.

TABLE 1: FRICTION SURVEY FREQUENCY

Number of Daily minimum turbojet aircraft landings per runway end	Minimum Friction Survey Frequency
LESS THAN 15	1 YEAR
16 TO 30	6 MONTHS
31 TO 90	3 MONTHS
91 TO 150	1 MONTH
151 TO 210	2 WEEKS
GREATER THAN 210	1 WEEK

When a friction test identifies a pavement surface with inadequate friction characteristics, the cause, such as rubber accumulation, is often obvious. Friction testing is performed by use of a metered device (CFME = Continuous Friction Measuring Equipment) that can either be towed behind a vehicle or be self-contained.

RUBBER REMOVAL

Runway rubber removal is an essential function to maintain safe landing areas for the aviation industry. The CAAs requires that strict standards for runway skid resistance be attained and maintained at all airports. One technique that has been used successfully throughout the world to enhance runway skid resistance is the cutting of grooves in the surface of those areas of the runway where touchdown and braking are critical. The use of grooved runways provides an increased level of safety by furnishing enhanced drainage through increased pavement macrotexture, which reduces the potential for hydroplaning when runways are wet. Increased macrotexture leads to increased pavement surface friction, which in turn leads to increased amounts of rubber deposits. An average landing leaves as much as 1.4 lb (700 g) of rubber in a thin layer on the runway. To make matters worse, the heat generated during the interaction causes a chemical reaction called polymerization that changes the rubber deposits into a hard, smooth material. This buildup of rubber fills the micro-and macrotexture of the pavement, causing a serious loss of skid resistance when the runway is wet; as a result, the rubber deposits must be periodically removed.

There are four methods to remove runway rubber: waterblasting, chemical removal, shotblasting, and mechanical means (including sandblasting, scraping, brooming, milling, and grinding). The use of these methods varies across the airports based on a number of reasons ranging from environmental restrictions to the availability of competent rubber removal contractors. The research on these methods has not been comprehensive and consists of individual evaluations of at most two methods. In addition, field experience has shown that if these methods are not properly applied, they can cause damage to the runways and especially to the grooves. Much of the equipment that is in use is also proprietary, making it difficult for airport operators to develop standards and specifications that can be used to confidently achieve the desired end result. Thus, given these above circumstances, this technical paper synthesizes the state of the practice in runway rubber removal.

The objective of this paper is to synthesize the current information available in runway rubber removal, including the effects each removal method has on runway grooving, pavement surface, and to appurtenances normally found on an airport runway. Some regard this field as more of an art than a science. Thus, this report paper to find those factors that can be controlled by the engineer when developing a runway rubber removal program. The synthesis identifies different approaches, models, and commonly used practices, recognizing the differences in each of the different rubber removal methods.

RUBBER REMOVAL TECHNIQUES

The most common methods of pavement retexturing are:

1. High Water Pressure;
2. Ultra High Water Pressure (TrackJet);
3. Chemical;
4. Shot Blasting; and
5. Mechanical Process

High Pressure Water blasting (HPW)

Rubber is removed by means of rotary devices that move along the surface as it cleans. This is done utilizing up to 30 gallons of water per minute at pressures of between 100 to 1,000 bar. The water that penetrates the surface effectively cleaning rubber deposits creates an hydraulic effect. This helps to increase the frictional values and surface texture of the pavement. A combined suction part or a sweeper that picks up the rubber debris during its operations usually accompanies it. This allows for the pavement to be easily and quickly returned to operations and is especially advantageous in airport operations where time constraints and short possession time is common.

Benefits of using this technique are:

- The speed at which rubber is removed (1,200 m^2 per hour are claimed).
- The cost efficiency of the process (water is generally provided).
- The improved friction characteristics of the pavement due to penetration of the water and the removal of rubber.
- The ease of getting off the runway in the event of an emergency.
- Its usage is independent of weather and can be operated in cold, damp wintry conditions.

Disadvantages are:

- Noise from the operation requires the wearing of hearing protection.
- Eye protection should also be worn in the vicinity of the machine while in operation.
- Appropriate disposal of waste material is required.
- Does loosen surface matrix encouraging the loss of fine materials.
- Cleaning rate is 70% with one run.
- Heavily damages certain asphalt types like antiskid.
- Damages grooves and pavement surfaces over time (8 years).
- Damages sealing.
- Cannot be used to clean AGL.

HPW is most effective on sprayed seals and asphalts that show loss of texture due to flushed bitumen. This results in safer operating conditions for pavements.

TrackJet (Ultra High-Pressure Water blasting)

The TrackJet, an Ultra High-Pressure Water blasting machine developed by Bernd Weigel in Germany, is widely used at BAA airports and other leading airports in Europe, as well as European highways for retexturing and paint marker removal.

Through its modern technology of retexturing, this machine has consistently removed 100% of rubber build-up and pavement markings from pavements without touching the pavement micro or macro texture. It utilizes a nozzle system that is truck mounted, applying very little water at very high pressure through a unique computer-controlled system.

This enables an environmentally friendly and most effective maintenance for all kind of surfaces. Cost savings through increasing rubber removal intervals without damaging or destroying the aggregates on the pavement surface result in an increased pavement life.)

Benefits of this technology are:

- Optimum treatment with care of pavement surface.
- Reduces direct and indirect renovation cost by prolonging cleaning and resurfacing cycles.
- Applicable to all kinds of surfaces; for example asphalt, anti-skid, petro-grip and concrete.
- Best possible friction values, therefore prolongs the time interval till next cleaning.
- High environmental compatibility is reached due to very low water consumption and very low eroded road/runway substance volume.
- No damage to grooving, runway lighting systems, marker paints and joint sealing.
- Clearing out of expansion joints.
- Only needs one personnel to operate.
- The ease of getting off the runway in the event of an emergency; runway can be evacuated in 3 minutes leaving the working area tidy and surface like new.
- Its usage is independent of weather and can be operated in cold, damp wintry conditions or warm temperatures (2 to 40 degrees centigrade).
- High environmental care due to extremely low water and fuel consumption; the TrackJet works with clean water without chemical adhesives and requires only 10 to 20% of the water and 30% of the fuel HPW systems normally require.
- Low expenses with waste removal, because no chemical is used to separate the rubber waste from waste water.

This system is also universally suitable for cleaning sealing joints, concrete renovation, cleaning of steel and concrete areas, apron areas and oil spill removal.

Disadvantage of systems:

- Appropriate disposal of waste material is required.

- Some airport staff claim that up to 800 m² per hour cleaning (but 100% rubber removed) is too little.

Chemicals

Environmentally friendly chemicals have been developed that are safe and effective in cleaning rubber from contaminated surfaces. This is done by spraying the chemicals onto the pavement surface and then scrubbing, brushing and working them into the rubber deposit over several hours. The chemicals break down the polymerized rubber into a soft jelly like substance.

The substance is then flushed off the runway by water blasting when the process is completed. During this process, the runway cannot be reopened until the process is completed due to the runway surface being slippery.

The debris cannot be swept up using conventional sweepers since the chemicals will react with the rubber seals within the sweeper. Even though the debris is considered to be biodegradable, the chemical is not and as a result, the usual method of clean up is: flush the soapy residue off the pavement surface onto the surrounding soil after completion of works.

Over time, the debris accumulates and may eventually cause an environmental problem requiring remediation. The cost of chemical removal is usually double the cost of HPW and TrackJet due to the cost of the chemicals

Benefits of this method are:

- Rubber is cleaned at the same rate as HPW.
- Lit softens and removes polymerized rubber.
- The work can be accomplished using airfield staff and equipment.

Disadvantages are:

- Once the process begins, the pavement/runway must remain closed until clean up is complete.
- It is expensive in comparison to HPW and TrackJet.
- Poses an environmental problem due to chemicals not being biodegradable over time.

- Time taken for process to be completed.
- Requires more than one personal to carry out process.
- Reacts with rubber seals in conventional sweepers and on runways.
- Large amount of effluent needed to be disposed of.

High Velocity Impact Removal or Shot Blasting

Propelling abrasive particles onto the runway surface that blast the contaminant from the pavement surface using Shot-blasting. The operation is environmentally clean since it is self.

contained and the equipment can be adjusted to produce the desired surface texture result. On a non-grooved surface it collects the abrasive particles, loose contaminants and dust from the runway surface. The steel is then recycled for re-use. The primary reason using this method is for paint removal and the resurfacing and retexturing of pavement surfaces and not necessarily the removal of rubber deposits

Benefits are:

- It retextures pavement and removes rubber deposit in excess of 1,000 m^2 per hour.
- Retexturing is done by removing a thin layer of the pavement and coincidentally removing rubber deposits as well.
- The equipment is truck-mounted and can easily be removed from the runway (like HPW and TrackJet) in case of an emergency landing.
- The equipment cleans the surface while working.

Disadvantages are:

- Expensive to mobilize.
- Overall cost is expensive.
- Noise and vision hazards due to operation process of machine.

- Care is required to carry out machine operation.
- FOD hazard on airfields where steel shot becomes semi-embedded into the surface and then dislodged later in time.

Mechanical Removal (Grinding or Milling)

Mechanical Removal is generally carried out either by grinding or milling. Like shot blasting, the primary reason for the machine is not the removal of rubber from pavement surface.

It is most effective in removing rough patches on highways and profiling high spots on pavements. It also removes rubber deposits as its process is carried out

Benefits are:

- Removes high areas such as bumps on pavement surfaces or at joints where slabs have shifted or faulted.
- Mills asphalt surface for preparation of overlaying.
- Improves pavement surface friction characteristics by removing a thin surface layer.

Disadvantages:

- Can cause micro-cracking of the structure leading to accelerated aging of the surface.
- Damages surface texture.

Comparative Analysis of Retexturing Methods

The table below is a comparative analysis of the different attributes associated with each type of retexturing method.

In comparing the different methods of retexturing against key operative variables it can be deduced that the specific requirements of the user will determine which method suites them best.

In table 1, HPW is used as the basic method from which the other methods were measured against using several different factors

TABLE 2: COMPARATIVE ANALYSIS OF RETEXTURING METHODS

Technology	Cost per m²	100% Rubber Removal area	No. of staff used	Environment impact	Pavement evacuation time	Pavement retexturing ability	Safety/Noise	Speed of 100% Cleaning
Chemicals	+	-	+	+	-	-	-	-
HPW	=	-	+	+	=	-	=	-
Shot Blasting	+	-	+	=	-	-	-	-
Mechanical Removal	+	-	+	=	-	-	-	-
TrackJet Technology	=	=	=	=	=	=	=	=

Key to table: comparison of all technologies against TrackJet UHPW

= approximately the same like UHPW,

+ greater/more than UHPW

- less than UHPW

For cost, rubber removal, speed of cleaning, and pavement retexturing the TrackJet has a distinct advantage and equals HPW in the other factors. For pavement retexturing it should be noted that depending on the surface type whether asphalt or concrete there are advantages in using specific methods.

Shot blasting is more effective on concrete than it is on asphalt pavements. TrackJet is the only technology that removes paint markings without any damage to the texture below.

FIGURE 7: TRACKJET VEHICLES USED FOR AIRPORT RUNWAY CLEANING

FIGURE 8: AIRPORT RUNWAY HIGH PRESSURE WASHING VEHICLES

FIGURE 9: LINE MARKING REMOVAL MACHINE

FIGURE 10: HIGH PRESSURE RUNWAY CLEANING

Operating pressures range from 1000 to 2600 BAR to ensure the most stubborn of materials can be cleared from the runway.

FIGURE 11: EXTREME RUBBER REMOVAL

This figure shows how much rubber can be cleared from the runway.

FIGURE 12: CONCRETE RUBBER REMOVAL

A comparison between a treated and non treated section of concrete

FIGURE 13: ASPHALT RUBBER REMOVAL

A comparison between a treated and non treated section of asphalt.

FIGUREN 14: LINE CLEANING

Runway markings can be cleaned to make them more visible

FIGURE 15: CLEANING RUNWAY LINE MARKINGS

The cleaning of line markings can contribute to runway safety

FIGURE 16: RUBBER REMOVAL CONCRETE

The runway cleaning vehicle is able to use water at very high pressure to remove rubber from the surface of the runway without damaging the concrete.