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RUNWAY CLEANING SYSTEMS



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## INTRODUCTION

It's been raining buckets. You're the pilot of an Airbus A320 accelerating for take-off, but still well short of V1. Then the nose wheel starts aquaplaning. Control becomes an issue, and you discontinue take-off.



Just such an incident occurred at Melbourne airport in January 1998.

The pilot in command discontinued take-off on runway 27, later attempting to take-off from runway 34.

The aircraft returned to the terminal after an unrelated problem with the inertial reference systems. It's often referred to as aquaplaning.

Frequently the actual incident turns out to be caused by something different, but still part of what we generally refer to as the "*wet, slippery runway*" problem.

**Slipperiness:** Control of an aircraft during ground operations depends on adequate tire contact and friction between tire and pavement surface. This interaction is relied on for lateral control and to oppose side forces such as cross wind. Equally significant is the retarding force for braking. In situations where tire contact or friction are deficient, there is a loss of directional control and braking, generically known as slipperiness.

Three basic modes of slipperiness have been identified: *dynamic hydroplaning, viscous hydroplaning and reverted rubber skidding.*

**Dynamic hydroplaning or aquaplaning:** This can occur when an aircraft lands fast enough on a wet runway. Where aircraft speed and water depth are sufficient, inertial effects prevent water escaping from the footprint area, and the tire is buoyed or held off the pavement by hydrodynamic force.

*Viscous hydroplaning:* This occurs when a tire is unable to puncture the thin residual film left on a pavement in the footprint area. This water lubricates the surface and friction is reduced. The most positive method of preventing this lubrication is to provide a texture to the pavement surface.



*Reverted rubber skidding:* This is a complex phenomenon which over the years has been the subject of a variety of explanations. Reverted rubber skidding is akin to viscous skidding in that it occurs with a thin film of water and a smooth runway surface. This situation often follows dynamic or viscous hydroplaning where the aircraft wheels are locked. The locked wheels create enough heat to vaporize the underlying water film forming a cushion of steam that eliminates tire to surface contact. Once started, reverted rubber skidding will persist down to very low speeds, virtually until the aircraft comes to rest. During the skid, there is no steering capability. Indications of a reverted rubber skid – albeit after the event – are distinctive white marks on the pavement and a patch of reverted rubber,

<b>MODE</b>	<b>PREREQUISITE</b>
Dynamic hydroplaning	Flooded runway. High speed.
Viscous hydroplaning	Thin water film. Smooth surface. Wheel free to roll.
Reverted rubber skidding	Thin water film. Smooth surface. Locked wheel.

What aerodrome operators need to know about managing slippery runways?

## **AERODROMES**

Similar to the uncured state, on the tire, from the perspective of aerodrome management, it is useful to summarize the following key points:

- The principal dangers to aircraft are greatly increased stopping distance and loss of directional control

- Given sufficient water depth, the critical speed for dynamic hydroplaning increases with the square root of the tire inflation pressure.
- Nose wheel control can be a consideration at lower speeds, because of their lower tire inflation pressure.
- Experience suggests dynamic hydroplaning will not occur unless the runway is heavily flooded. This indicates the importance of runway shape; with cross fall and longitudinal grade such that long drainage paths are avoided. There is also a need for continued surveillance and urgent maintenance, when pavement shape is compromised by depressions or “bird baths”.
- The combination of smooth or excessively worn tires on a smooth surface has the potential to be lethal in wet conditions. (This is why tire-wear criteria must be established and monitored in accordance with aircraft maintenance manuals.)

Friction requirements: The International Civil Aviation Organization (ICAO) recommends that the average surface texture depth of a new surface should be not less than 1.0mm. Of greater significance is the ICAO Standard which says “measurements of the friction characteristics of a runway surface shall be made periodically with a continuous friction measuring device using self wetting features”.

The standard requires member States to specify two levels:

- A maintenance friction level below which corrective maintenance action should be initiated.
- A minimum friction level below which information that a runway may be slippery when wet should be made available to pilots. ICAO now provides guidance information for States to determine friction levels. Suggested friction values are tabulated for new runway surfaces, for maintenance planning purposes, and for runway surfaces in use. Values are listed for various alternative friction measuring devices.



Australia’s rules and practices for aerodromes (RPAs) require the aerodrome to “ensure that tests are conducted at a frequency of not less than once a year to determine the friction of runways serving RPT jet aircraft”. These tests refer to surface texture measurement, rather than the continuous friction measuring devices. With the assistance of specialist advice, aerodrome owners can set their own friction

values based on the ICAO guidance information, “new construction” datum levels, and the specific conditions at the particular aerodrome. This practice is prudent in cases where rubber build-up is evident, and needs to be monitored. Australian design standards for licensed aerodromes require paved runways used by regular public transport aircraft to have an average surface texture depth greater than 1.0mm as measured by the grease patch test (in line with the ICAO recommendation). The test is described in the Recommended Practices Aerodromes (RPAs).

*Continuous friction measuring devices:*



Many friction measuring devices have been used. These include the diagonal brake vehicle (DBV), The Swedish Skid meter, the airport surface friction tester (ASFT) the British Mumeter, and the “Grip tester” trailer. The Mumeter, a lightweight three-wheeled trailer, has been extensively used in Australia, with some success. These trailers have the necessary mobility to take measurements with a minimal amount of runway down time, and importantly, they provided fast repeatable results.



*Runway Treatments:* The simplest form of surface treatment is the removal of rubber deposits. This is normally done by specialist contractors, using either chemical or water blast techniques. Mechanical grinding has also been used effectively to remove heavy deposits. Aerodrome operators should always be vigilant with regard to rubber buildup. In addition to reduced friction, rubber deposits have been known to dislodge under traffic becoming a hazard to aircraft. Such was the case with a Boeing 767 at Melbourne last year. Grooving is normally the preferred treatment for concrete and bituminous concrete surfaces, for all airport types. Engineers can always “buy an argument” on the specification to be adopted; I favor Transverse grooving with groove size of 6mm x 6mm. The groove spacing has increased over recent years from 32mm to 38mm.<sup>1</sup>

<sup>1</sup> Graham Bailey is a Canberrabased aerodrome consultant.



Rubber deposit smeared on the runway is suggested by the authorities, to be one of the major risk factors jeopardizing the landing safety. It is the consequence of the extensive heat generated by the touch of the static wheels to the runway surface.

The melted rubber gets smeared on the surface of the runway and minimizes the effect of the anti skid layer ergo the friction level. Even a thin layer of water on the runway causes the aircraft to start aquaplaning. This, as a result, abates the controllability of the plane and its ability to brake.

## **RUNWAY SAFETY STANDARDS :**

According to ICAO standards, the runway friction rate of the airports must be 0,74 on new runways. This rate is the friction coefficient of the runway. Statistics from 1995 up to today, suggest that over 40 planes per year have been victims of accidents caused by runways with sub standards friction level. (*Source: The Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force*)

## **THE FORMATION OF RUBBER DEPOSITS ON RUNWAYS:**

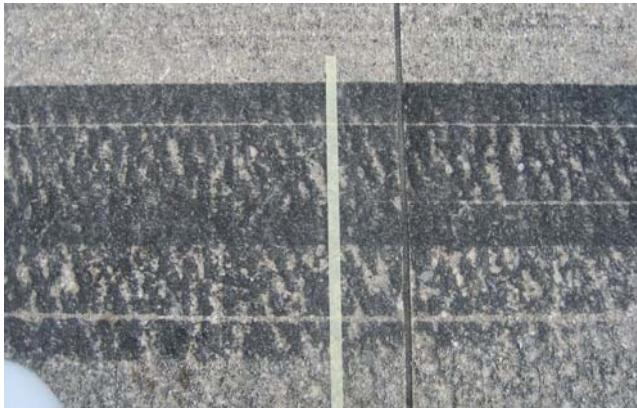
During landing, as the static wheels to the runway surface, an extensive heat is generated and the melted rubber from the tires, is smeared on the runway. In time this thin layer of rubber thickens and fills the cavities of the “anti skid layer”. Consecutively, especially when wet, this thick layer of rubber deposit is suggested to be one of the major risk factors jeopardizing the landing safety.

Pictures 1 and 2, demonstrate the layer of the rubber deposit both after a single landing and after three months' time.

**Picture 1**

**AHL (Istanbul International Airport)**

**Runway 06-24**



**Picture 2**

**AHL (Istanbul International Airport)**

**Runway 06-24**



Above photos were taken from a runway that is closed everyday between 06 :00 and 24:00 for cleaning. However the cleaning of the said runway is made by the airport authorities using high pressure water jet. We shall go into the details of various cleaning methods in the coming chapters.

When the water jet is applied with 1700 – 2000 bar pressure, it cleans the rubber deposit completely; however, it also destroys the “anti skid” layer covering the surface of the runway. Consequently, although this process cleans the rubber deposit, by destroying the “anti skid” layer completely just after 2 cleanings, it causes more harm than good.

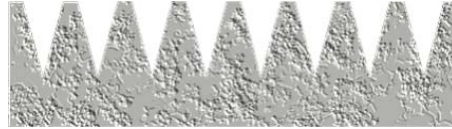
The anti skid layer costs approximately 20€ per sqm to renew. Moreover, the renovation of this layer requires a construction period, during which the runway will be closed to traffic.

For this reason, many runways are being cleaned by low pressure water jet on a level of 700 bars but yet, under this compression, it is not possible to clean the rubber deposit completely.

Pictures 3, 4 and 5 demonstrate the clean anti skid layer, a dirty one and one damaged by high pressure water jet.

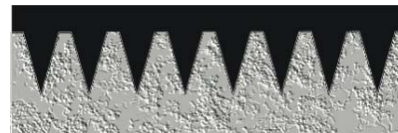
**Picture 3**

**A profile of a new runway surface**



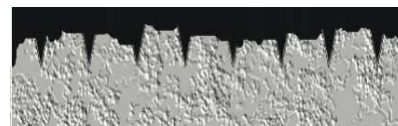
**Picture 4**

**A profile of a dirty (tarnished) runway surface**



**Picture 5**

**A profile of a destroyed runway surface**



Runways of the Istanbul International Airport, like many runways of East European airports have lost this "anti skid" layer completely because of the damage by water compressed cleaning vehicle and consequently all these runways have become flat and extremely slippery.

Below pictures represent as an example, of the ideal runway surface and the photos showing their state after being cleaned by the water jet help us realize how false cleaning application destroys the runways and creates a safety risk.

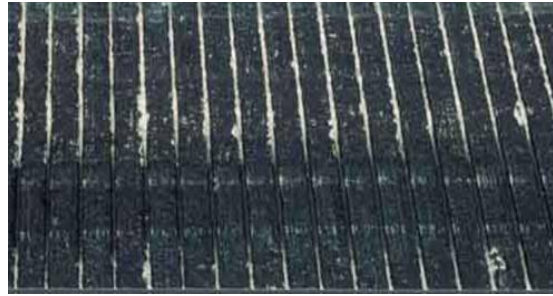
**Picture 6 – 7 ( An ideal runway surface)**

The anti skid layer hasn't been destroyed and it functionally holds.

**Clean runway surface**



**A runway surface with rubber deposit**



**Picture 8**

**A profile of a runway surface with no anti skid layer**

**(Ist. Int. Airport. runway 06-24)**



**Picture 9**

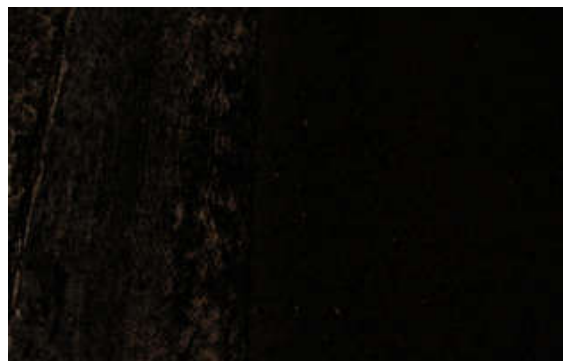
**A profile of a runway surface with no anti skid layer**

**(Ist. Int. Airport. runway 06-24)**



**Picture 10 -11**

**Runway surface completely covered with rubber deposit (Ist. Int. Airport. runway 06-24)**



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### Color Codes Used For the Headings of the Pictures 6-11:

- GREEN** The runway surface which poses no treat to landing safety .
- ORANGE** Low risk runway surface still having " anti skid" function despite having been dirtied by rubber deposit.
- PURPLE** A runway surface which is open to risks such as rubber deposit, mass of water and freezing due to loss of anti skid function",
- RED** A runway surface with no "anti skid function" and below safety standards due to rubber deposit on it.

Additionally, Pictures 12 and 13 reveals that, even under low compression, keeping the water jet vehicle at one point for five seconds has caused a deep cavity on the runway. (The area marked with yellow circle) This track is the proof showing how the compressed water system damages the runway surface.

**Picture 12**



**Picture 13**



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At the airports where the international safety rules are strictly applied, complete cleaning periods are carried out once a year in order to prevent anti skid layer from being damaged.

In spite of this, after two years' time which includes two cleaning up periods, it becomes necessary to renovate the layer .Thanks to chemical cleaning systems which don't damage the "anti skid" layer, the intervals of runway cleaning have been



decreased to once in 3 or 6 months although it was required once in a year before.

Another disadvantage of the high pressure water jet application is to the runway grouting which cracks and becomes out of order in a very short period of time.

Space among the concrete tiles forming the runway are filled using elastic grouting which protects the runway surface against being damaged during a possible bending or expansion due to thermal changes. While the grouting functions as a protector, it isolates the space, in which it is applied, against water. The cracks and tears on the grouting cause this isolation to weaken, so water penetrates deep into the concrete and it decreases its resistance.

The chemical cleaning solutions don't entertain such risks. However, the use of chemicals before Air-O has not been very popular as they were not only difficult to apply and caused environmental pollution, but also it threatened the personnel's health.

The detailed information related to this matter is covered under the relevant heading.

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## THE RUNWAY CLEANING METHODS

Today, three runway cleaning methods come forward, each having their advantages and disadvantages

- Cleaning with Pressurized Water Jet
- Cleaning with Chemicals
- Cleaning with Compressed Hot Air

We shall focus on methods 1 and 2 and compare them to each other as those two have been the most widely used.

### ***Cleaning with Pressurized Water Jet***

High pressure water jets are used to clean the rubber residue on the runway. This



method is based on the application of water jet pressurized at 500 to 2500bars. When the water hits the surface with such power, it simply sweeps all rubber residues from the surface of the runway. However, there is factor of balance between the cleaning effect and the

potential collateral damage it causes.



When the jet is applied with maximum power, while sweeping and cleaning the rubber thoroughly, it damages the anti skid layer that is crucial to maintain the high safety standards of the runway. On the other hand, if lower pressure is applied to protect the anti skid layer, the system fails to completely clean the rubber. Another disadvantage of water jet is the fact that the vehicles applying water jet move with a ground speed of approximately 2km/hr. As an example of the total work hour, the Kennedy Airport's runways present a surface area of approximately 110.000 m<sup>2</sup> out of which over 60.000 m<sup>2</sup> need constant cleaning of rubber. That is a work of weeks considering the runway can be closed to traffic for rubber cleaning for maximum 6 hours a day.

### ***Cleaning with Chemicals***

The chemical is sprayed onto the dirty surface by a sprayer truck. There is 30-40 minutes waiting time till the chemical penetrates the rubber and melts it. Once the

rubber is softened, by use of low pressure water jet at 100 – 120 bars (Equal to pressure used by car wash jets) the soft and broken rubber is swept off the runway surface.

With the use of low pressure water jet, the anti skid layer is protected from being damaged. Consequently, the cleaning interval, instead of once a year is decreased to twice or three times a year. This does not only mean a more effective and efficient runway maintenance but also an highly increased factor of safety on the runway.

However, at this point we must mention a factor which makes the chemical system less usable than the other :



**ENVIRONMENTAL PROTECTION and PERSONNEL HEALTH.**

Chemicals have been used in the runway cleaning process, but they have caused as many disadvantages as advantages.

We shall see the runway cleaning chemicals in two basic groups:

### **Strong Acids and alkalis.**

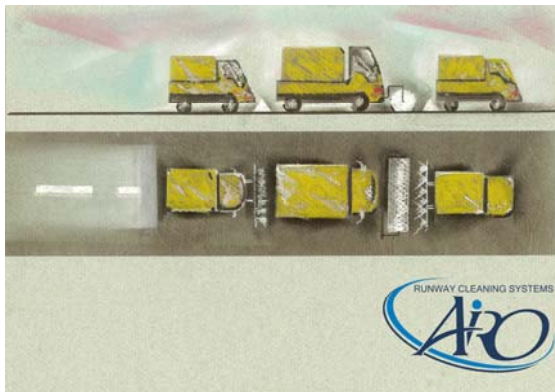
Dense acids used to melt the rubber such as hydrochloric acid, while working the rubber, damage the surface of the runway. Their storage has to be done with care. Moreover, not only during the application but also after the application and at the cleaning stage, they entertain a risk for the environmental and personnel's health.

The second group is alkali solutions. Caustic Soda is used in runway doesn't damage the concrete, however and more importantly, it poses a strong threat to environment and personnel health. It needs to be stored with excessive care, used with caution and its disposal has to be in compliance with strict regulation. Alkali solutions are generally not preferred due to the fact that they have to be diluted with water and the ratio may reach 1/30. With all the disposal regulations to be complied with and the cost of dilution, base solutions are not widely preferred.

## **Air-O, THE NEW, INNOVATIVE RUNWAY CLEANING CHEMICAL**

Air-O is a brand new product, totally different from those two groups. Air-O is a mild acid with pH 4-5 which is 1000 times less acidic than lemon juice and 100 times less acidic than orange juice. The pH level of Air-O is same with drinking water and tomato juice. Air-O is not a chemical but it is a cleaning system consisting of two phased application of chemicals.

### **APPLICATION OF AIR-O RUNWAY CLEANING SOLUTIONS**



#### **Step 1**

Air-O 01 is applied by a sprayer truck.



Our technical team offers service of planning and customizing a commercial truck into the sprayer truck with minimum cost.

#### **Step 2**

For a faster result, brushing can be applied



#### **Step 3**

Air-O 02 is applied by a sprayer truck. At 100 – 120 bars of pressure to neutralize the reaction and to sweep the decomposed rubber from the runway surface




Our technical team offers service of planning and customizing a commercial truck into the sprayer truck with minimum cost.

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## WHAT MAKES AIR-O SUPERIOR TO OTHER RUNWAY CLEANING CHEMICALS

- It does not entertain any risk for the personnel's health.
- It does not pollute the environment.
- It cleans quickly and affectively. 30.000 m<sup>2</sup> per hour.(It may change depending on the thickness of the rubber.)
- It extends the life of the "anti skid" layer up to ten times, in comparison with the compressed water applications.
- It cleans the runway lines but it does not erase them.
- It does not damage the grouting.
- It does not damage the runway wiring.
- It damages neither the kennels by the side of the runway nor the water installation
- It enables the airport operator reach a higher safety standard as the cleaning intervals can be much shorter
- It does not need special care in storage
- It is not corrosive to metal or concrete
- It has a shelf life of 5 years
- It is not subject to environmental regulations of disposal
- It is easy to apply, does not require high cost equipment

Ration of Hydrogen ions to pure water	pH Scale		Examples of solutions to the relative pH scales
10.000.000	<b>pH=0</b>	<b>ACID</b>	Battery acid
1.000.000	<b>pH=1</b>		Hydrochloric acid
100.000	<b>pH=2</b>		Lemon juice, Stomach acid
10.000	<b>pH=3</b>		Orange juice
1.000	<b>pH=4</b>		Tomatoes juice
100	<b>pH=5</b>		Drinking water
10	<b>pH=6</b>		
1	<b>pH=7</b>	<b>NEUTRAL</b>	Pure water
10	<b>pH=8</b>	<b>BASE</b>	Sea water
100	<b>pH=9</b>		Baking soda
1.000	<b>pH=10</b>		Salt lake
10.000	<b>pH=11</b>		Ammoniac
100.000	<b>pH=12</b>		Soapy water
1.000.000	<b>pH=13</b>		Bleach
10.000.000	<b>pH=14</b>		Liq drain cleaner

## THE REPORT OF A RUNWAY CLEANING TEST IN ISTANBUL INTERNATIONAL AIRPORT

Below, is the report presented to the management of Istanbul International Ataturk Airport:

Test reference	AHL/2006/03-2
	Runways Cleaning Test
	Istanbul International Ataturk Airport,
The date and time of test	01, April, 2006 _ 00:30 - 02:00
The runway the test was conducted	06 24
Open-air temperature	+9°C
Relative humidity	% 75
Pressure	1032

Air-O technical team have visited 06 24 runway to carry out rubber removal tests. The runway has been examined by our experts and consequently the area seen on Picture 14 has been determined as the area with thickest layer of rubber with 12-13mm.

**Picture 14**



A test area of 80 m<sup>2</sup> (4m \* 20m) has been marked and photographed. See pictures 15, 16, 17, 18.

**Picture 15 – 16 – 17 Step 1 Determination of the test area :00:30**



**Picture 18 - Step 2 The application of the solvent solution: 00:45**



Between Step 1 and 2, depending on the thickness of the rubber, our experts have waited for 35 minutes so that the solvent solution can penetrate the layer of rubber thoroughly.

During this test, brushing was not needed so not applied.

However, in order to accelerate the time of penetration of Air-O 01 into the rubber, we recommend a brushing car to go into the sprayed area at 10<sup>th</sup> minute. This way, the 40 minutes required for the chemical to penetrate the deeper layers of rubber, may be taken down to 15-20 minutes depending on the thickness of the rubber residue.

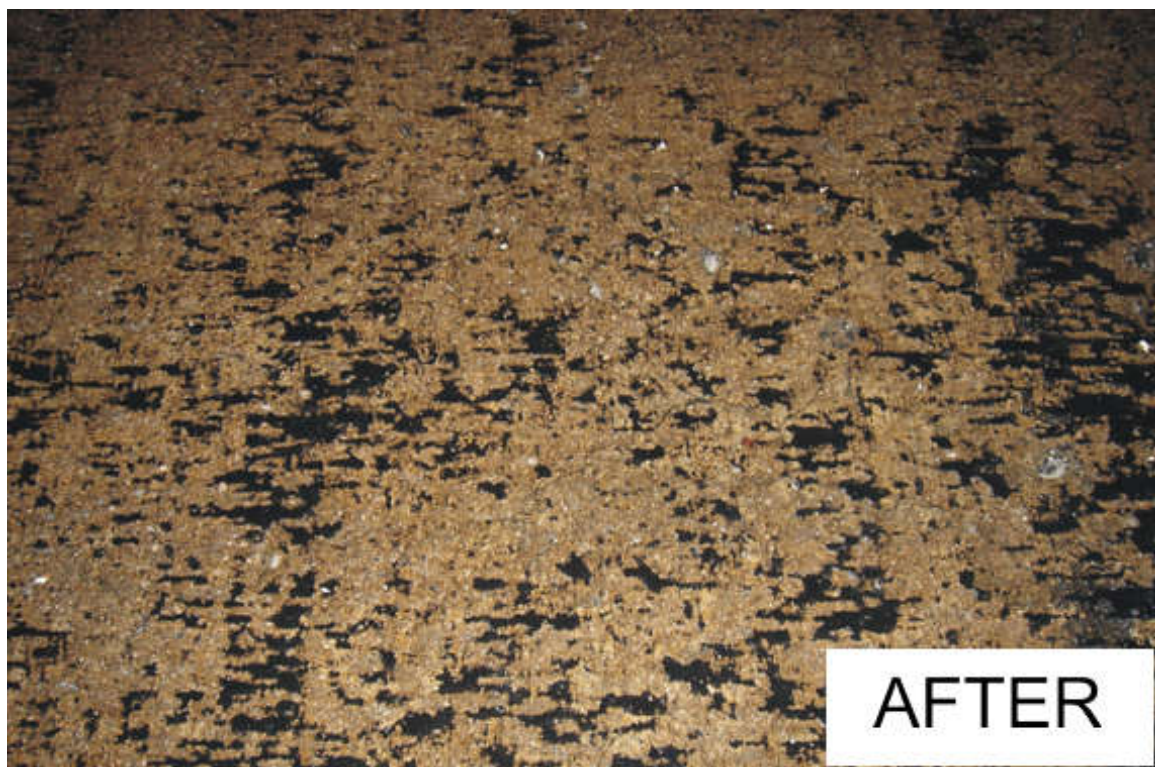
Picture 19 - Step 3 The application of neutralization solution 01:20



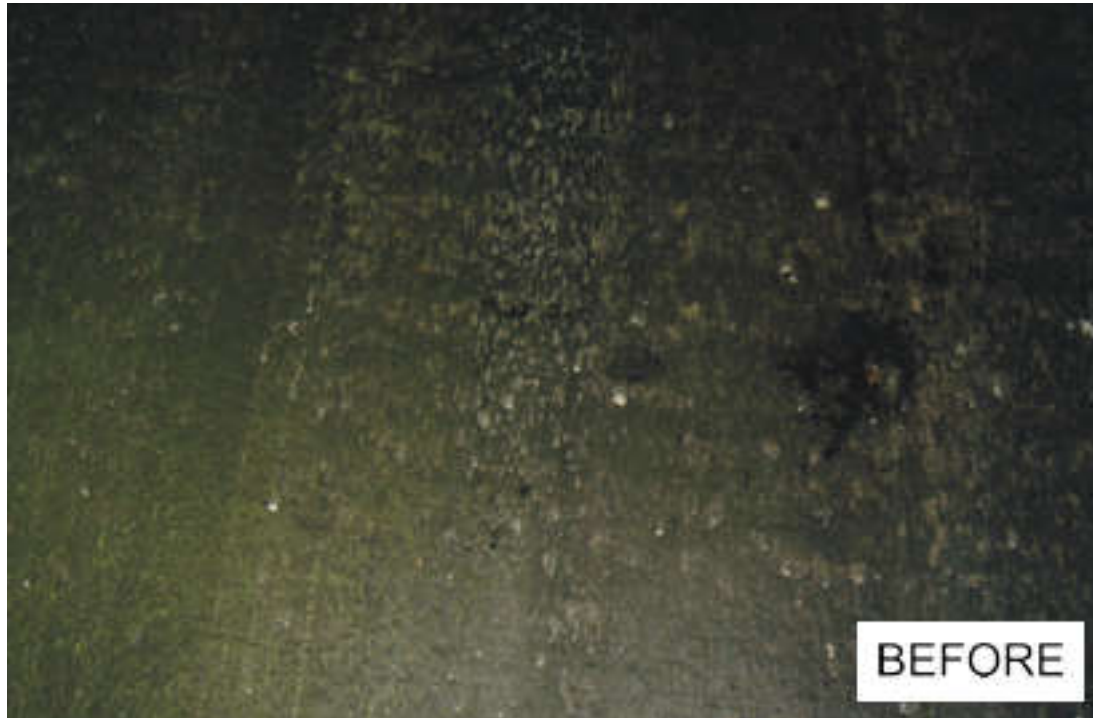
Picture 20 - Result (Detail 1)



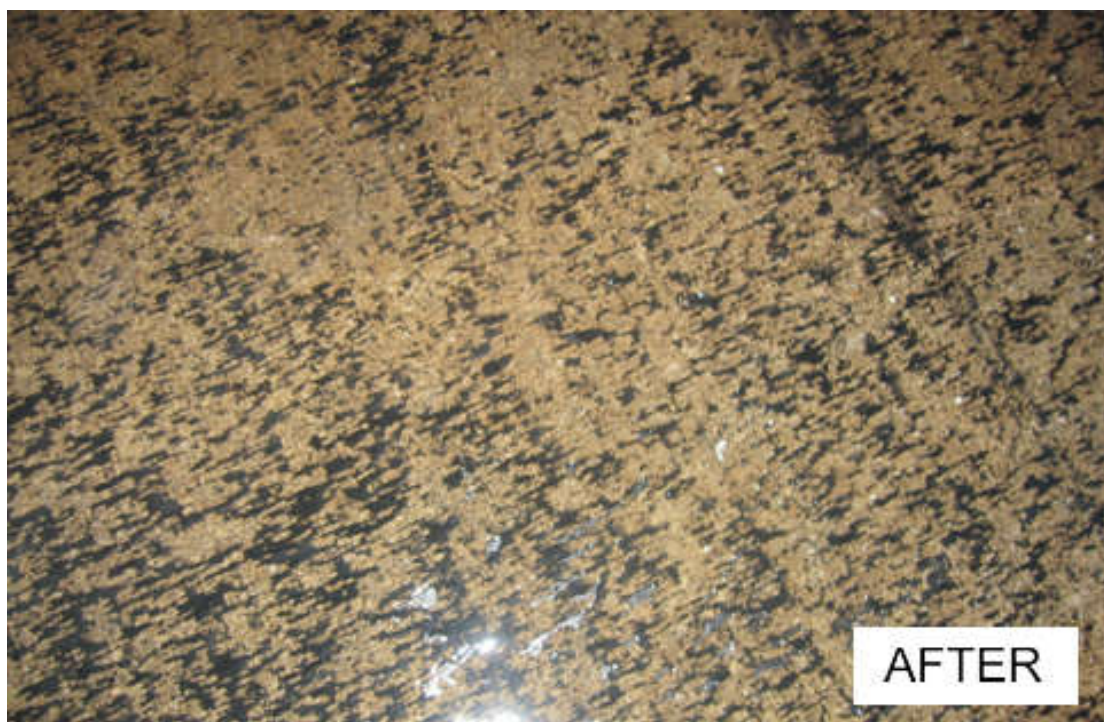
Picture 21 - Result (Detail 2)



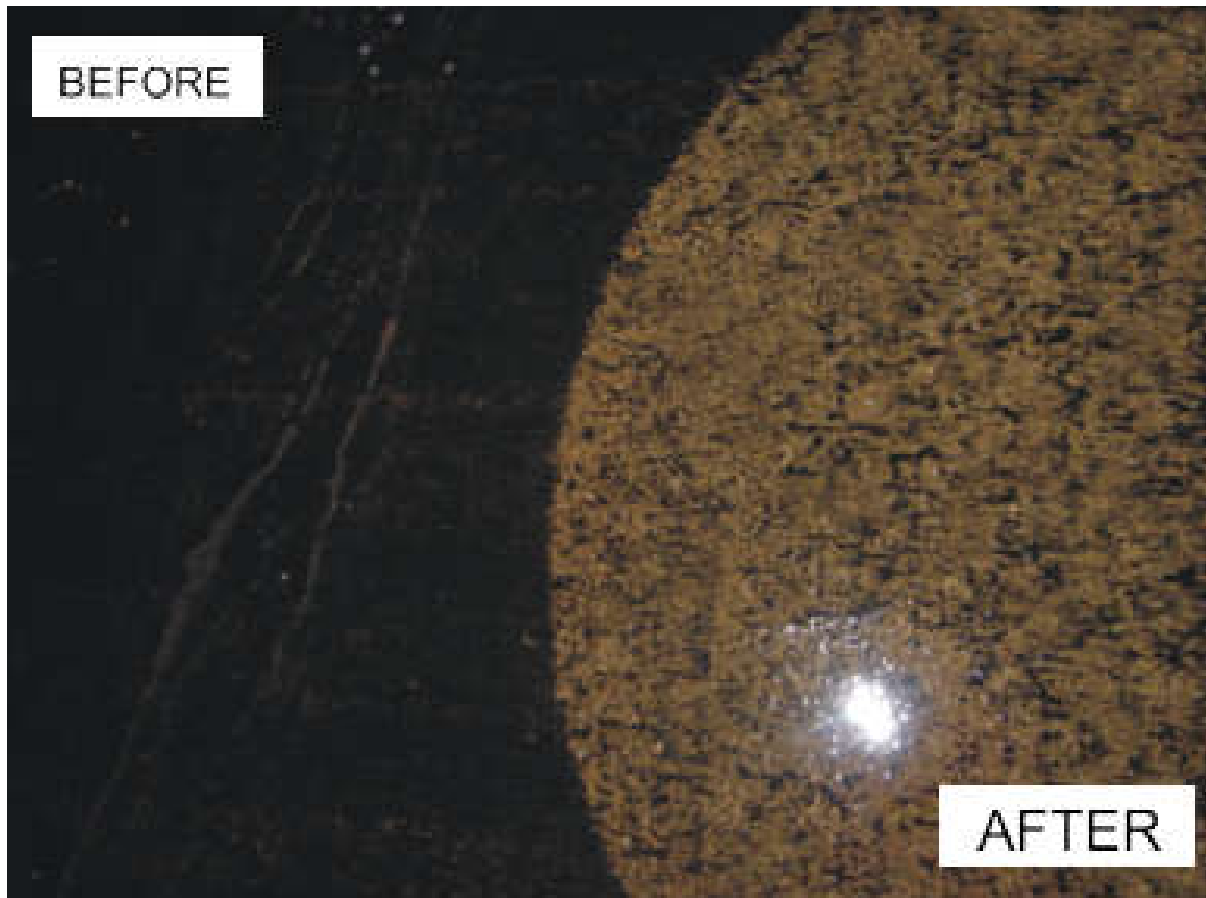
Picture 22 - Result (Detail 3)



Picture 23 - Result (Detail 4)



Picture 24 - Result (Detail 5)



At the time of the same test, our company has had the opportunity to compare a runway cleaning operation performed by compressed water jet vehicle with the one performed by Air-O Runway Cleaning Solution. The photos taken during this comparison will also enable you to realize how much more effective the Air-O Runway Cleaning Solution is.

**Picture 25 – 26 The tire track cleaning operation by compressed water jet**



**Picture 27**

**The Result Obtained by Water Jet Application**



**Picture 28**

**The Result Obtained by Air-O Application**



As you can see on the detailed photos, it has been observed that the rubber layer on the runway surface has been cleaned completely. We declare and confirm that none of the chemical materials used in the cleaning process contain carcinogen or toxic materials that could cause environmental pollution.

Air-O 1 and Air-O 2 are tested for damage to runway concrete, electric cable and expansion joints by laboratories accredited by Institute of Turkish Standards. The copies of said tests are downloadable at [www.air-o.net](http://www.air-o.net)