

# QUALITY REQUIREMENTS FOR DAILY MARKINGS OF AIRPORTS

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This article is about airfield markings and suitable materials used for their implementation depending on their quality requirements. I have collected and analysed the available sources and information. Then I have compared different methods and materials used for road markings and suggested the best suitable for airport environments. Below are described detection and measurements of the necessary properties before and after the implementation of road markings. Then materials used for road markings and requirements on them. It also deals with application of road markings and machinery used to provide that. And finally there are described some methods of airport markings removal.

**K e y w o r d s:** Glass beads, Marking removal, Paints, Retro reflection, Road markings, Thermoplastic

## 1 INTRODUCTION

The increasing number of handled passengers demonstrates the growing trend of aviation and thus the importance of airports. Precondition for a well-functioning airport is to have a sufficient capacity and good track systems. The focus on runway safety incorporates many initiatives to reduce runway incursions. Among such initiatives, airfield markings are being enhanced to increase visibility for those who need them: the pilots and others who operate on airfield surfaces. Although new marking schemes are intended to increase situational awareness for pilots and others operating on airfield surfaces, unless those markings are installed correctly, the efforts may not help. Airfield markings for runways, taxiways, and apron areas can be expected to provide excellent performance for several years under a range of operational and site conditions. It is not difficult to apply markings, but it can be difficult to apply them well.

## 2 ROAD MARKINGS ON AIRPORT MOVEMENT AREAS

Runway markings shall be white. It has been found that, on runway surfaces of light colour, the conspicuity of white markings can be improved by outlining them in black. It is preferable that the risk of uneven friction characteristics on markings be reduced in so far as practicable by the use of a suitable kind of paint. Markings may consist of solid areas or a series of longitudinal stripes providing an effect equivalent to the solid areas. Taxiway markings and aircraft stand markings shall be yellow. Apron safety lines shall be of a conspicuous colour which shall contrast with that used for aircraft stand markings.

## 3 MEASUREMENTS OF SURFACE PROPERTIES

Measurement is made in specified section on longitudinal lines at the range of about 0.5 km, unless the customer does not wish it differently. The measurements must be made at least at 10 places. In given place is the measurement carried out at least on 3 points that are apart approximately 1m. For each location is calculated the average of individual measurements. White road

markings occupies not inconsiderable areas of the runway. However to surface characteristics of these surfaces is not paid enough attention. This would indicate that the value of the coefficient of friction and road signs should meet the same requirements as the track surface without marking. Anti-slip characteristics of road markings when they are wet are the same level as of ice. This means that even in the summer, there are such places on runway, which must be removed in the winter. Markings paint completely covers the macrotexture and microtexture of concrete or asphalt surface and creates a smooth surface similar to ice. When an aircraft is intensively braking, the wheels get on one side of the color coding and on the other side the wheels remains on the rough surface, so forces between the tire surface and landing gear of runway are so different that it can cause skidding, or deflection plane direction and thus the crash. Perhaps out of ignorance of the case is then referred to by accident, that it occurred from unidentified causes. After the first measurement of the surface properties of the Slovak airports there are attempts undertaken to carry out road markings to have better anti-slip characteristics. A permanent solution for road markings can be using a special non-skid safety modifications based on thermoset binders (eg polyurethane, epoxy resin) and special aggregates. These color adjustments have a several times higher lifetime than conventional paint spraying and during their lifetime a very good non-slip properties are guaranteed. The supplier, that carries out road markings must demonstrate, that it is able to carry out road markings at the minimum level of evaluation "Minimum Friction Level" for the lifetime of the horizontal markings. The supplier should prove this requirement by reference measurements of skid resistance on earlier work that was carried out, as it is required according to slovak specifications TP 213.

Due to the fact that the requirements for the surface properties of the new runway are very high (the value of the coefficient of friction at a speed of 65 km/h  $FP = 0.76$ ), it is necessary to pay attention to the design of a new surface, particularly in terms of anti-skid properties. Inconsistent road surface is given by different technology of surface roughening, where macrotexture is created by dragging jute. This method of surface roughening is very unreliable, depending on how clean mined jute is and also on consistency of cement concrete. If it is too thin and jute tends to haul the laitance to the surface and if the consistency of concrete is too stiff, than

the jute with its weight wont create the macrotexture anymore. The loss of macrotexture quickly smoothes also the microtexture, generated by the cement mortar with sand, and as a result is insufficient slip resistant. Concrete surface modification with dragged jute on motorways is performed mainly due to lower noise compared to treatment with cross texture. However for airfields this runway surface modification is not required. Therefore it is considered as bad to perform roughening of runways with dragged jute. Modern technology, which is currently used for cement-concrete surfaces is transverse grooving with negative texture. This technology not only improves antiskid properties, but it also has the ability of drainage, when it quickly diverts water from runway surface and thus reduces the possibility of aquaplaning.

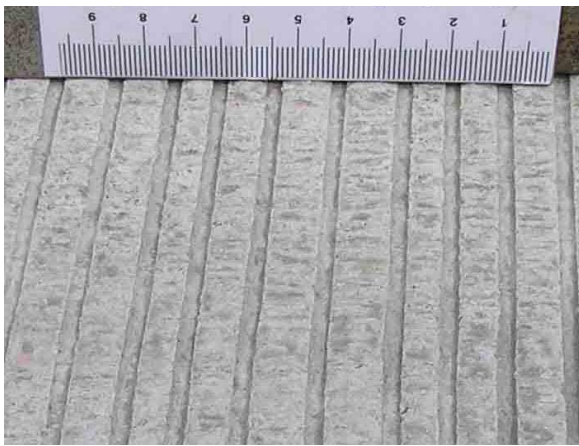


Figure 1. Transverse grooving with negative texture

#### 4 MATERIALS USED FOR ROAD MARKINGS

Traffic signs have to provide information. To fulfill this purpose they must be clearly specified, effective and visible during day and at night. An important feature of each marking is its durability. When selecting the material for airfield markings the importance should be given on the durability. Use of durable materials minimizes the costs for maintenance of daily markings and restrictions in airport traffic. The durability of marking does not depend only on the density of traffic, but also on the adhesion ability of the coating. It is the between molecular attraction between the paint and road surface.

Verification of the properties of materials designed for road markings is performed on the test section. Before the actual implementation of the test section there must be available information about the texture of the road surface (it is necessary to determine the depth of macrotexture by sand and microtexture by pendulum). Determination of time for in materials installation is affected mainly by weather conditions, which should be suitable for all kinds and types of tested materials. Products for temporary road markings are tested for a period specified by the manufacturer or importer. Samples of different types of materials are applied on the test section either by transverse lines (ie, transverse to the

axis of the road across the entire width of the lane), or longitudinal lines (ie, the longitudinal axis of the road). All the lines of each sample are properly marked with a serial number. The material for road marking with additional material on the scattering is applied consistently with the requirements of the manufacturer or importer, which may include special preparation material, possibly specific requirements for the application.

At the simplest level consists airport markings airport from a combination of binder and glass beads. Choosing the right materials is for the work very important. Airport environment, traffic density, safety issues, operational plans, pavement types and existing material used for marking must be taken into account when determining the suitability of other materials to road markings. Selection of optimal material may increase the initial costs, but in the long term it can be a more efficient solution that will lead to save of costs and increased security.

Materials used for road markings:

- Liquid materials (eg water-borne or solvent-borne paints),
- Thermoplastics, i.e. materials in the form of blocks, granules or powders, which are heated to melting and as they melt they are applied to the road surface,
- Cold plastics, ie. two-component materials in liquid, paste or solid state, which are applied to the road surface after mixing the components in the prescribed ratio,
- Pre-prepared road markings, ie. ready-prepared materials (eg plastic film, thermoplastic), which is applied to the surface by means of adhesives, heat, pressure or their combination,
- Road studs, i.e., horizontal guidance devices that reflect the incident light.

To ensure the visibility of the road markings at night and to improve their anti-slip properties there are added different spreading materials to the surface during the road markings application process. They may also be part of the material (such as paint) designed for road markings. Beads or a mixture of glass beads and anti-skid additives are applied immediately after the installation of the coating system. Exceptions are foils and some previously prepared thermoplastic materials, for which the additional material sprinkling applied already at its production.

Profiled road markings are produced from paints, thermoplastics or cold plastic by using an appropriate coating. They have a different structure and irregular profile, which ensures their visibility in rain conditions and creates an acoustic warning when the tire of the vehicle contacts the marking surface. Each material, which is used for road markings, is applied according to their technical specifications. They may include preparation of the material and the road surface, method of application, any requirements for special machinery,

model applications, application rate and type, amount and method of adding gritting materials.

**4.1 Anti-skid additives**

Types of anti-skid additives:

- Cristobalite,
- Corundum,
- Fragmentised glass.

Almost all road markings on airport surfaces are made so, that the marking of the material to an additional sprinkle clearly stands out from the surface and thus from the water film, thus the visibility in wet conditions and during rain significantly improving, and thus the requirement for retroreflection is fulfilled. Such road markings are usually made of plastic materials.

**4.2 Compatibility of materials**

Once the need for marking maintenance has been determined, the composition of the existing marking material should be identified. For best results, the new material must be compatible with the existing pavement marking material. For example, water-borne paint is versatile, and it can be applied over any type of existing (old) material, provided it is in good condition, (i.e., well adhered and less than 40 mils of paint build up). However, both epoxy and methyl methacrylate can only be applied to themselves. Attention to material compatibility is a best practice. The selection of temporary marking materials based on the ease of removal is a best practice. Temporary marking tapes are easily removed, but these can become foreign object debris if they loosen prematurely. Water-borne paints are most commonly used for temporary markings because they are easier to remove than other binders. One method that will facilitate removal of temporary markings from asphalt surfaces is to apply a layer of wax-based curing compound material prior to the application of the temporary markings. This curing compound sloughs (or flakes off) the pavement over a period of time, and it does not bond to the surface. If an applicator sprays curing compound on areas that will be temporarily marked, removal of the temporary markings can be facilitated in some cases, and reduce scarring to the pavement. Different environments present unique challenges for airfield markings. Selecting appropriate materials for an airport is a consideration when designing a project; it is also important when resolving an issue related to the markings. Attention to existing conditions such as those described below is a best practice. Moist, warm, humid environments promote the growth of algae, which often covers and obscures airfield markings on non-trafficked areas. When needed, water-borne paints can be modified to resist algae growth. Some environments have high iron content in soils, ground water, or even in the pavement aggregate. Modifications to standard materials can be made to resist the staining of the markings caused by the

iron contaminant. Other considerations, such as a short work window or application during cold temperatures may dictate the use of certain materials over others. Careful consideration must be given to the composition of an existing marking if a new coating will be applied. When restriping thick, durable markings, such as thermoplastic, methyl methacrylate, and epoxy, the build-up of material can quickly become an issue.

Table 1. Material compatibility index

Existing Material (Old Coating)	Restripe (New) Material				
	Waterborne Paint	Solvent Paint	Epoxy	MMA	Thermoplastic
Waterborne Paint	✓	✗	✗	✗	✓
Solvent Paint	✓	✓	✗	✗	✓
Epoxy	✓	✓	✓	✗	✗
MMA	✓	✓	✗	✓	✗
Thermoplastic	✓	✓	✗	✗	✓

**5 IMPLEMENTATION OF ROAD MARKINGS**

Road markings can be performed only under appropriate weather conditions (except provisional road markings). However, these conditions can not be generalized. During the application of road marking should be followed the instructions of material manufacturers/suppliers, which specifies the requirements for the application of materials. This is mainly compliance the climatic conditions (air temperature, temperature of the base, relative humidity, etc.). Therefore, before starting the work it is necessary to verify whether these requirements are fulfilled.

When performing road marking contractor shall ensure that:

- The instructions of the manufacturer/supplier related to the handling, processing and dosage of materials are followed,
- Material is homogeneous,
- The additional scattering material does not contain clumps, which avoid the regular flow of dispenser,
- Dosage of material and material to additional scattering is set correctly,
- Dosage of material is uniform,
- Dosage of material to additional scattering is even and individual grains are sufficiently integrated.

Assessment of the correctness of incorporation for additional scattering material is done visually. Individual grains should be immersed in the mass, a about 60% of its diameter. Contractor must record in site diary data related with the installation process and activities associated with installation.

The construction diary must contain the following information:

- Identification of used mass,
- Identification of the material used for additional scattering,
- Dimensions of markings carried out,
- Amount of applied material,
- Amount of applied material for additional scattering,
- Location and placement of markings carried out,
- Relative humidity,
- Air temperature,
- The amount and type of the solvent for the color (if used).

Next, it should be mentioned the time for drying / curing / hardening and any other relevant information on the work carried out, that could affect the quality of the road markings. The carried out road markings must be suitably secured against traffic, until the time when the new traffic will not damage the new road marking.

## 6 MACHINERY AND EQUIPMENT USED FOR THE APPLICATION OF ROAD MARKINGS

Road markings can be applied using either machinery or by using hand spray. Hand sprayed markings are usually carried out on places, where marking machines can not be used. For that are used spray guns using templates or hand-held marking machines. The easiest way of road marking implementation is to use paint spraying machine with automatic spray guns. Colors dry up by evaporation of solvents and diluents. Continuous spray marking can be achieved by perfect machine preparation ie. cleanliness of color tanks and hoses, through which flows the paint to guns or nozzles of spray guns. Geometrically accurate labeling can be increased by correct height adjustment of spray guns. The quality of sprayed paints can be ensured especially compliance with the appropriate color consistency, compliance spray uniformity across the entire width and suitable speed of a marking machine.

Most commonly used machines for airfield markings are from German company Hofmann. Machines of H33 series were used to apply markings at Alicante airport in Spain, in Abu Dhabi, Kyjev, Hamburg and Muscat. In Prague and Dublin was used a machine H35 which is described below.

H 35 is a compact and narrow universal machine with high capacities and excellent hill climbing ability. Its robust, high-effective 7-ton construction machine axle with hydraulically switchable speed ranges combined with a high-speed hydraulic motor. The hydraulic drive can be disengaged completely to enable you to tow the machine in case of emergency, even for longer distances. It comes with two pressurised glass bead tanks. Filling

openings for glass beads at the side of the machine in ideal filling height. Option: Pneumatic agitator for homogenising of glass beads. The cockpit is with all operating elements laterally adjustable without the need to install guides. Arrangement of operating and supervising instruments can be easily modified according to individual requirements. Adjustable, easy extractable spraygun support for center- and edge line markings. Individual applications units are exchangeable (exchangeable container) with low effort by quick opening device systems and modular design principle. At rear of the machine is a turn-up-platform. Engine compartment is easily accessible for service work. High ground clearance also eases service works from below. It provides excellent panoramic view, also when driving backwards.

## 7 MARKING REMOVAL

Preparing (cleaning) the pavement surface must be done so that the newly applied marking will bond to the pavement and/or existing markings. This includes cleaning of loose and flaking marking material from the pavement surface, which removes some of the paint, but only what is poorly bonded. In addition to cleaning the surface, it may also be necessary to remove markings from pavement surfaces for various reasons. The desired level of removal depends on the type or condition of pavement under the markings. Portland cement concrete (PCC) and asphaltic cement concrete (ACC) are the two basic pavement types. PCC is more resistant and "forgiving" to a paint removal operation; it can withstand the aggressive pressures needed to remove markings. New ACC will withstand a paint removal operation with less scarring than old, cracked, brittle asphalt. Because ACC is more prone to deterioration as a result of repeated remarking and the stresses exerted by the coatings, the removal process will remove previously damaged asphalt along with the marking.

Pavement marking removal is the mechanical eradication of markings from the pavement to a reason will dictate the degree of eradication. Different types of marking removal and degrees of removal can be specified. Not all of removal situations require 100 percent, 95, or even 85 percent removal of the markings. Two key factors are included in a successful removal operation:

- (1) specifying in the construction documents or specifications what process is expected and
- (2) explaining exactly where and how much of the markings will be removed.

If marking removal is needed in more than one area and for more than one reason, the degree of removal should be clearly defined for each area. This information prepares the contractor, provides expectations for the owner, enables the inspector to validate results, and is a best practice. The degree of removal is dictated by the reason for conducting the paint removal.

In 100 percent removal, all of the marking is removed. Depending upon the condition of the pavement under the marking, 100 percent removal has the potential of causing the most scarring. If the underlying pavement can sustain the forces of the removal operation and complete eradication is specified, then 100 percent removal should be achieved. If pavement damage begins to occur with one method, the process should stop and the engineer/inspector should consider other methods or combinations of methods that may achieve the desired result without causing damage to the underlying pavement.

After 90 to 95 percent of an existing marking is removed, a small amount of marking material will remain after the removal operation is complete. In contrast to 100 percent removal, 90–95 percent removal of markings can spare the pavement from damage. Between 90–95 percent removal is recommended when changing marking colors, and between 85–90 percent removal is appropriate to remove excessive marking build up.

Removing 80 to 85 percent of existing markings is required prior to the application of a seal coat. Leaving 15 to 20 percent of an existing marking will expose enough pavement so that a seal coat or other surface treatment will bond to the underlying pavement.

When an incompatible material is applied over different and existing markings, the degree of removal depends on the new coating. For example, if epoxy markings are being applied over anything except epoxy, 100 percent of the existing marking must be removed. However, if solvent-borne paint is being applied over water-borne paint, removing 85 percent of the existing coating would be acceptable.

Different reasons exist for removing markings from pavement, including the following:

1. A new pattern or configuration will make older markings obsolete. The old markings must be completely obliterated to prevent confusion.

2. Markings should be removed prior to overlaying asphalt or applying a seal coat. Leaving the markings may prevent a good bond of asphalt or sealant to the painted surface. Removal of some but not all of the existing marking would ensure a better bond.

3. Similar reasons for removing markings are outlined next, and the recommended degrees of removal are given for each instance.

Pavement markings that are no longer needed should be physically removed by sand blasting, chemical removal or other means, not painted over. Painting over the old markings merely preserves the old marking, will require additional maintenance, and in certain conditions, can be misleading to pilots.

Markings that are no longer needed are considered “obsolete.” Since “blacking them out” is no longer an acceptable practice, 95 to 100 percent of the markings should be removed and this is a best practice. Black paint and seal coat will wear off over time allowing the old marking to reappear. With black paint, even if the marking looks obscured during the daytime, the glass

beads in the old marking will shine through at night. Additionally, under low visibility conditions, especially when the pavement is wet, a blacked-out line looks like a normal line. Because markings convey information, misleading markings have the potential to confuse and contribute to surface incidents. If markings are to be applied over a different color, the underlying markings must be removed before applying the new color. Often the new marking will wear off, exposing the other color below. For example the holding position marking painted over with a black background will be useless. As the black wore off, the underlying yellow markings showed through, potentially causing confusion. At least 90 to 95 percent of a different-colored marking should be removed before a new color is applied.

Equipment designed to remove markings is available by purchase, lease, or contract, depending upon an airport’s locale and budget. Selecting the right equipment is a best practice, and is based on many factors, including:

1. Amount (quantity) of removal.
2. Type of pavement.
3. Condition of pavement.
4. Thickness and condition of material being removed.
5. Type of material being removed.

As with surface preparation, the skill and experience of the equipment operator determines the quality of the removal product. A best practice is getting references from the paint removal equipment operator or contractor to ensure the capability of the operator. Marking removal equipment is similar, if not identical, to equipment that is used for surface preparation. However, a few important differences exist:

1. A slower speed is needed to remove the marking.
2. Higher pressures are required when using water.
3. Special care must be taken to avoid damage to the underlying pavement.

Marking removal will leave a visible scar. Depending upon the integrity of the pavement under the paint, pre-existing conditions can compound damage to the pavement. All markings that will be removed must be carefully evaluated, which will indicate the method of removal, degree of the removal, and the expectations for the project.

## 7.1 Methods of marking removal

Grinding, milling, or rotopeen machines are drum units that can be hand operated or mounted on a skid steer or other motorized vehicles. Scarring left on asphalt from the impressions of the grinding blades fade over time. Grinding is effective on asphalt, especially if aged and cracked. It also effective on concrete, although the scars are permanent. Is a slow process, typically depending on thickness and type of material. Is not recommended for grooved surfaces.

Sandblasting combines compressed air, sand or other abrasive material which is propelled toward the surface. A relatively slow process for removing airfield markings it can be used for small areas when other equipment is difficult to acquire. Sandblasting is suitable for removing paint on any surface. It requires a precise maneuvering and control of wand. Is a relatively slow process and requires to use protective gear.

Shotblasters propels steel shot, walnut shells, or other abrasive material onto a surface at a high rate of speed. The shot pulverizes the markings and an integrated vacuum system picks up most of the shot and debris. The shot is separated from the debris and recycled into a hopper. The process of using the shotblaster eroded the grooves in the asphalt. However, the pavement under the markings is already deteriorated, and any paint removal operation would have rounded off the grooves. The paint is bonded to the asphalt, and the asphalt is cracked and damaged. When the paint is removed, the damaged asphalt is removing as well. Shotblasting is best used on a non-grooved surface. It captures the majority of shot and dust as the removal proceeds. It may lose some of the shot which can be a foreign object debris issue, especially on grooved surfaces. Its advantage is that it leaves the surface dry, although rinsing with water before applying new markings is advisable to remove residual grit. Recovers most of the stray shot with a bar equipped with a magnet. Shotblasting can be a source of rust spots on a new marking if stray shot remains.

Waterblasting can be categorized by pressure and water volume. Each type of equipment has its advantages and disadvantages, but waterblasting represents a best practice for removing markings from airfield surfaces.

All waterblasting systems offer the following advantages:

- No airborne dust particles, lead, or other toxic substances,
- Clean surface when followed by vacuum sweeper.
- Economical; only water is used.

The disadvantage of waterblasting is that it leaves a damp or wet surface after the work has been completed. The surface must dry before new markings can be applied.

Chemicals designed to remove paint are a viable option, but these are generally restricted to be used in small areas. Characteristics of chemical-removal follow:

- Can be caustic and thus must be contained. Read the label,
- Can be environmentally safe, but slow to react and remove one layer at a time,
- Tend to be expensive,
- Is a slow process,
- Leaves a residue that can be cleaned up with pressure washing. Both chemicals and the water must be contained, tested, and disposed of.

- Is good on most surfaces.

## 8 CONCLUSION

Road markings are continually improving with emerging trends. Quality requirements are in most standards and regulations designed to capture all kinds of roads from motorways to III. Class roads. Therefore they contain a number of general information and necessary compromises. Airport operators should take into account not only the costs, but the airport markings are loaded much more not only by weather but also by mechanical wear. Airfield markings are a small component of a large construction project. Therefore they are often incidental to the overall job. As with anything worth doing, for markings, details must be monitored, procedures must be followed, results must be inspected, and most important, specifications must be enforced. When the process is done well, the markings can perform effectively for up to five years or more. When the process is done poorly, the markings can fail within weeks or months. So although markings may be an incidental item in a large airfield project, they can pose as a significant problem when performance is shortened and safety is compromised. When choosing the proper material it is also necessary to consider that marking in a runway touchdown zone at aerodromes with a high traffic density will quickly become coated with rubber, and therefore it is not efficient to apply more expensive materials with longer durability.

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