Each type of bead described, and compared in size in figure 3-3, has a different coverage rate, based on its size and/or specific gravity. Whereas Type I and Type III glass beads are suited to any material, Type IV is best suited for thicker materials because of its size and the need to properly embed it in the wet binder. Selecting the type of bead suitable to the binder being applied is a best practice. Retro-reflectivity ranges at installation are provided in the figure as a guide for performance criteria.

Retro-reflectivity of airfield markings ranges from 100 – 1300 mcd/m²/lux. The higher the retro-reflectivity, the brighter the marking appears, and the further away it can be seen.

FIGURE 3-4. POOR TYPE I BEAD DISTRIBUTION; READINGS AVERAGED ONLY 135 mcd/m²/lux.

FIGURE 3-5. GOOD TYPE I BEAD DISTRIBUTION; READINGS AVERAGED 300 mcd/m²/lux.
3.1.2.1 Type I Low Index Beads (1.5 IOR)

The TT-B-1325, Type I low index beads have been used on highways for decades, and they were adopted by the FAA and USAF in the mid 1990s for use on airports. Made from recycled glass, Type I beads have the smallest diameter compared to the other approved beads.

Type I glass beads have a coverage rate of seven pounds per gallon of water-borne or solvent-borne paint. At installation, Type I, applied properly in a white binder, should yield retro-reflectivity readings ranging from 300–450 mcd/m²/lux. Figure 3-4 shows an example of poor Type I bead distribution, and figure 3-5 demonstrates good Type I bead distribution. Excellent bead distribution should yield up to 450 mcd/m²/lux at installation.

3.1.2.2 Type II Beads

Type II beads are no longer included in the specification and should not be used in airfield markings.

3.1.2.3 Type III High Index Beads (1.9 IOR)

TT-B-1325, Type III high index glass beads are made from virgin materials that provide a higher IOR; this results in a concentrated beam of returned light, (see figure 3-6). In comparison, Type I or Type IV beads return a diffused light beam. When installed in white paint, Type III beads should yield reflectivity values between 600–1300 mcd/m²/lux at installation, and they represent the highest potential reflective values of any of the specified glass beads. Type III beads are recommended when long-term performance is desired. When higher retro-reflectivity readings are achieved at installation, and the beads are well anchored and embedded, the marking will remain effective for a longer period.

FIGURE 3-6. DEMONSTRATES THE GREATER RETURN OF LIGHT FROM THE 1.9 IOR (TYPE III GLASS BEADS) WHEN COMPARED TO THE 1.5 IOR (TYPE I OR TYPE IV GLASS BEADS).
Type III beads are the densest of the glass beads, and require distribution of ten pounds per gallon due to their high specific gravity. Although more expensive than either Type I or Type IV, Type III beads are expected to provide 1) better initial retro-reflectivity and 2) if applied properly, better long-term performance. For example, if markings have initial readings of 800–900 mcd/m²/lux, it will take longer for the markings to lose their effectiveness, resulting in less maintenance. Conversely, if the low index beads are installed properly with initial readings of 300–500 mcd/m²/lux, reflectivity will drop below acceptable levels more quickly, thus requiring more frequent maintenance, more paint build up, etc. Figure 3-7 shows poor distribution, figure 3-8 shows excellent distribution.

Studies conducted by FHWA and other agencies have concluded that, “minimum retro-reflectivity values are speed dependent. Preview or visibility distance is the distance that the delineation provides the driver to see changes in roadway alignment. Preview distance is important, especially at higher speeds [that occur during landings and take-offs of aircraft]. When drivers [or pilots] are provided with higher reflectivity values, longer preview distances are achieved, which is desirable from an information acquisition, information processing, and safety point of view”.  

3.1.2.4 Type IV Low Index Beads (1.5 IOR), Type A and B

TT-B-1325, Type IV “big beads” were approved for use by the airport industry in 2005. Also made from recycled glass or by direct melt, they are larger than any of the specified glass beads. When applied in standard white water-borne paint, the reflectivity readings should range between 350–500 mcd/m²/lux at installation.

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However, given the size of the glass bead (0.84–1.68 mm for Type A, and 0.59–1.19 mm for Type B), they are best suited for use in the high build acrylic binder with a specified wet film thickness of at least 25–30 mils (TT-P-1952, Type III). In contrast, TT-P-1952, Type I or II binder should only be applied between 12 and 16 mils to avoid cracking of the dry film and premature failure. When Type IV glass beads are applied to standard water-borne traffic paint at 15 mils wet film thickness, results are poor (see figures 3-9 through 3-11). Type IV glass beads are applied at the rate of eight pounds per gallon of water-borne or solvent-borne paint. After only six months of service, the markings in figure 3-9 are no longer functional at night. When the markings were applied, the coating thickness was insufficient to anchor the large glass beads, and normal traffic dislodged them.

A considerably thicker wet film thickness (wft) must be applied to achieve proper bead embedment and anchoring with Type IV glass beads. Accordingly, TT-B-1325 Type IV beads should be used only with a TT-P-1952, Type III high build acrylic binder with a specified wet film thickness of at least 25-30 mils. TT-B-1325 Type IV beads should not be used with TT-P-1952 Type I or Type II binder.

Figure 3-10 shows what happens when glass bead guns do not uniformly cover the marking being applied. Figure 3-11 is a magnified illustration of poor embedment of beads in an insufficient coating thickness. The beads in figure 3-11 are barely anchored in the binder, and they will dislodge with very little traffic, as seen in figure 3-9. Although bead distribution was good in figures 3-10 and 3-11, reflectivity readings were only 125 mcd/m²/lux on the yellow marking. The readings would increase to a range of 200-350 mcd/m²/lux for yellow markings if the beads were properly embedded in the paint.
3.1.2.5 Coatings or “Coupling Agents” for Glass Beads

Coatings improve performance of glass beads and are recommended by the FAA in AC 150-5370-10, Section 620, Paragraph 2-3. Reflective Media: “Glass bead treatments are specifically designed to enhance the performance characteristics of the pavement markings in the binder systems approved for use on airfields.”

- **Adhesion coatings** improve the overall durability of the painted marking by promoting adhesion of the glass to the specified paint.

- **Flotation coatings** aid proper embedment of the beads in the marking material. Research has shown that beads embedded between 50 and 60 percent (figure 3-12) in the wet marking material will provide the optimal (brightest) retro-reflective values. The marking material “behind” the bead acts as a mirror. If there is too little or too much embedment, not enough light will reach the back of the bead and return to the observer. Additionally, beads that are not embedded deeply enough will dislodge from the marking, reducing the effectiveness of the marking during darkness and other low-visibility conditions, when they are needed most (figure 3-9, seen previously).

- **Moisture resistance coatings** repel moisture; they assist with flow properties and inhibit clumping or agglomeration of glass beads.

- **Dual coatings**, often recommended for water-borne paint, help promote both adhesion and flotation of beads.

![Figure 3-12. Glass Bead Embedment in Both Wet and Dry Paint Film.](image)

3.2 OTHER APPROVED MATERIALS

Other marking materials are approved in most guidance literature. Although water-borne paints are used predominantly on domestic, private, and military airports, some circumstances warrant the use of other approved materials.
3.2.1 Solvent-Borne Paint (A-A2886A, Type I or II)

Solvent-borne (oil-based) paint is a single-component paint containing alkyd resins, acrylic resins, chlorinated polyolefins, or chlorinated rubber. It typically contains volatile organic compounds (VOC) such as toluene, heptanes, VM&P (Varnish Makers & Painters) naphtha, and MEK (methyl ethyl ketone), all of which exceed the EPA limits for VOCs. The use of the solvent-borne paint may be warranted in cool, humid environments, because in such environments, application restrictions are not as critical as with water-borne paints.

3.2.2 Durable Marking Materials

Three marking materials are commonly classified as durable, (i.e., their life expectancy is longer than that of water-borne or solvent-borne paints): epoxy, methyl methacrylate, and thermoplastic. Used predominantly on highways, durable markings are effective on airfield pavements that are subjected to constant traffic and wear. Two warnings should be heeded about using durable materials on airfield pavements: (1) they are difficult to remove if they become obsolete, and (2) if subjected to snowplows, the glass beads may shear, causing the marking to lose reflectivity and effectiveness during darkness and other low-visibility conditions. This is a difficult problem to repair because of the durability of the material and the cost to remove and/or reapply it.

3.2.2.1 Epoxy

Epoxy is a durable, two-component system consisting of a pigmented resin base and a hardener. During installation, both components are mixed at a ratio of 2 parts resin to 1 part hardener, and the material is applied with specialized equipment. This material is sprayed onto the surface at approximately 1200 psi with an airless system. Airless pumps can be set to deliver the two components at the correct ratio. Epoxy striping material is classified as 100 percent solids; this means that evaporation (of solvents or water) is not used to cure the material. Thus, without this evaporation process, a typical application rate at 60 square feet per gallon yields 30 mils wet and dries to 30 mils. Epoxy striping material is cured via a chemical reaction, and it can be applied at temperatures as low as 35°F. It can be applied over other epoxy materials, but only once. After a second application, the old material must be removed. For epoxy, Type I glass beads should be applied at 14 pounds per gallon, Type IV glass beads at 15 pounds per gallon, and Type III beads at 20 pounds per gallon.

3.2.2.2 Methyl Methacrylate

Methyl methacrylate is a two-component system; it is 100 percent solid material and chemically reactive, containing no volatile solvents. The components consist of a pigmented material (the
“A” component) and a liquid or powder catalyst (the “B” component). The catalyst makes the material harden. The components are mixed together as they are applied, and this material can be installed at colder temperatures than conventional water-borne paint.

Specialized equipment is required when methyl methacrylate is used, and it should comply with the manufacturer’s recommendations. This marking material should be applied to the pavement according to the manufacturer’s recommended methods at 1.5 mm (60 mil) minimum thickness at a rate of 30 square feet per gallon. In this case, glass beads should be applied at 14 pounds per gallon for Type I, 15 pounds for Type IV, and 20 pounds per gallon for Type III beads.

3.2.2.3 Thermoplastic (Hot Melt)

Thermoplastic is a blend of solid ingredients (resins, pigments and fillers) that becomes liquid when heated to 400–425 F. The material becomes solid again after it cools. It is generally applied from 60 to 120 mils, depending upon the marking requirement. There are two types of thermoplastic: (1) hydrocarbon, a petroleum derivative, and (2) alkyd, synthetic resins formed by the condensation of polyhydric alcohols with polybasic acids. Both types are available in loose granular and block forms, and both have “intermixed beads” in the product (glass beads added to the mixture during manufacture). When installed, a “top dressing” of glass beads is applied to enhance initial reflectivity. As the marking wears, some of the “intermixed” beads are exposed, providing a lower level of reflectivity for an extended period of time.

When applied to asphalt, the 400º molten plastic melts the bitumen, bonding to the surface when it cools. Concrete pavements do not melt when hot thermoplastic is applied, so other bonding mechanisms like primers are relied upon, including water-borne or solvent-borne paints. The adhesive bond to concrete is inferior to the thermal bond on asphalt. However, when this material is used on concrete, the hydrocarbon type works better than the alkyd type.

3.3 COMPATIBILITY OF MATERIALS

<table>
<thead>
<tr>
<th>Existing Material (Old Coating)</th>
<th>Restripe (New) Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waterborne Paint</td>
</tr>
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<td>Waterborne Paint</td>
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</tr>
<tr>
<td>Solvent Paint</td>
<td>✓</td>
</tr>
<tr>
<td>Epoxy</td>
<td>✓</td>
</tr>
<tr>
<td>MMA</td>
<td>✓</td>
</tr>
<tr>
<td>Thermoplastic</td>
<td>✓</td>
</tr>
</tbody>
</table>

**TABLE 3-3. MATERIAL COMPATIBILITY INDEX**

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. Table 3-3 presents a material compatibility index. 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.

3.4 TEMPORARY MARKING MATERIALS

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 (FOD) 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.

3.5 MATCHING MATERIAL TO AIRPORT ENVIRONMENT

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.

- As demonstrated in table 3-3, 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.
3.6 MATERIAL TESTING

Material testing is performed at the option of the Engineer (per FAA AC 150/5370-10). Manufacturers’ material certifications for each batch or lot are an accepted practice for verification of compliance.

Military guidelines ETL 97-18 (USAF) and UFGS 32 01 11.51 (Navy, Army, Marines) specify that when materials are delivered to the job site, they must be sampled by the contractor in the presence of the inspector, labeled, and sent to an independent laboratory for analysis and verification of compliance. Enforcement of this specification is inconsistent, but when it is required, the testing is both time-consuming and expensive. Each material specification contains testing requirements (i.e., TT-P-1952E or TT-B-1325D).

Investigation has shown that some applicators thin the paint when loading it into the machines, thus causing the material to be out of compliance when applied. Sampling the material directly from the containers does not detect this problem.

Reliance on material certifications alone is expedient, but not advisable.

The other extreme of sampling and testing each batch by an independent laboratory is both time-consuming and expensive. When enforcement is inconsistent, there is a disparity in competitive bidding.

A best practice is to take a 1-quart sample of each batch from the striping machine, label and retain for the warranty period under manufacturer-recommended storage conditions. Material certifications will suffice unless there is a problem with the coating within the warranty period.
4 SURFACE PREPARATION

To perform as expected, pavement markings must adhere to the pavement surface. Thus, the pavement surface must be prepared properly prior to applying markings. Surface preparation and paint removal are two separate procedures. Surface preparation involves the cleaning of a variety of contaminants such as curing compound, rubber, loose and flaking material/paint, algae, rust, oil, dirt, and other substances. A range of practices can be used to clean (prepare) surfaces, depending on the specific requirements of a project.

Chapter 4 addresses the activities and methods associated with surface preparation prior to applying markings to airfield pavement. The types of contaminants that may need to be cleaned off and the methods that can be used to clean them are discussed. Chapter 4 addresses cleaning (preparing) markings to improve the bond between the surface and the new marking. Chapter 5 addresses removing markings when the markings are no longer applicable or for other reasons. Table 4-1 indicates the personnel who will gain the most benefit from the material in this chapter. Table 4-2 summarizes the best practices presented in this chapter.

TABLE 4-1. CHAPTER CONTENTS MAY BENEFIT:

| Applicators |
| Airport Operators |
| Designers/Engineers |
| Inspectors |

TABLE 4-2. BEST PRACTICES FOR SURFACE PREPARATION

<table>
<thead>
<tr>
<th>Section Reference</th>
<th>Best Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1, 4.3.1</td>
<td>Waterblasting is best for surface preparation.</td>
</tr>
<tr>
<td>4.1</td>
<td>Perform surface preparation before painting.</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Remove curing compound on new concrete.</td>
</tr>
<tr>
<td>4.2.4, 4.4.2.4</td>
<td>Remove algae, don't paint over it; use treated paint.</td>
</tr>
<tr>
<td>4.2.5, 4.4.2.5</td>
<td>Rust remedied by cleaning and modified paint formula.</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Remove oily substances before marking.</td>
</tr>
<tr>
<td>4.3.5</td>
<td>Sweep, blow with air, or rinse with water after cleaning.</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Surface preparation is specified as separate line item in project.</td>
</tr>
</tbody>
</table>

4.1 DEFINITION OF SURFACE PREPARATION

Surface preparation is the cleaning and removal of *anything* that would reduce the bond between a newly applied material and the surface. All current guide specifications convey the *intent* to adequately prepare the surface, but the process is generally overlooked.

“The Engineer should specify any additional surface preparation required and should specify the type of surface preparation to be used when existing markings interfere with or would cause adhesion problems with new markings.”

Source: FAA AC 150/5370-10
Airfield surfaces should be cleaned before being repainted. Given the unusual conditions to which they are subjected, airfield markings can quickly become a maintenance problem when they are repeatedly painted over without adequate cleaning.

Many airfield markings appear well bonded. However, when cleaned by waterblasting with only 6,000–8000 psi as seen in figures 4-1 and 4-2, old paint that was oxidized and brittle yielded, having lost its “glue” and elasticity from UV deterioration. Waterblasting as a method of surface preparation is a best practice. Applying more paint without cleaning the marking only adds to paint build-up, which results in the conditions shown in figures 4-3 through 4-7. Figure 4-3 demonstrates that repeated painting on concrete without preparing the surface results in delaminating of the paint layers. The marking will

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**Surface preparation is a necessary step that should be completed prior to the application of any airfield marking.**

Seventy-five percent of all coating failures are attributable to deficient surface preparation and/or application. The unit cost of repair is normally two and one half times higher than the original coating application unit cost and frequently results in lower quality due to adverse application conditions. This analysis does not include the potentially staggering cost of down-time and loss of facility production. Source: S.G. Pinney & Associates

S. G. Pinney & Associates is a protective coatings inspection firm. Although pavement markings are not protective coatings, they are prone to similar failures when surfaces are not properly prepared.
require paint removal before repainting. When asphalt is repainted without cleaning the surface, the multiple layers of paint can crack, causing premature deterioration of the asphalt, seen in figures 4-4 and 4-5. New coatings are designed to bond well to the pavement. However, if they are applied on top of old layers, and if the old layers are weak, the fresh coating will cause the old layers to crack and pull apart. The asphalt will crack as well, because the paint bonds better to the asphalt than the asphalt does to itself, evident in figure 4-5. Water penetrates into the pavement and erodes the asphalt. The freeze-thaw cycle worsens the problem, and soon the asphalt surface qualifies as a pre-existing, damaged condition.

The benefits of preparing the surface before painting it are obvious, but it takes time and money. Busy airports give applicators limited time, mostly overnight, to maintain the markings. It is not unusual for them to reapply all of the markings three or more times per year. Some of the reasons for not performing proper surface preparation include the following:

1. A lack of equipment.
2. Difficulty in coordinating surface preparation operations and marking schedules.
3. The amount of time required to prepare the surface.
4. Interruption to airport operations.

Figure 4-6 shows a marking with a single coat of paint that is 30-months old, and the coating is cracked. It would benefit from cleaning prior to repainting. The life of the pavement under thick paint is much shorter than the life of an unpainted surface next to it (figure 4-7). When the markings are not cleaned before the application of more paint, the accumulating layers turn into chunks of paint, beads, and asphalt, which break apart and become FOD. The voids (missing pieces of the centerline marking) were chunks of paint, glass beads, and asphalt that dislodged and were loose on the runway.
The old saying goes: “If you always do what you always did, you’ll always get what you always got.” Changing practices to include surface preparation will provide longer-lasting markings, reduce build up of markings, and reduce the potential for FOD. Consistently performing surface preparation is a best practice. Whatever can be done in the time allotted should be done well.

4.2 CONTAMINANTS TO BE REMOVED

The term “contaminants” is used to describe surface conditions that should be corrected before applying marking materials to the pavement. Whether on a brand new surface or over existing markings, the surface must be prepared appropriately to ensure a good bond of the new markings to the pavement.

4.2.1 Curing Compound

A curing compound is sprayed on new concrete to produce a moisture-resistant membrane. The membrane generally wears off the concrete during the course of one year, depending upon traffic. If markings are to be applied, the best practice is to remove the membrane first. If paint is applied on top of the curing compound, it will flake off as the membrane sloughs off, as seen in figure 4-8. Most specifications state that all new concrete pavements shall be free of any curing compound before markings are applied.

Pavement marking contractors are normally hired by a general contractor to apply markings on newly constructed pavement. Although the marking contractor’s work should include the removal of the curing compound on new concrete pavement, this is sometimes done poorly or not at all. If this happens, the markings eventually flake off.
4.2.2 Rubber Deposits

Rubber builds up on the touchdown zone of a runway surface. As aircraft touch down the stationary tires drag from zero to the speed of the landing aircraft almost instantly. This causes high heat and melting of some of the rubber from the tires. The hot rubber is spread onto the pavement and gradually fills the micro texture, and eventually macro texture, of the pavement, seen in figure 4-9. When the rubber cools, it hardens. When the pavement texture is covered with the rubber deposits, as seen in figure 4-9, the build up should be removed, figure 4-10. Busy airports accumulate rubber deposits quickly, obscuring the centerline marking within days of being painted. At some airports, removal of rubber deposits may be scheduled to be performed monthly, but the centerline markings are repainted every one to two weeks in some cases. This is not a best practice, but it is a practical one, since the visibility of the runway centerline is important. Ideally, rubber deposits are cleaned before applying markings.

4.2.3 Loose and Flaking Marking Material
Loose, flaking and poorly bonded material from previous marking applications is the most common condition dictating surface preparation. UV deterioration, jet blast, and freeze/thaw cycles affect markings and pavements, but the markings react differently compared to the pavement. Figure 4-11 resulted when paint was applied non-uniformly, heavier in the middle of the line, lighter on the edges. The thick paint in the middle cracked. If the stressed and damaged material is not removed through preparation of the surface, repeated coatings cause asphalt pavement to deteriorate prematurely. Most markings (coatings) absorb moisture and expand/contract differently than the pavement, contributing to the cracking seen in figure 4-12.

4.2.4 Algae

Algae grow in warm, humid environments, particularly on surfaces that have light traffic. Airport pavements out of the traffic path are susceptible to algae growth. Algae invade everything in their path, covering airfield markings and the pavement. When the markings become “gray” or “black” with the contaminant, they become obscured, as observed in figure 4-13. Although the markings may appear faded or gone, they are merely covered with algae. If new markings are applied over the algae-covered surface, the bond will be poor, and the algae that become sandwiched between the layers of paint will thrive when moist.

There are two methods that can be used to distinguish microbial (fungal and algal) growth from dirt on airport markings: (1) Wearing gloves and eye protection, spray household bleach on a portion of the area, where the airport markings have become darkened. If this discoloration turns lighter after the bleach has been applied, there is microbial growth. If the discoloration does not change color, it is dirt. (2) Spraying water on a darkened surface may eventually result in blooming effects such as a greenish tinge. If this occurs, algae are present.

Figures 4-14 and 4-15 were taken 18 months apart. The markings were washed off with water from the airport’s
fire truck prior to being painted by the contractor. As an expedient and cost-conscious measure, rinsing the algae-coated markings was better than doing nothing, but within a short time, algae covered the markings again, perpetuating the cycle.

On another project, the algae-covered surface was prepared with high-pressure waterblasting equipment before repainting. The “before and after” pictures in figures 4-16 and 4-17 demonstrate the value of thorough preparation. Not only was the algae washed off, so was all loose and poorly bonded paint: a best practice.

On the same airport project, eighteen months after repainting most of the runway with an algae-resistant formulation, the “treated" threshold markings seen in figure 4-19 were free of algae,
4.2.5 Rust Discoloration

Iron present in aggregate and in underground soils and water stains white airfield markings, affecting compliance with the color standards maintained by all governing agencies. The iron contaminants on the pavement surface are transported by rainwater across the runway. The standard water-borne paint is porous, and it absorbs the rust contaminant, but generally where it first comes in contact with the paint. In other words, the leading edge of the painted marking is affected the worst, as seen in figure 4-23. Figure 4-24 shows depressions where water flows or stands, and the rust discoloration appears heavy there as well.

Where the pavement is grooved, rust stain is noticeable in the grooves, but not as much on the surface. Where the grooves end before the sideline, the rust discoloration becomes more obvious again.

The “whiter” sideline next to the aiming point marking seen in figure 4-25 is further evidence that this stain is caused from rainwater runoff, the leading edge of the marking is stained the most.
In some instances the rust discoloration enters the markings from the bottom up, and the entire marking is discolored, as seen in figure 4-26. Figures 4-27 and 4-28 illustrate a more obvious example of contaminated ground water affecting the surface marking by seeping up through a crack in the pavement. Figure 4-28 was taken two years after figure 4-27, demonstrating the advantage of using a modified formulation of TT-P-1952 to resist the rust staining.

When remarking rust-discolored markings, cleaning them to remove as much of the rust deposits as possible is a best practice. Figure 4-29 is an example of a stained marking that was not cleaned before it was repainted. Within a few months, the stain bled through and the marking became discolored again.

A commercial rust remover was tested on severely rust-discolored markings. As seen in figures 4-30 and 4-31, the chemical agent that removed the rust also damaged the glass beads, making them ineffective during darkness.
4.2.6 Oil, Jet Blast Residue, and Similar Substances

Oily substances coat the pavement and the markings; and they prevent a new coat of paint from bonding. Whenever these substances are encountered, removing them before applying new markings is a **best practice**. Figures 4-32 and 4-33 show areas before cleaning; figure 4-34 is after cleaning; and figure 4-35 is the same area and markings three and one half years later.

The equipment that was used to clean the surface is a pressure washer attached to a floor machine (see figure 4-34). The floor machine houses a rotor bar equipped with spray nozzles. When water charges the system, the force of the water spins the bar in a circular pattern so that the floor machine cleans a swath of pavement as it is pushed along the surface. A small amount
of detergent added to the water helps break down the oils both on the surface and in depressions in the pavement. A vacuum attachment recovers the oily wastewater for proper disposal.

Jet blast residue is another contaminant that accumulates at thresholds and in areas where aircraft test their engines. Figure 4-36 shows the difference between pavement with jet blast residue and pavement where the residue has been cleaned by waterblasting. It is a best practice to clean off jet blast residue before applying more material to the marking.

4.2.7 Dirt and Loose Rocks

Loose materials are more obvious and are generally cleaned before markings are applied. Figure 4-37 shows how a paint-removal process leaves dust that must be blown off, and then vacuumed before the new markings can be painted. The surface to be marked should be free of anything that would prevent the marking material from bonding to the surface.