CARDINAL
INTERNATIONAL
GROOVING AND GRINDING INC.

Originators of the SAFE-T-GROOVER®

Contents

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General Information on Airport Grooving

As most airport officials and engineers know, grooving is recommended as the only effective way to eliminate hydroplaning on wet runways both bituminous (asphalt) and Portland cement concrete. In addition to hastening the drying of the pavement, grooving also helps to reduce stopping distances permitting the user of shorter runways and/or larger aircraft.

In a study for the FAA it was proved that not only did grooving improve runway surface friction on clean runways, but it was also more effective on surfaces with rubber accumulation. As an added benefit the rate of rubber accumulation on grooved runways is less than on ungrooved runways with the same level of usage.

Enclosed with this Cardinal Specification Manual are answers to some of the most often asked questions about grooving. A major concern to most airport managers is the inconvenience and loss of revenue while a runway is being grooved. The length of time it takes to groove a runway is mainly dependent upon the size and power of the grooving equipment as well as the type of diamond blades used. Additionally, the type of pavement, bituminous or Portland cement concrete, as well as the hardness of the aggregate and the allowable work hours per day are also important factors in determining the number of days required for grooving a runway.

Since high capacity grooving equipment utilizes multiple heads with preset spaced diamond blades, and because of the requirement that grooves not be any closer than required by specifications to existing transverse joints, the spacing of these joints in the runway is important and must be equal throughout the runway length.

Diamond blades require a continuous supply of water for cooling during grooving operations. Clean water must be available either on the airport site or within a reasonably close distance from a hydrant capable of delivering approximately, 500 gallons per minute so that there is no delay in shuttling water by tank trailers to the grooving operation on the runway.

The availability of as many continuous working hours as possible also serves to lower the grooving cost. This is because a minimum amount of time is required to start grooving at the beginning of a shift and an additional segment of time is required at the end of this shift to prepare the runway for aircraft use.

The contractor should be prohibited from allowing any of the fines generated during grooving from entering either storm sewers or drains. In order to keep grooving costs to a minimum it is recommended that the highly diluted water carrying fines of approximately 50 mesh in size be distributed in the adjacent grass area. Not only is this material nonhazardous but it has also been proven to be of nutritional value to the vegetation. This can be accomplished by simply continuously flushing the runway with large quantities of water during the grooving operation.

If the contractor elects to vacuum the concentrated solids generated by smaller low-capacity grooving equipment, it is recommended that the collected material be removed from the area by trucks rather than deposited in piles in the grass area where it will interfere with lawn maintenance equipment.

In order to avoid disruption to normal aircraft operation many airports require grooving to be done at night when there is less air traffic and inconvenience to airport users.

Answers to Concerns About Safety Grooving on Airport Runways

1. **Will grooves hold up in bituminous concrete (asphalt) pavement?**

   If the pavement is stable, of sound density and on a proper subbase, there is no danger of grooves spalling or closing up in bituminous (asphaltic) concrete pavement. Approximately 90% of all the grooved runways in the United States are asphalt.

2. **Will grooves increase spalling of Portland cement concrete?**

   Not if care is taken to leave a 3" to 9" space adjacent to the transverse joints. However, existing spalls and random cracks should be repaired prior to pavement grooving. All runway grooving is transverse and therefore grooving crosses all longitudinal joints without any detrimental effect.

3. **Will grooves fill up with rubber and dirt?**

   Experience indicates that grooves are self-cleaning from traffic and rainfall with normal maintenance. Military installations with frequent touch-and-go operations sometimes use a cresylic acid solution and a metal broom sweeper to facilitate the removal of rubber deposits. However on balance, grooved runways probably require less rubber removal than ungrooved runways.

4. **Will grooved pavement be damages when ice freezes in the grooves?**

   Freezing does absolutely no damage to runway grooves. It also has been found that grooves facilitate dispersion of thin ice that forms at the top of the groove if freezing weather should occur when the grooves are filled with water.

5. **What is the optimum groove pattern?**

   Grooves are always 1/4" wide by 1/4" deep on centers (spacing) from 1 1/8 inches up to 2 inches. Naturally the closer the grooves, the greater the water carrying capacity and therefore the speedier water removal from the runway dries the pavement faster. However in recent years the FAA has recommended 1 1/2" spacing because it is believed that this is adequate for water removal under almost all rainfall conditions. Spacing of grooves further than 1 1/2" is impractical since the money saved by fewer grooves does not offset the risk of hydroplaning on an improperly drained or a slow draining runway. Spacing closer than 1 1/2" was originally used on military bases where "skip" grooving was installed. Skip grooving is the alternate grooving was installed. Skip grooving is the alternate grooving of the runway say for three lineal feet longitudinally and then skipping three feet and repeating the pattern throughout the runway length. The only instance in which a runway has ever been grooved at less than 1 1/4" centers is the J.F.K. Space Shuttle Landing Facility at Cape Canaveral, Florida because the runway was 300 feet wide and more grooves were needed to carry more than two times the normal amount of water at more than double the distance usually found on commercial airport runways.

6. **What is the cost of grooving?**

   Generally, the cost of grooving consists of the cost of diamond blades, cost of labor to perform the grooving, miscellaneous administrative expenses and the cost of mobilization to the airport. The predominant factor determining diamond blade cost is the type of pavement (bituminous or Portland cement concrete), the hardness of the aggregate, and the sand. Labor costs to groove are dependent on the prevailing wage rates in the area, the speed of grooving which varies with the aggregate as well as groove spacing, the number of uninterrupted hours available for grooving per shift, and the size of the grooving equipment. Although this is an oversimplification, grooving prices vary from a low of 50

cents to a high of $3.00 or more depending on all of the variables. All other conditions being equal, Portland cement concrete is more costly to groove than bituminous concrete.

7. What happens to the debris, slurry, waste water and fines generated during grooving?

Debris, defined as particles between 1/4" and 1/2" in size, rarely appears during grooving because debris comes from an unstable pavement surface. Nevertheless, if they do occur, particles of this size are immediately picked up by the involuted shroud surrounding the blades.

Slurry, defined by the ASTM as a mixture containing more solids than liquids, can come about by the failure of the grooving contractor to supply sufficient clean cooling water to the blades. It will also occur as a result of loss of water brought about by evaporation or casual runoff causing a high concentration of solids. This can be prevented by continually flushing the runway. Excessive water loss will also result in drying of the mixture, adhesion of fine particles to the pavement surface, fines entering the surface pores and discoloration.

Fines are defined as particles generated by the grinding action of the diamond blades. Fines are usually the size of table salt.

Waste water, defined as water already used to cool the diamond blades, must be addressed along with *fines* since they cannot be economically separated as you would separate dust from air in a dry vacuum and simply return the air to the atmosphere. Waste water can be collected by vacuuming but this is expensive and unnecessary. For all practical purposes it is simply water discolored by suspended fines. Not only will its collection and accompanying disposal add 40% or more the to the grooving cost but its removal from the surface is impossible to define quantitatively. Has 50% been removed? 70%? 90%? Who determines how much to remove and how do you prove it occurred.

Another serious drawback to vacuuming if used with modern high-production equipment is disposal cost. The practice of disposing the collected materials in piles in the grass area that eventually interferes with lawn maintenance equipment is not permitted.

Obviously continual flushing of the runway is the best way to dispose of the generated fines. The use of a sufficiently clean cooling water avoids any high concentration of fines (and development of slurry) and flushing into the grass area disperses the fines in such a manner as to be virtually indiscernible. Fines from both Portland cement and bituminous concrete are nonhazardous and nutritionally beneficial to vegetation. Continuous high pressure flushing of the runway prevents fines from lodging in surface pores and also prevents the adhesion that causes a fine residue or film which becomes extremely difficult to remove as water evaporates and the material dries. The resulting discoloration is almost impossible to correct.

8. What portion of the runway should be grooved?

Since there is no way of knowing (particularly during a rainstorm) exactly where a plane will touch down it is highly recommended that the entire length of the runway be grooved. In order to allow maneuverability of the grooving equipment the entire width of the runway should be grooved to within ten feet of each edge.

9. How long does it take to groove a runway?

The time required to groove a runway depends mainly on the size of the grooving equipment, both width and power. For example, the Cardinal SAFE-T-GROOVER which is capable of grooving a full 12-foot wide swath of runway in one pass powered with two diesel engines in excess of 1000 horsepower, can easily groove between 1000

and 3000 square yards per hour. Type of aggregate, width of the runway, and allowable daily working hours are the factors that most affect the time required. Smaller 3-foot wide grooving equipment obviously takes four times longer.

10. How can you keep grooving costs to a minimum?

In order of importance, try to avoid:

a. Vacuuming of generated fines and accompanying expensive disposal.

b. Short daily working hours and limited work weeks.

c. Hard aggregates.

d. Small grooving quantities affecting amortization of mobilization costs.

11. Can the time allowed for grooving legally be limited based on production capacity of today's equipment?

Grooving techniques have been common knowledge to contractors since the 1950's. Limiting the time allowed to perform grooving work based on the capability of using large equipment would not be considered bid restrictive. Such equipment is available to all contractors and if the contractor prefers to use smaller equipment it is simply a matter of using more machines. Since grooving usually occurs after all other construction work is completed and after passing of the cure period, the length of time to groove a runway is a visual factor and failure by the contractor to complete in the allotted time should bear a significant and meaningful penalty.

12. Is pavement grooving really effective?

NASA says yes. See NASA SP-5073 *Pavement Grooving and Traction Studies* which attests to this.

LAPA says yes. The ACPA Base TB-10 *Airports, Pavements, and Airline Pilot's Viewpoint* contains interesting comments regarding grooving.

The FAA says yes. See Advisory Circular No. 150/530-12B, Section IV, *Grooving of Runway Pavements*.

Friction Studies prove it. See SAE *New Methods for Rating, Predicting, and Alleviating the Slipperiness of Airport Runways*.

The managers of airports with grooved runways agree grooving reduces stopping distance 40% and makes a significant contribution to aviation safety.

General Grooving Notes — Purpose and Explanation

Preparation

Grooving is generally the last item of work to be performed before opening a new or rehabilitated runway to traffic. Often times, because of the required cure period, a runway is temporarily marked and striped so it can be utilized for air traffic during the cure period.

On existing runways the following items should be completed prior to grooving when required:

a. Removal of rubber deposits.

b. Removal of excessive paint buildup.

c. Repair of random cracks, spalled areas, and resealing of joints.

d. Electrical work.

e. Striping and marking.

On new or rehabilitated runways the following should be completed:

a. Complete overlay.

b. Electrical work.

c. Temporary or permanent striping and marking.

d. Final grading and new seeding should be delayed until after grooving.

e. Difference in elevation between runway and existing grade should be limited to the depth of the final layer of topsoil.

Cure Time

Although Portland cement concrete can be grooved prior to the normally accepted 21 day cure time, it is not recommended because Portland cement concrete that has not been fully cured will cause excessive wear on diamond blades, thereby increasing the price of the grooving. Although uncured concrete can be grooved faster, the labor saving will not offset the additional diamond blade cost.

Bituminous concrete pavement, if placed at the proper density, requires very little cure time. On airports where runways are very active, it is common to groove within 24 hours of the asphaltic pavement placement. However the FAA advisory Circular suggest a 30 day cure period in order to be certain that the grooving operation will not ravel the pavement. With new asphalt technology, it appears that a cure period of two weeks is more than sufficient.

Groove Pattern and Dimensions

Grooves should be specified to be 1/4 inch wide ± 1/16 inch, by 1/4 inch deep ± 1/16 inch. Except where unusual rainfall circumstances dictate otherwise, grooves should be placed on 1 1/2 inch centers. Obviously the closer the groove spacing, the faster the runway drains. However, the FAA recommends 1 1/2 inch spacing as a standard. The small amount of money that is saved by spacing grooves farther apart is offset by the possibility of restricting runway drainage to the point where a dangerous hydroplaning condition may occur.

Grooves should be stopped within ten feet of the runway edge on each side in order to permit maneuverability of the grooving equipment. The effect on runway drainage of the grooves stopping short of the full width is inconsequential. The normal tolerance for the ten foot stopping distance is ± 9 inches.

If the runway contains a paved shoulder at least ten feet in width, grooves can be placed for the entire width of the runway.

Grooves should be placed perpendicular to the center line of the runway with a tolerance of ± 3 inches in alignment for 75 feet. Realignment of the grooving equipment should occur every 500 feet or as required.

Grooves should not be placed closer than three inches nor further than nine inches from transverse joints in the runway. Grooves can be sawn through longitudinal or skewed joints.

Grooves should not be closer than three inches nor farther than 33 inches to any obstructions in the runway such as in-pavement light fixtures.

Groove spacing between arbors on successive passes of the grooving equipment should be no closer than 1 1/4 inches nor farther than two inches.

Grooving Method

Grooving should be performed by using diamond blades. Since water is used in cooling the diamond blade, the fines generated during grooving are suspended in the water in a highly diluted manner. Fines generated by grooving bituminous and/or Portland cement concrete pavements are considered NONHAZARDOUS. Actually they are nutritionally beneficial to vegetation when disposed of by flushing with water. The waste water containing highly diluted and suspended material must be continuously removed from the pavements surface by flushing, sweeping, or vacuuming. If flushed with sufficient water the finely suspended particles will be virtually indiscernible and unrecoverable. If insufficient water is used during the grooving operation, a slurry defined as a mixture containing more solids than liquid will form, necessitating vacuuming, and the material collected should not be disposed of in the grass area by pumping through a hose since this leaves a measurable accumulation that will interfere with the operation of the grass maintenance equipment. If a sufficient quantity of water is lost from the mixture then the remaining solids, which will approach the consistency of slurry, must be broomed or vacuumed, collected, and disposed of at a predetermined location onsite or offsite. The runway is to be left in a sufficiently clean condition so that the surface is not slippery and has not been visually discolored by the grooving operation residue. A high pressure washdown is required to prepare the runway for the resumption of air traffic.

Under no circumstances should any solids be permitted to enter the storm or drain sewers. Adequate protection is generally afforded by using a filter such as a hay bale or burlap.

Water Requirements

A source of water should be provided at no cost to the contractor, capable of producing approximately 500 gallons per minute under pressure. A hydrant located in a place accessible by paved roads on the site or within a reasonable distance from the runway is sufficient for this requirement. Water is to be hauled by the contractor as required using his own equipment.

Freezing Weather

Because of the quantity of water required to cool the diamond blades while grooving, it is impractical to consider grooving if the temperature drops below 32 degrees over the total time period required to perform the job. The reason for this is because fine spray nozzles are used to cool the diamond blades, and these freeze quickly when the temperature drops below 32 degrees. This freezing not only damages the equipment buy also presents difficulty in thawing out the frozen water lines.

Production

The speed of grooving is very important to most airports. Not only does slow grooving result in loss of revenue to the airport but it results in a significant inconvenience to travelers, airline flight schedules, and private aircraft. If the runway is within normal tolerances of flatness it is no problem to groove up to **3000 square yards per hour** in favorable aggregates such as limerock. Harder aggregates such as glacial and river gravel may

only be grooved at approximately 1000 square yards per hour. Other aggregates such as traprock, dolomite, limestone, granite, etc. can be grooved at rates between 1000 and 3000 square yards per hour.

It is important that the contractor be given the maximum allowable work hours per day. The reason for this is that approximately 45 minutes are lost at the beginning of each shift to stage the equipment on the runway and prepare it for actual grooving. Another 45 minutes is consumed at the end of each shift to remove the equipment from the runway and perform high-pressure washdown to make certain that the runway is clean for landing aircraft. The greater the time allowed daily, the less effect the unproductive time has on grooving production on a percentage basis.

Special Conditions

Because of the requirement that grooves not be placed any closer than three inches nor further than nine inches from longitudinal joints, Portland cement concrete runways should avoid transverse contraction joint spacings that vary. Obviously once the equipment is set up to groove a certain width, it is costly to make changes.

Taxiway Grooving

Taxiways used as high-speed turnoffs should be grooved transverse to the center line, ten feet from each edge and in a step pattern adjoining the runway grooving. The recommend grooved length of a taxiway is 200 to 250 feet from the runway.

Guide Specification — Runway Grooving

The following specification guide should be used in conjunction with Section IV "Runway Grooving" of the Department of Transportation, Federal Aviation Administration Advisory Circular AC No. 150/5320-12B contained in this manual.

Please note two typographical errors as follows:

- Paragraph 26h: "... grooves shall be sawn no closer than 6 inches (15 cm) and no more than 18 inches *46 cm)..." Change "18 inches" to "36 inches (92 cm)."
- Paragraph 26j (3): "The waste material should not be allowed to drain onto the grass shoulders adjacent to the runway..." Change "grass" to "paved."

All specifications for runway grooving should contain at least the following information:

1. **Description**.

    a. The work covered by this section of the specification includes grooving of runway/s and taxiway/s as indicated on the plans. The area to be grooved consists of _____ square yards of _____ concrete pavement as indicated on the plans.

2. **Groove Pattern**.

    a. The transverse groove configuration shall be 1/4 ± 1/16 inch by 1/4 — 1/16 inch deep on 1 1/2 inch centers. Grooves shall be perpendicular to the runway center line and start and stop 10 feet ± 9 inches from the edge of the runway as indicated on the plans. Groove spacing between successive passes of the grooving equipment should be no closer than 1 1/4 inches nor farther than 2 inches.

    b. In areas where there are flush runway lights in the pavement, grooving shall be terminated within 3 inches but not more than 33 inches from the runway light as indicated on the plans.

    c. If cables are close enough to the pavement surface to be damaged by grooving, the grooving shall be terminated within 3 inches but not more than 9 inches from the kerf containing the cable.

    d. Grooves shall not be sawn closer than 3 inches nor farther than 9 inches from transverse joints in bituminous or Portland cement concrete pavement.

    e. The runway intersection shall be grooved to match the grooving in runway _____.

    f. Grooves shall start and stop 10 feet from each end of the runway.

3. **Grooving Method.**

    a. Grooving shall be done by diamond impregnated saw glades mounted on one or more multi-blade arbors on a machine that has been built especially for grooving of pavements. Flailing type grooving work will not be permitted.

    b. Grooving depth control is important and should be maintained within the tolerance. The grooving equipment shall have depth control points no more than 36 inches apart to prevent excess variance in depth caused by irregular profile of the pavement. The depth control points must be in line with the cutting blades to ensure constant depth control across the runway surface.

    c. Grooves shall be sawn perpendicular to the runway center line maintaining an alignment of ± 3 inches in a 75 foot length. Alignment adjustment is to be made as required but not more than 500 foot intervals.

4. **Clean Up**.

    a. Clean up shall be continuous throughout the operation. If insufficient water is used

and the waste material becomes a slurry (more solids than liquid) it must be vacuumed before it dries on the pavement.

b. Highly diluted solids suspended in the water used for cooling can be continually flushed off the pavement surface. Any remaining particles must be pressure washed from the surface of the pavement.

c. Vacuumed material shall not be allowed to be disposed of in visible piles and must be evenly sprayed into the grass area or disposed of as directed by the owner.

d. Solids will not be permitted to enter any storm or drain sewers.

5. **Water**.

a. Water for grooving will be made available at no cost from a hydrant located onsite accessible over paved roads at flow rates not less than 500 gallons per minute.

6. **Working Hours.**

a. Working hours for this project shall be _____ to _____. Special working hours for Runway _____ intersection with Runway _____ will be _____. The runway being grooved will be closed to air traffic unless an emergency occurs that requires the use of the runway. In the event of such an emergency the contractor will be advised by the Airport Manager to clear the runway and leave it in a suitable condition for use by air traffic. Machinery and trucks must be moved at least 200 feet from any active pavement and the runway must be cleared of vehicles and obstacles that might interfere with the safe operation of aircraft. Clearing of the runway must be completed within 30 minutes of notification by the airport management.

b. Contractor will be responsible for providing adequate lighting for any work while grooving at night.

7. **Completion Time**.

a. Completion time is important to minimize interference with normal air traffic. A total of _____ working days will be allowed for the project beginning after the passing of the required cure time.

b. Work days will include Saturdays, Sundays, and legal holidays.

c. Liquidated damages shall be assessed at the rate of _____ for each day that contractor is delinquent in completion of the project.

8. **Method of Measurement**.

a. Pavement grooving shall be measured by area to the nearest square yard of runway grooved and accepted as specified. No deductions in are will be made for grooving omitted adjacent to joints, lighting cable, saw kerfs, or electrical fixtures.

9. **Basis of Payment**.

a. Payment for runway grooving at the contract prices per unit of measure shall be compensation in full for all labor, materials, equipment, and other incidentals necessary to complete the work as specified, except for emergency evacuations which shall be paid at the specified contract price for this item.