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SURVEYS OF GROOVES IN 19 BITUMINOUS RUNWAYS.(U)
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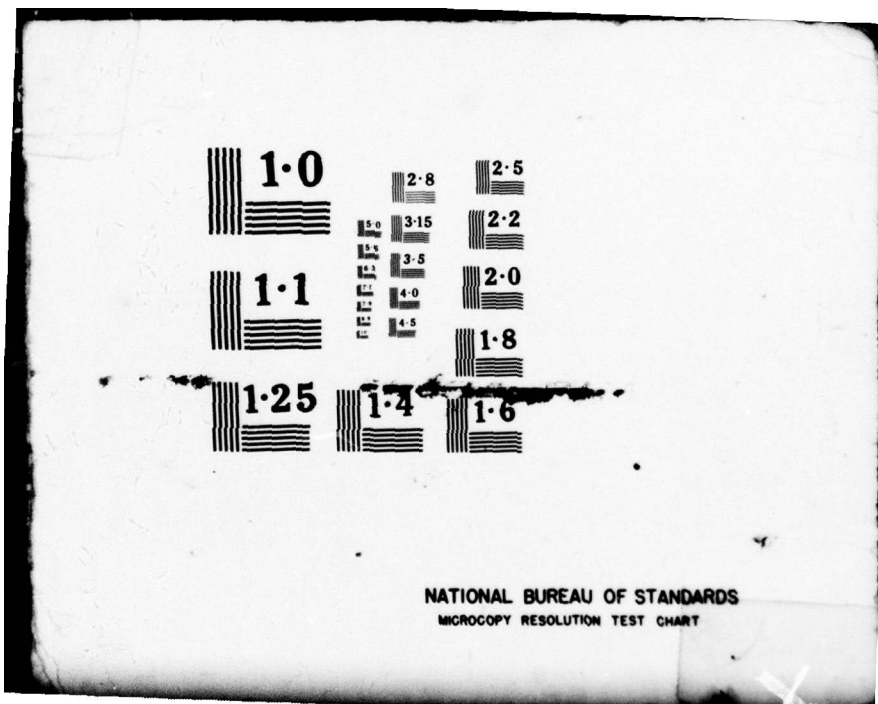
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Report No. FAA-RD-79-28

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**SURVEYS OF GROOVES IN
19 BITUMINOUS RUNWAYS**

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**Richard Melone
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Lakehurst, N. J. 08733**



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| 16. Abstract ↓ This report presents the results of a survey of grooves cut into the bituminous runway surfaces at 19 airports throughout the eastern half of the United States. The survey was conducted during the period 20 March 1978 to 25 May 1978. The objectives of the survey were to determine the extent and frequency of problems, such as chipping, cracking, rounding, wearing, distorting, and contaminating of the grooves. A total of ten different problem areas was identified during the survey with wear, "running together" (closing), and rubber deposits being the most serious of the ten. In general, the grooves were in satisfactory condition and have not resulted in abnormal deterioration of runway surfaces. Three of the 19 runways surveyed appeared in need of resurfacing and/or regrooving. Groove depths averaged less than the required 1/4 inch, while groove width and pitch measured close to specified dimensions. ↑ | | | | 13. Type of Report and Period Covered 9 Final Report 12 61 p. | |
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I INTRODUCTION

A. Since the mid 1960's, transverse pavement grooves have been cut into runway surfaces to channel water and reduce hydroplaning, thus improving aircraft braking and steering capabilities in wet weather. The grooves are saw cut into both concrete and bituminous surfaces with a recommended pattern of 1/4-inch deep by 1/4-inch wide with a center-to-center distance (pitch) of 1-1/8 to 2 inches (see reference a). The FAA has received reports from several sources which indicate that grooves cut in bituminous runways are deteriorating. They have, therefore, requested that the Naval Air Engineering Center by amendment to Inter-agency Agreement DOT-FA74WAI-423, conduct a survey of airports with grooved bituminous runways. The object of the survey being to determine the seriousness, the extent and frequency of problem areas in grooved bituminous pavement, such as:

1. "Running together" (closing).
2. Chipping, rounding, and cracking.
3. Deformations, distortions in groove pattern.
4. Climatic effects.
5. Contaminants, wear, and loading.

B. In response to the FAA request, the NAEC Test Department, Code 9421 prepared a proposal for the Runway Groove Survey (reference b) which was submitted to and approved by the FAA. The proposal specified the following inspection method:

II INSPECTION METHOD

A. The entire grooved portion of the runway will be surveyed. Particular attention will be paid to touchdown, braking and turning areas, and to specific problem areas reported to the FAA.

B. When a defective area is located, the procedure will be as follows:

1. Estimate extent of defective area.
2. Note area on runway layout.
3. Determine nature of defects, that is, classify as:
 - a. Running together.
 - b. Chipping, rounding, cracking.

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- c. Deformation of groove pattern.
- d. Contaminated (with rubber, sand, etc.).
- e. Wearing.
- f. Crushing.
- g. Other.

C. Measurement of grooved depth, width, and spacing, will be made where necessary.

D. The defective areas will be photographed when necessary. In addition, a survey questionnaire, see enclosure (1), was administered to personnel at each airport.

III LIST OF RUNWAYS INSPECTED

The initial list of runways to be inspected, as supplied by the FAA, is shown below. The modified list is shown in Table I.

| <u>Airport</u> | <u>State</u> | <u>Runway</u> |
|------------------------------|--------------|---------------|
| Newark International | NJ | 4L/22R |
| Philadelphia International | PA | 9R/27L |
| Lovell Field (Chattanooga) | TN | 2/20 |
| JFK International | NY | 13L/31R |
| La Guardia | NY | 4/22 |
| Miami International | FL | 9L/27R |
| Ft. Lauderdale International | FL | 9L/27R |
| Herlong (Jacksonville) | FL | 7/25 |
| Allentown-Bethlehem-Easton | PA | 6/24 |
| Erie International | PA | 6/24 |

| <u>Airport</u> | <u>State</u> | <u>Runway</u> |
|------------------------------------|--------------|---------------|
| Cleveland-Hopkins International | OH | 5R/23L |
| Greater Pittsburgh International | PA | 10R/28L |
| Kanawha (Charleston) | WV | 5/23 |
| Greater Cincinnati | OH | 18/36 |
| Albany County | NY | 1/19 |
| Logan International (Boston) | MA | 4L/22R |
| O'Hare International (Chicago) | IL | 4L/22R |
| Detroit Metropolitan Wayne Co. | MI | 3R/21L |
| Minneapolis-St. Paul International | MN | 11L/29R |
| Washington National | DC | 15/33 |

This list was eventually modified for the following reasons:

A. NEWARK INTERNATIONAL RUNWAY 4L/22R--

On the day of inspection, the parallel runway 4R/22L was down for maintenance. This doubled the traffic on 4L/22R and made inspection of that runway unfeasible. Runway 4R/22L, which is a 9,800-foot bituminous runway grooved in 1973, was inspected in lieu of Runway 4L/22R which is 8,200 feet in length and grooved in 1970.

B. HERLONG (JACKSONVILLE) 7/25-- This airport was mistakenly included in the original list. The intended runway for inspection was Jacksonville International Runway 7/25.

C. CLEVELAND-HOPKINS INTERNATIONAL RUNWAY 5R/23L--

This runway was overlaid just prior to our inspection and was not yet regrooved. As a substitute, Runway 10L/28R was inspected. This runway is 6,000 feet long and was grooved in 1974.

D. LOGAN INTERNATIONAL RUNWAY 4L/22R--

This runway was unavailable for inspection due to heavy traffic. Runway 15R/33L, which is 10,000 ft. and grooved in 1972 and 1973, was inspected instead. 4L/22R is 7,800 feet and was grooved in 1975.

E. CHICAGO-O'HARE INTERNATIONAL RUNWAY 4L/22R

This runway was unavailable for inspection due to heavy traffic. Runway 14L/32R, which was closed for resurfacing, was inspected instead. Runway 4L/22R is 7,500 feet and grooved in 1976, Runway 14L/32R is 10,000 feet and grooved in 1974.

F. DETROIT METROPOLITAN WAYNE COUNTY RUNWAY 3R/21L

The airport was mistakenly included in the original list. There are no bituminous grooved runways at Detroit Metropolitan. All runways are concrete.

G. MINNEAPOLIS-ST. PAUL INTERNATIONAL RUNWAY 11L/29R

Runway 11L/29R is concrete. Runway 11R/29L, which is 10,000 feet bituminous was inspected instead.

The actual list of runways which were inspected during the survey along with the various groove patterns as specified by the airports is shown in Table I on the next page.

IV GROOVE PROBLEMS, DEFINITIONS

In conducting the survey of 19 airports, ten factors were identified as groove problems or possible groove related problems. A record of each occurrence of these factors was made showing severity and location on the runway. The factors are:

A. WEAR -- Groove depth measuring 1/8 inch or less (all were supposed to be 1/4 inch). (See Figure 1)

B. CLOSING -- Groove width was 3/16 inch or less (1/4 inch is called for) or noticeably lipped over. (See Figure 2)

C. RUBBER -- Rubber in grooves themselves, not just on surface. (See Figure 3)

D. CRACKING -- Reflective (from concrete subsurface) or cold seam cracks were not noted; however, where cracks propagated along grooves a record was generally made. (See Figure 4)

E. MIGRATING -- Flowing of asphalt resulting in a wavy groove pattern which may affect water runoff rate. (See Figure 5)

F. DEEP/SHALLOW CUT -- Adjacent grooves of different depths because of improper control of cutting blade heights or non-level surface. (See Figure 6)

TABLE I

| AIRPORT/RUNWAY | GROOVE PROFILE | PITCH |
|--|----------------|--------|
| ① CHATTANOOGA (LOVELL FIELD) 2/20 | | 1 1/4" |
| ② GREATER CINCINNATI 18/36 | | 1 1/2" |
| ③ PHILADELPHIA INT'L 9R/27L | | 1 1/4" |
| ④ JACKSONVILLE INT'L 7/25 | | 2" |
| ⑤ FT LAUDERDALE-HOLLYWOOD INT'L 9L/27R | | 1 1/2" |
| ⑥ MIAMI INT'L 9L/27R | | 1 1/2" |
| ⑦ J.F.K. INT'L 13L/31R | | 1 1/2" |
| ⑧ LA GUARDIA 4/22 | | 1 1/2" |
| ⑨ NEWARK INT'L 4R/22L | | 1 1/2" |
| ⑩ ALLENTOWN-BETHLEHEM-EASTON 6/24 | | 1 1/2" |
| ⑪ GREATER PITTSBURGH INT'L 10R/28L | | 1 3/4" |
| ⑫ CHARLESTON, W VA (KANAWHA) 5/23 | | 1 1/4" |
| ⑬ ALBANY COUNTY 1/19 | | 1 1/4" |
| ⑭ ERIE INT'L 6/24 | | 2" |
| ⑮ CLEVELAND-HOPKINS INT'L 10L/28R | | 1 1/2" |
| ⑯ CHICAGO-O'HARE INT'L 14L/32R | | 1 1/4" |
| ⑰ MINNEAPOLIS-ST PAUL INT'L 11R/29L | | 2" |
| ⑱ BOSTON-LOGAN INT'L 15R/32L | | 2 1/4" |
| ⑲ WASHINGTON NATIONAL 15/33 | | 1 3/4" |

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G. ROUNDING -- Wearing away of sharp groove edges. (See Figure 7)

H. SPALLING -- Disintegration, breaking up of asphalt surface.
(See Figure 8)

I. CHIPPING -- Breaking away of aggregate and/or filler material
in sharp edges of groove. (See Figure 9)

J. EROSION -- Washing out of fine filler or binder material leaving
exposed aggregate. (See Figure 10)

V DISCUSSION

A. Included in the above listed problems are several which would occur without the presence of grooves. Wearing, cracking, migrating, spalling, and eroding are inherent to bituminous pavements and are just as likely to occur to an ungrooved surface. However, since grooving may aggravate these problems they are being considered potential groove problems (see Chart I on the next page).

B. Chart I contains a complete listing of all problems encountered at the 19 runways which were surveyed. The ten problem areas are the column headings. Columns have then been subdivided into four major runway areas (threshold, touchdown, braking, and turning). For the purposes of this report, threshold areas are aircraft turn-on areas at each end of the runway, approximate STA 0 to STA 300; touchdown areas are approximately STA 800 to STA 1500; braking areas are usually just prior to primary or secondary turnoffs; turning areas are located at both high-speed or conventional turnoffs and in some cases at cross runways or taxiways. Locations of these four areas were determined jointly by the survey team and the various airport personnel who participated in the actual inspections.

1. The relative severity or extent of each problem cannot be determined from the chart. However, the fact that the problem was noted indicates that the problem is fairly extensive and not just an isolated case. One should keep in mind in studying the chart that the incidence of rubber in the grooves is highly dependent on when the runway was last cleaned of rubber. Some runways were cleaned twice a year and others not at all.

Chart I can be used in the following manner. To determine what problems were found at a particular runway, locate the runway in the left hand column and read horizontally. For instance, JFK Runway 13L/31R, had no record of chipping, cracking, erosion, spalling, closing, or rubber; migrating and rounding were found in the braking area, wear was found in all sections of the runway, and deep/shallow cuts were found in threshold and touchdown areas.

| AIRPORT RUNWAY NO. | CHIPPING | | MIGRATING | | ROUNDING | | CRACKING | | WEAR | | EROSION | | SPALLING | | CLOSING | | DEEP/SHALLOW CUT | | RUBBER* | |
|-------------------------------------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|-----------|---------|------------------|---------|-----------|---------|
| | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING | THRESHOLD | TURNING |
| CHATTANOOGA (LOVELL FIELD) 2/20 | X | | X | | | | | | X | | | | | | X | | | | | X |
| GREATER CINCINNATI 18/36 | | X | | | | X | | X X X | X X | | | | | | | | | X | | |
| PHILADELPHIA INTL 9R/27L | | | | X | | | | | | X | | | | X | | | X X X | | | |
| JACKSONVILLE INTL 7/25 | | | X X | | | | | | X X | | | | | | X | | | | | X X X |
| FT LAUDERDALE-HOLLYWOOD INTL 9L/27R | | | X X X X | | | | | | X | | | | | | X X X | | | | | X X |
| MIAMI INTL 9L/27R | | | X | | | X X | | | | | | | | | X X X X | | | | | X X X |
| JFK INTL 13L/31R | | | X | | | X | | | X X X X | | | | | | | | X X | | | |
| LA GUARDIA 4/22 | | | | | | | | | X X | | | | | | | X | | | | X |
| NEWARK INTL 4R/22L | | | X | | | | | | X X X | | | | | | | | X X X X | | | X X |
| ALLEN-TOWN-BETHLEHEM-EASTON 6/24 | | | X X | | | X X X | | | X | | | | | | | X X X X | | | | X X |
| GREATER PITTSBURGH INTL 10R/28L | | | X | | | | | X X X X | X X X X | | | | | | | X X | | | | |
| CHARLESTON WVA (KANAWHA) 5/23 | | X | | | | | | | | | | | | | | | | | | |
| ALBANY COUNTY 1/19 | | X | | | | | | | | | | | | | | X X X | | | | |
| ERIE INTL 6/24 | | | | | | | | X X X X | | | | | | | | | | | | X |
| CLEVELAND-HOPKINS INTL 10L/28R | X | | X | | | | | X X X X | X | | | | | X | | X X | | | | X |
| CHICAGO-O'HARE INTL 14L/32R | | | | | | | | X X X X | X X X X | | | | | | | X | | | | X X |
| MINNEAPOLIS-ST. PAUL INTL 11R/29L | | | X | | | | | X X | X | | | | | | | X X X | | | | X X |
| BCSTON-LOGAN INTL 15R/33L | X X | | X X | | | | | | | | | | | | | X X X | | | | X X |
| WASHINGTON NATL 15/33 | X X | | | | | | X | | | | | | | | | X X | | | | X X |

* Existence of rubber deposits dependent on when runway was last cleaned.

CHART I - LOCATION OF GROOVE-RELATED PROBLEMS

2. If more specific data are required for a particular runway, the inspection data sheets in Appendix A and the individual runway survey reports, Appendix B, can be referred to.

3. The following comments are also evident from Chart I,

a. Wear, closing, rubber, and cracking are the most common problems.

b. Chipping, rounding, erosion, and spalling are the least common problems.

c. Chipping was found only in touchdown and braking areas.

d. Migrating is most common in threshold areas.

e. Rounding is most common in braking areas.

f. Cracking was found in all runway areas and was limited to cold-weather airports.

g. Rubber deposits were found mainly in touchdown and braking areas.

h. Touchdown and braking areas were, in general, the most heavily damaged, while turning areas suffered the least damage.

C. To further analyze the data presented in Chart I, Chart II through VIII have been prepared. The purpose of these charts is to separate the various airports surveyed into characteristic groups so that comparisons can be made. The characteristics selected for comparison are:

Chart II: High-use versus low-use airports

Chart III: Cold-weather versus warm-weather airports

Chart IV: Warm-weather high-use airport versus warm-weather low-use airport

Chart V: Cold-weather high-use versus cold-weather low-use airports

Chart VI: Runways with groove pitch less than 1-1/2 inches versus runways with groove pitch greater than 1-1/2 inches.

Chart VII: Runways grooved in 1973 or earlier versus runways grooved 1974 or later.

Chart VIII: Runways 10,000 feet or longer versus runways 6,300 feet or less

D. Chart II compares runways surveyed at high-use airports including Washington National, Boston-Logan, O'Hare, Newark, Pittsburgh, Philadelphia, JFK, Miami, and La Guardia with low-use airports including Minneapolis, Ft. Lauderdale, Cleveland-Hopkins, Erie, Allentown-Bethlehem-Easton, Kanawha (Charleston, W. Va.), Chattanooga, Cincinnati, and Jacksonville. Analysis of Chart II (on next page) indicates that:

1. There is no appreciable difference in the incidence of chipping, rounding erosion, or rubber¹ accumulation.
2. Migrating, cracking, and closing do not occur in any greater frequency on the runways at high-use airports and are, therefore, not traffic related.
3. Wear, spalling, and adjacent cuts of deep/shallow¹ grooves are more common on runways at high-use airports.

High-use runways have correspondingly greater amounts of damage than their low-use counterparts. Chart II indicates that this is true only for wear and spalling. For the runways surveyed, chipping, rounding, erosion, migrating, cracking, and closing did not result from heavy aircraft traffic (see Chart II on the next page).

E. Chart III (shown on page 10) compares runways in cold-weather airports (Minneapolis, Boston, Albany, Erie, O'Hare, and Pittsburgh) with runways warm-weather airports (Jacksonville, Miami, Ft. Lauderdale). Only 3 warm-weather airports were surveyed so data is sketchy. Caution must be used in comparing the actual number of problems recorded, since 6 cold-weather sites are being compared with only 3 warm-weather sites. Several trends are apparent.

1. Migrating is most common at warm-weather airports
2. Cracking is most common at cold-weather airports.
3. Chipping, erosion, and spalling were found only at the cold-weather sites visited.

¹Further comparisons of these 2 problems will not be considered since rubber deposits are dependent on when the runways were last cleaned, and the incidence of adjacent cuts of deep/shallow grooves are dependent on the cutting machine and/or runway surface level.

CHART II - COMPARISON OF HIGH-USE VERSUS LOW-USE AIRPORTS

| FACTORS | HIGH-USE RUNWAYS*† | | | | LOW-USE RUNWAYS*‡ | | | |
|--------------|--------------------|-----------|---------|---------|-------------------|-----------|---------|---------|
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | 2 | 2 | - | - | 1 | 2 | 1 |
| MIGRATING | 2 | 1 | 3 | - | 5 | 3 | 2 | 1 |
| ROUNDING | - | 1 | 3 | 1 | 1 | 1 | 2 | 1 |
| CRACKING | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 2 |
| WEAR | 4 | 5 | 5 | 4 | 3 | 3 | 4 | 3 |
| EROSION | 1 | 1 | - | - | - | 1 | 1 | 1 |
| SPALLING | 2 | 3 | 2 | 1 | - | - | 1 | - |
| CLOSING | 4 | 2 | 6 | 1 | 5 | 5 | 5 | 2 |
| DEEP/SHALLOW | 4 | 3 | 2 | 1 | - | - | 3 | 2 |
| RUBBER | 1 | 6 | 5 | - | - | 7 | 4 | 1 |

* Runways were grouped into high- and low-use categories based on the annual estimated air-taxi operations.

† Washington, Boston, O'Hare, Newark, Pittsburgh, Philadelphia, JFK, Miami, and La Guardia.

‡ Minneapolis, Ft Lauderdale, Cleveland, Erie, Allentown-Bethlehem-Easton, Charleston, Chattanooga, Cincinnati, Albany, and Jacksonville.

CHART III - COMPARISON OF COLD-WEATHER VERSUS WARM-WEATHER AIRPORTS

| FACTORS | COLD-WEATHER AIRPORTS* | | | | WARM-WEATHER AIRPORTS† | | | |
|--------------|------------------------|-----------|---------|---------|------------------------|-----------|---------|---------|
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | 1 | 2 | - | - | - | - | - |
| MIGRATING | 2 | 1 | 1 | - | 2 | 2 | 2 | 1 |
| ROUNDING | - | - | - | - | - | 1 | 1 | 1 |
| CRACKING | 3 | 4 | 4 | 3 | - | - | - | - |
| WEAR | 3 | 3 | 3 | 3 | - | 2 | 1 | - |
| EROSION | - | 1 | 1 | 1 | - | - | - | - |
| SPALLING | 2 | 2 | 1 | - | - | - | - | - |
| CLOSING | 3 | 3 | 5 | 1 | 3 | 2 | 2 | 1 |
| DEEP/SHALLOW | 1 | - | 1 | - | - | - | - | - |
| RUBBER | - | 4 | 3 | - | 1 | 3 | 3 | 1 |

* Minneapolis, Boston, Albany, Erie, O'Hare, and Pittsburgh.

† Jacksonville, Miami, and Ft Lauderdale.

F. Chart IV and V were prepared to determine the effect of traffic volume in the two climatic extremes. In Chart IV, high-use and low-use airports are compared under the same warm climatic conditions while in Chart V high-use and low-use airports are compared in the same cold climatic conditions.

1. Conclusions drawn from Chart IV (shown on page 12) are not statistically significant, since only 2 airports are involved, but the following trends were noted:

- a. Migrating is independent of traffic conditions.
- b. Rounding appears to be dependent on traffic conditions.

2. Conclusions reached from Chart V (shown on page 12), which compares runways at Boston, Pittsburgh, and O'Hare airports with runways at Minneapolis-St. Paul, Erie, and Albany airports are as follows:

- a. Spalling was limited to higher use airports, and therefore, appears to be traffic dependent.²
- b. Erosion is apparently not traffic dependent occurring only in low-use airports.²

G. Chart VI (shown on page 13) compares four runways with a small pitch of 1-1/4 inches with four runways with a large pitch (2 to 2-1/4 inches). Runways having a small pitch have a greater number of grooves, and therefore, a greater amount of material removed. They should be more susceptible to certain types of damage. In fact, there does appear to be more wear and more erosion on the runways with a small pitch. In addition, small pitch runways had comparatively more damage in the turning areas.

H. Chart VII (shown on page 13) compares eight runways grooved in 1973 or earlier with eight runways grooved 1974 or later. There appears to be no significant difference in the rate of occurrence of chipping, migrating, cracking, spalling, or closing. Wear and rounding occurs to a greater extent on the older runways, while evidence of erosion was found only on the newer runways and is apparently more dependent on the bituminous mix used in the runway than on time.

²A similar conclusion was reached in the analysis of Chart II.

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CHART IV - COMPARISON OF WARM-WEATHER HIGH-USE AIRPORT WITH WARM-WEATHER LOW-USE AIRPORT

| FACTORS | WARM-WEATHER AIRPORTS | | | | | | | |
|--------------|-----------------------|-----------|---------|---------|--------------------------|-----------|---------|---------|
| | HIGH-USE MIAMI | | | | LOW-USE FT LAUDERDALE | | | |
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | - | - | - | - | - | - | - |
| MIGRATING | - | - | 1 | - | 1 | 1 | 1 | 1 |
| ROUNDING | - | 1 | 1 | 1 | - | - | - | - |
| CRACKING | - | - | - | - | - | - | - | - |
| WEAR | - | - | - | - | - | 1 | - | - |
| EROSION | - | - | - | - | - | - | - | - |
| SPALLING | - | - | - | - | - | - | - | - |
| CLOSING | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - |
| DEEP/SHALLOW | - | - | - | - | - | - | - | - |
| RUBBER | 1 | 1 | 1 | - | - | 1 | 1 | - |

CHART V - COMPARISON OF COLD-WEATHER HIGH-USE AIRPORTS WITH COLD-WEATHER LOW-USE AIRPORTS

| FACTORS | COLD-WEATHER AIRPORTS | | | | | | | |
|--------------|--|-----------|---------|---------|--------------------------------------|-----------|---------|---------|
| | HIGH-USE BOSTON, PITTSBURGH, O'HARE | | | | LOW-USE MINNEAPOLIS, ERIE, ALBANY | | | |
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | 1 | 1 | - | - | - | 1 | - |
| MIGRATING | 1 | 1 | 1 | - | 1 | - | - | - |
| ROUNDING | - | - | - | - | - | - | - | - |
| CRACKING | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 |
| WEAR | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| EROSION | - | - | - | - | - | 1 | 1 | 1 |
| SPALLING | 2 | 2 | 1 | - | - | - | - | - |
| CLOSING | 2 | 1 | 3 | - | 1 | 2 | 2 | 1 |
| DEEP/SHALLOW | 1 | - | - | - | - | - | 1 | - |
| RUBBER | - | 2 | 2 | - | - | 2 | 1 | - |

CHART VI - COMPARISON OF SMALL-PITCH VERSUS LARGE-PITCH GROOVES

| FACTORS | SMALL PITCH (1-1/4 INCHES) | | | | LARGE PITCH (2 TO 2-1/4 INCHES) | | | |
|--------------|---|-----------|---------|---------|---|-----------|---------|---------|
| | CHATTANOOGA, PHILADELPHIA, O'HARE, ALBANY | | | | BOSTON, MINNEAPOLIS, ERIE, JACKSONVILLE | | | |
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | - | 1 | - | - | - | 2 | - |
| MIGRATING | 1 | - | - | - | 3 | 2 | - | - |
| ROUNDING | - | - | 1 | - | - | - | - | - |
| CRACKING | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| WEAR | 2 | 2 | 1 | 3 | 1 | 1 | 2 | - |
| EROSION | - | 1 | 1 | 1 | - | - | - | - |
| SPALLING | - | - | - | 1 | 2 | 1 | - | - |
| CLOSING | 1 | 1 | 2 | 1 | 2 | 2 | 2 | - |
| DEEP/SHALLOW | 1 | 1 | 1 | - | - | - | 1 | - |
| RUBBER | - | 2 | 1 | - | - | 4 | 3 | 1 |

CHART VII - COMPARISON OF RUNWAYS GROOVED IN 1973 OR EARLIER WITH RUNWAYS GROOVED IN 1974 OR LATER

| FACTORS | RUNWAYS GROOVED | | | | | | | |
|--------------|------------------|-----------|---------|---------|----------------|-----------|---------|---------|
| | 1973 OR EARLIER* | | | | 1974 OR LATER† | | | |
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | 1 | 2 | - | - | 1 | 1 | - |
| MIGRATING | 3 | 1 | 4 | - | 4 | 2 | 1 | 1 |
| ROUNDING | 1 | 2 | 4 | 2 | - | - | 1 | - |
| CRACKING | 2 | 2 | 2 | 1 | - | 3 | 3 | 3 |
| WEAR | 4 | 4 | 5 | 4 | 3 | 2 | 2 | 3 |
| EROSION | - | - | - | - | 2 | 1 | 1 | 1 |
| SPALLING | 2 | 2 | 1 | - | - | 1 | 1 | 1 |
| CLOSING | 4 | 4 | 4 | 2 | 6 | 2 | 4 | 1 |
| DEEP/SHALLOW | 3 | 2 | 2 | 3 | 1 | 1 | 2 | - |
| RUBBER | 1 | 5 | 4 | - | - | 6 | 4 | 1 |

* Cincinnati, Miami, JFK, La Guardia, Newark, Allentown-Bethlehem-Easton, Pittsburgh, and Boston.
 † Chattanooga, Philadelphia, Jacksonville, Ft Lauderdale, Albany, Erie, Minneapolis, and Washington.

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I. Chart VIII (shown on page 15) compares six long runways (10,000 feet or longer) with six short runways (6,300 feet or less). Different pilot technique and/or different types of aircraft traffic may have an effect on this comparison. Chart VIII reveals that wear is much more common in the longer runways and also shows considerably more total damage in the threshold areas of the longer runways. Apparently the heavier braking on the shorter runways does not add appreciably to grooving problems, while wide-body jet traffic, which is common only to the longer runways, does increase damage, particularly in the threshold areas. It should be noted that the longer runways surveyed were mainly high use, while the shorter runways were mainly low use.

J. In surveying the 19 runways, measurements were taken along the edge of each runway in an area of little or no wear to determine groove dimensions as cut. In the vast majority of cases, groove width and pitch measured close to specifications while groove depth measured somewhat less than the specified 1/4 inch. A tolerance of $\pm 1/16$ inch is recommended in reference (a) which would give a minimum groove depth of 3/16 inch. Grooving contractors are apparently setting the cutting depths at the minimum 3/16-inch value, since relatively few depth readings of 1/4 inch or greater were recorded. A depth of 3/16 inch was average for unworn areas of the runways surveyed.

K. This report has focused mainly on groove-related problems discovered in the 19 runways surveyed. The overall condition of the grooves should be considered to put the groove situation in proper perspective. In general, the grooved-bituminous runways are in good condition. Airport operators report no surface damage or reduced pavement life which can be attributed directly to grooving and all attest to its effectiveness.

Minor groove damage may restrict water run-off, but hydroplaning will always be reduced unless the groove is completely blocked or destroyed. Only 3 of the 19 runways surveyed were considered to be in questionable condition as far as grooving is concerned. They are: Miami International Runway 9L/27R, JFK Runway 13L/31R, and Greater Pittsburgh International Runway 10R/28L.

Each of these three high-use runways suffered from different problems. At Miami International the grooves on Runway 9L/27R were completely closed together and/or clogged with rubber in threshold, touchdown and braking areas. No channeling of water was possible in most cases. JFK Runway 13L/31R had large areas where grooves were completely worn out. No measurements in excess of 1/8 inch were recorded in areas where grooves remained. At Greater Pittsburgh International Airport, Runway 10R/28L had extensive cracking and spalling throughout its entire length.

Grooves at these three runways were cut in 1972, 1973, and 1973 respectively.

CHART VIII - COMPARISON OF RUNWAYS 10,000 FEET OR LONGER WITH RUNWAYS
6,300 FEET OR LESS

| FACTORS | RUNWAYS | | | | | | | |
|--------------|-----------------------------|-----------|---------|---------|--------------------------|-----------|---------|---------|
| | 10,000 FEET LONG OR LONGER* | | | | 6,300 FEET LONG OR LESS† | | | |
| | THRESHOLD | TOUCHDOWN | BRAKING | TURNING | THRESHOLD | TOUCHDOWN | BRAKING | TURNING |
| CHIPPING | - | - | - | - | - | 2 | 2 | 1 |
| MIGRATING | 1 | - | 3 | - | 1 | 1 | 1 | - |
| ROUNDING | - | 1 | 3 | 1 | 1 | 1 | 1 | - |
| CRACKING | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| WEAR | 4 | 3 | 4 | 4 | 1 | 1 | 1 | 2 |
| EROSION | - | - | - | - | 1 | 2 | 1 | 1 |
| SPALLING | 1 | 1 | 1 | 1 | - | 1 | 2 | - |
| CLOSING | 3 | 2 | 4 | 1 | 2 | 3 | 4 | 2 |
| DEEP/SHALLOW | 3 | 2 | 2 | - | - | - | 2 | 1 |
| RUBBER | 1 | 3 | 3 | - | - | 4 | 2 | - |

* Miami, JFK, Pittsburgh, Philadelphia, O'Hare, and Minneapolis.

† Allentown-Bethlehem-Easton, Charleston, Albany, Erie, Cleveland, and Washington.

L. Repair of Grooved Areas

At several of the runways surveyed, extensive cracking along cold seams and/or along the centerline light wiring trough necessitated repairing the damaged areas with cold patch (see Figures 11 & 12). The patches were typically 10 to 20 feet from the centerline and ran parallel to the centerline for hundreds of feet. No regrooving was attempted where these patches were made. The portion of the existing grooves between the centerline and the patched areas cannot effectively drain. Some effort should be made to regroove these patched areas to match the existing pattern as closely as possible.

VI CONCLUSIONS

A. Grooves at the runways inspected are generally in satisfactory condition.

B. Groove depths were shallower than specified, averaging 3/16 inch or less.

C. Groove widths and pitch were very close to specifications at all runways surveyed.

D. A total of ten groove problems were identified during the survey. They are chipping, migrating, rounding, cracking, wear, erosion, spalling, closing, adjacent cuts of deep/shallow grooves, and rubber deposits.

E. Patched areas running parallel to the centerlines of several runways were not regrooved and effective drainage of water was thereby prevented.

F. Numerous conclusions can be drawn from the data presented in Chart I through VIII. The validity of these conclusions may be statistically in question due to the relatively small sample size (19 runways) and the number of variables involved with the overall analysis. This being the case, conclusions have only been drawn where strong indications or trends are apparent.

1. Conclusions concerning specific problem areas are as follows:

a. CHIPPING - Chipping is a fairly uncommon problem found only in braking and touchdown areas of cold weather runways. There appears to be no relation to traffic volume or runway age.

b. MIGRATING - Migrating is most common in the threshold areas and was found at all the warm weather runways surveyed. There appears to be no relationship between the amount of migrating and traffic volume or groove age.

c. ROUNDDING - Among the least common of problems, rounding was found mostly in braking areas and on older runways.

d. CRACKING - Cracking is a fairly common freeze-thaw phenomenon found exclusively on runways at cold weather airports. All areas of the runway seem equally susceptible to this type of damage. Many of the cracks are reflection cracks from a concrete subsurface.

e. WEAR - Wear is the most common of the problems affecting grooved bituminous runways. High-use runways and older runways naturally show a greater amount of wear. There is more wear on runways having a small pitch and on the longer runways.

f. EROSION - Erosion is a relatively uncommon problem occurring at only 2 of 19 runways surveyed. Erosion is most likely dependent on deficiencies in the bituminous mix rather than traffic or climatic conditions.

g. SPALLING - Among the least common of problems, spalling was found mainly on runways at high-use airports and only in cold weather areas.

h. CLOSING - Closing is one of the more common runway groove problems. All areas of the runways in both hot and cold climates are affected. The extent of closing is more pronounced at the warm weather areas.

i. DEEP/SHALLOW CUTS - The incidence of alternate passes of deep/shallow grooves was noted at 8 of the 19 runways surveyed. The problem results from improper alignment of the cutting blade heights or from a non-level runway surface.

j. RUBBER - Rubber deposits and clogging of grooves is perhaps the most serious groove problem of all. Rubber removal operations must be regularly scheduled at most high-use airports. Considerable amounts of rubber were found clogging grooves in threshold and braking areas.

2. Conclusions pertaining to specific sections of the runway follow

a. THRESHOLD - Aircraft turning onto the runway and positioning for takeoff cause considerable migrating, closing, and wear in threshold areas.

b. TOUCHDOWN - Heavy rubber deposits, wear, and closing of grooves were the most common problems found in touchdown areas. Damage was of sufficient magnitude to enhance hydroplaning in many areas.

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c. BRAKING - Braking areas of the runways surveyed suffered considerable closing in addition to rubber deposits and wear.

d. TURNING - Turning areas were the least damaged portions of the runways surveyed.

VII RECOMMENDATIONS

On the basis of the survey, the following recommendations are made:

A. Additional surveys of warm weather airports should be conducted. (Only 3 of the 19 runways surveyed were in warm regions.)

B. Rubber removal techniques and scheduling based on the amount of rubber in grooves and on the surface should be investigated.

C. The effect of groove depth on hydroplaning should be investigated to determine when worn runways should be resurfaced and/or regrooved.

D. The recommended groove depth should be changed from $1/4 \pm 1/16$ inch to $1/4 \begin{matrix} +1/16 \\ - 0 \end{matrix}$.

E. Patched runway areas should be regrooved.

VIII REFERENCES

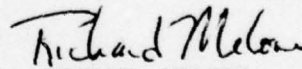
- A. DOT FAA Advisory Circular 150/5320-12, Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces, 30 June 1975.
- B. NAVAIRENGCEN Test Department Code 94421 Proposal for Runway Groove Survey, 23 January 1978.

IX BIBLIOGRAPHY

1. Anonymous, "Pavement Grooving and Traction Studies". NASA SP-5073, 1969
2. Dept of Transportation, Advisory Circular "Methods for the Design, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces". AC No. 150/5320-12, 1975
3. Gallway, B. M., "Tentative Pavement and Geometric Design Criteria for Minimizing Hydroplaning", Federal Highway Administration Report No. FHWA-RD-75-11, 1975
4. Yager, Thomas J., Phillips, W. P., Horne, Walter B. and Sparks, Howard C. "A Comparison of Aircraft and Ground Vehicle Stopping Performance on Dry, Wet, Flooded, Slush-, Snow-, and Ice-Covered Runways", NASA TN D-6098, 1970

Enclosure (1)

Sample of Groove Survey Questionnaire


RICHARD MELONE

RUNWAY GROOVE INSPECTION QUESTIONNAIRE REPT NO: NAEC-TD-MISC-R8

1. AIRPORT ALBANY COUNTY 2. INSPECTION DATE: 2 MAY 1978
3. RUNWAY DIRECTION: 1/19
4. AIRPORT CONTACTS:
- a. NAME ROY MC QUEEN PHONE #: 212 995-3747
JOB TITLE: FAA REGIONAL PAVING ENGINEER
- b. NAME JOHN MASKO PHONE #: 118 869-5312
JOB TITLE: AIRPORT MANAGER
- c. NAME _____ PHONE #: _____
JOB TITLE: _____
5. ILS TOUCHDOWN STATION: 1200
6. PRIMARY TURNOFF STATION: 4000
7. SECONDARY TURNOFF STATION: 4000
8. LOCATION OF ANY KNOWN PROBLEM AREAS IN GROOVED SURFACES: NO KNOWN
PROBLEM AREAS. _____

9. COMMENTS: RUNWAY GROOVING COMPLETED OCTOBER 1976.
SURFACE HAS NOT BEEN CLEANED SINCE GROOVING WAS COMPLETED.

10. SURVEY CONDUCTED BY: R. MELONE & W. WASTALLO

ENCLOSURE (1)

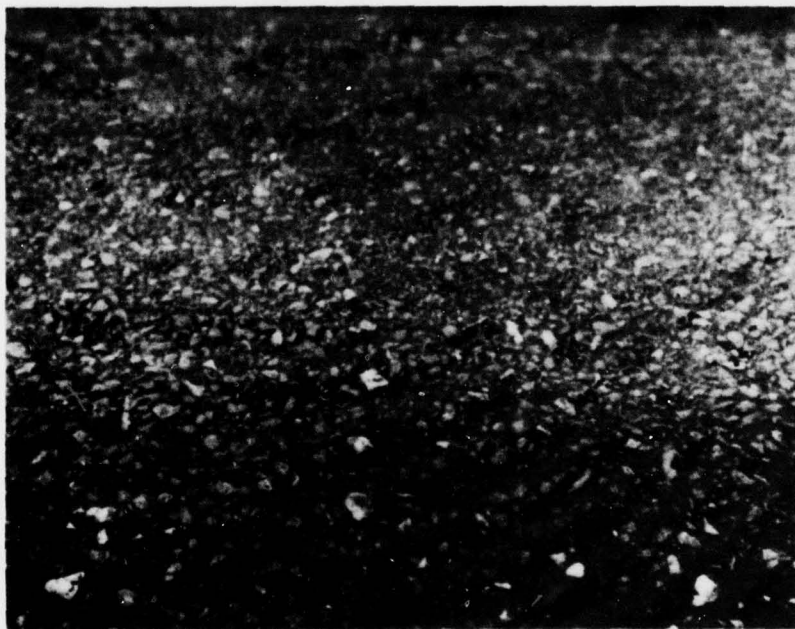


Figure 1 - Wear (Groove Depth of 1/8 Inch or Less) Identified During Runway Survey

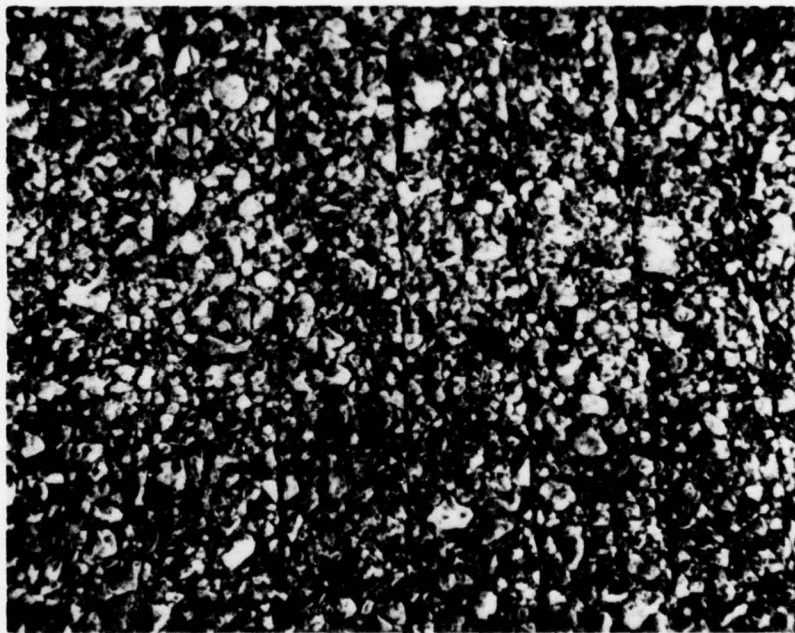


Figure 2 - Closing (Groove Width of 3/16 Inch or Less) Identified During Runway Survey

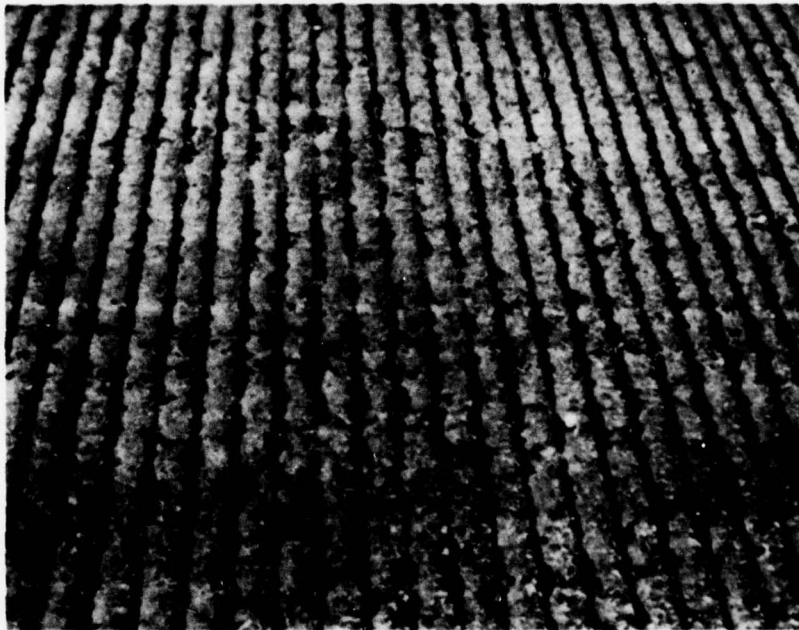


Figure 3 - Rubber Found in Grooves of Runway During Survey

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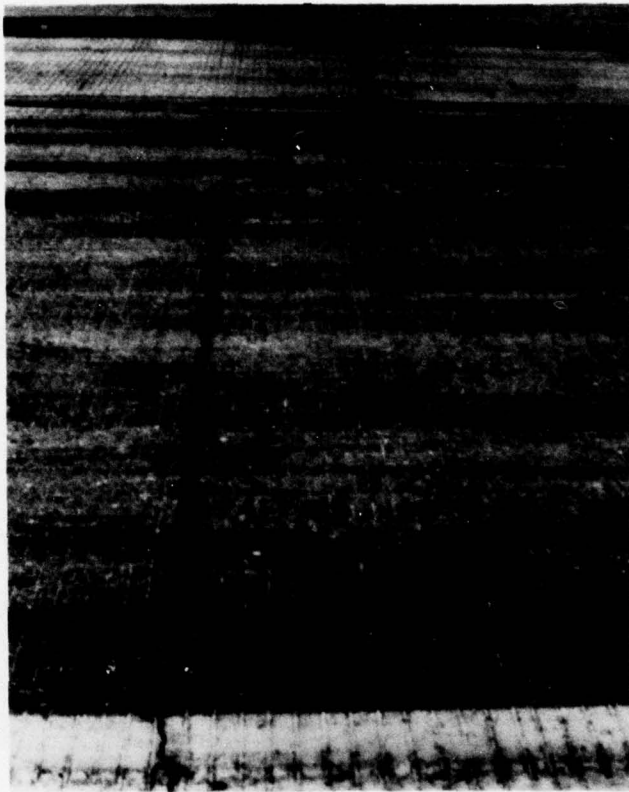


Figure 4 - Runway Cracks Identified During Runway Survey

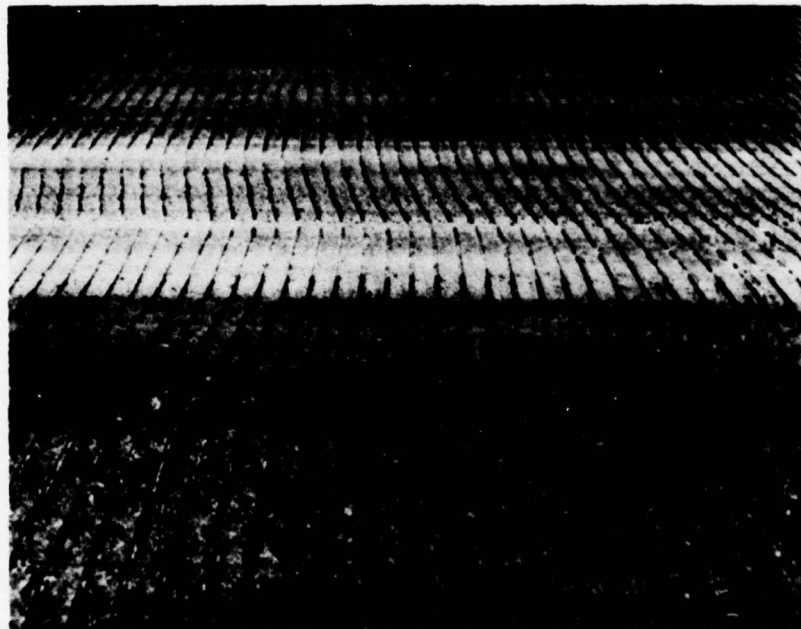


Figure 5 - Migrating Identified During Runway Survey

REPORT NO: NAEC-TD-MISC-R8

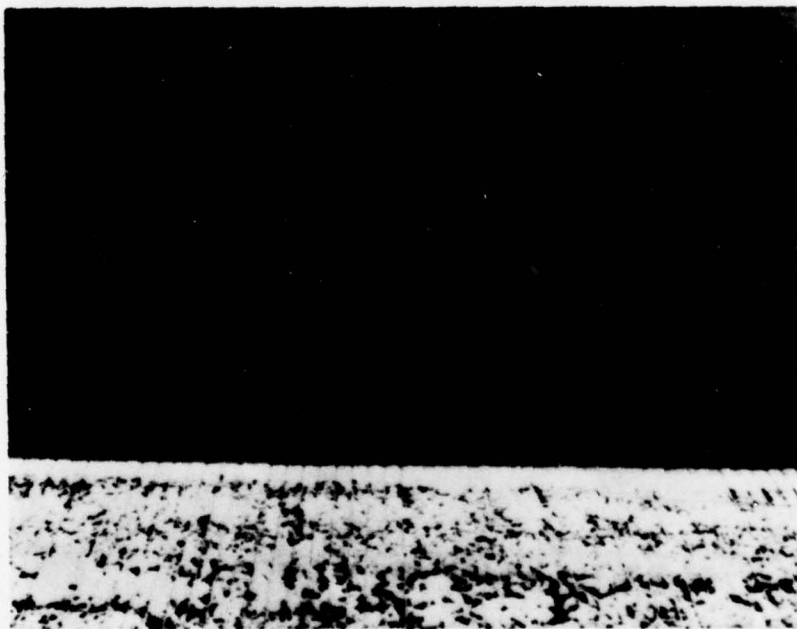


Figure 6 - Deep/Shallow Cut Identified During Runway Survey

REPORT NO: NAEC-TD-MISC-R8

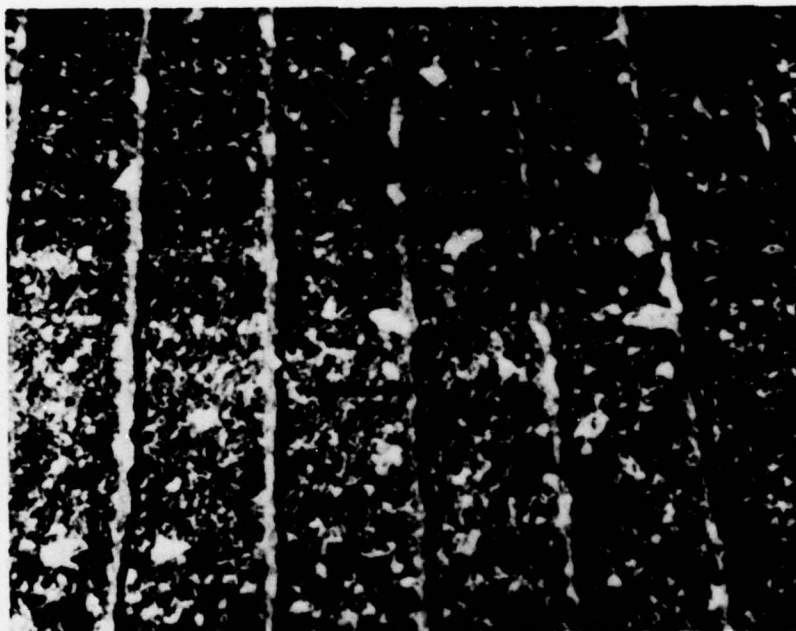


Figure 7 - Rounding Identified During Runway Survey

REPORT NO: NAEC-TD-MISC-R8

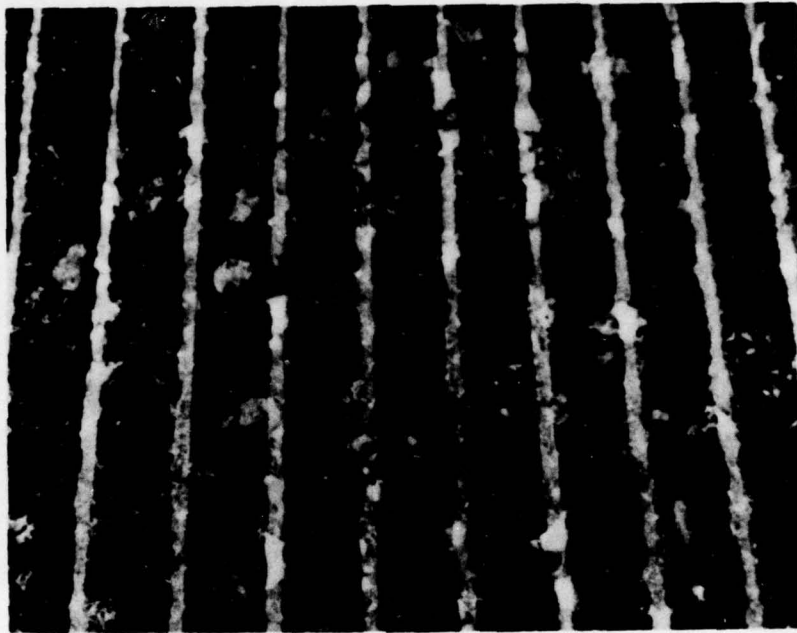


Figure 8 - Spalling Identified During Runway Survey



Figure 9 - Chipping (Breaking Away of Aggregate and/or Filler Material)
Identified During Runway Survey

REPORT NO: NAEC-TD-MISC-R8

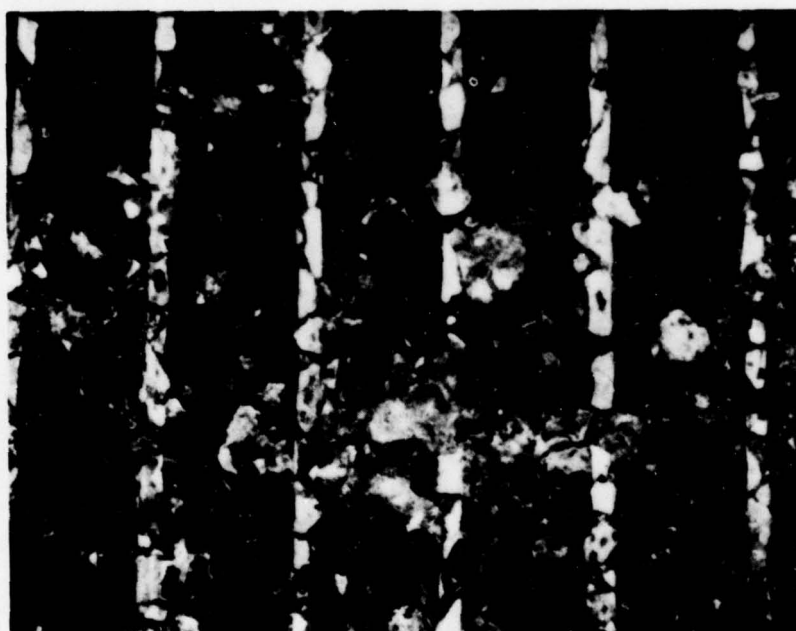


Figure 10 - Erosion Discovered on Runway During Survey

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Figure 11 - Cold Seam Cracking Discovered During Runway Survey

REPORT NO: NAEC-TD-MISC-R8

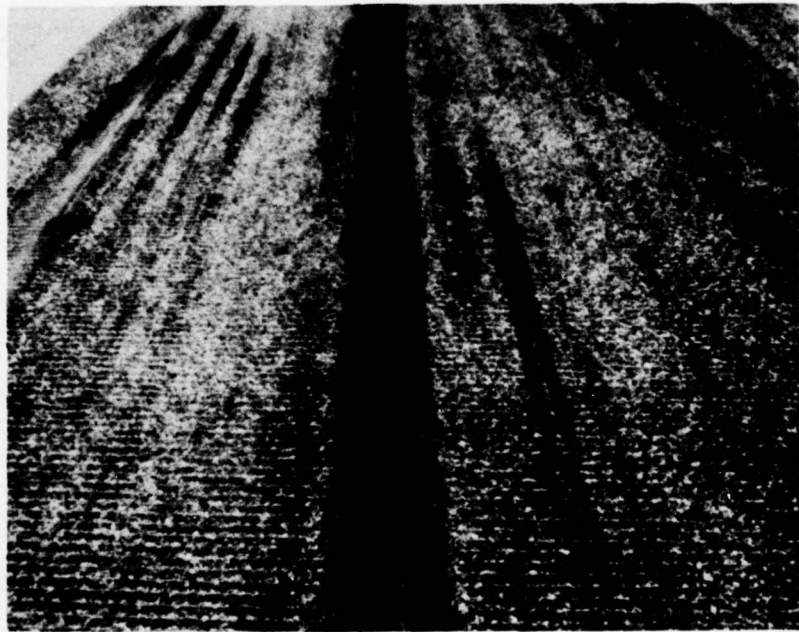


Figure 12 - Ungrooved Patch Discovered During Runway Survey

APPENDIX A - RUNWAY DATA SHEETS

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CHATTANOOGA

RUNWAY: 02/20

DATE: 21 MAR 78

| MAP KEY | LOCATION OF DAMAGED AREA | | AREA DAMAGED (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS | | NATURE OF DEFECT | COMMENTS |
|---------|--|---------------------------|----------------------------------|--------------|---------------------|--------------|------------------|--|
| | FROM 02 END OR RIGHT OF STATION CENTER LINE. | FEET LEFT OF CENTER LINE. | | | WIDTH | DEPTH | | |
| 1 | 0-100 | C/L TO 50L | 5000 | 1, 2 | 1/4 | 1/16, 1/4 | WAVY PATTERN | PATTERN ITSELF SHOULD NOT AFFECT TRACTION-DISTORTION DUE TO AIRCRAFT TURNING ONTO RUNWAY & HEAT. |
| | 0-100 | C/L TO 50L | | 3 | 1/4 | 1/16, 1-1/4 | WEAR | |
| | 0-100 | C/L TO 50L | | | 1/16, 1/8, 1/4 | 1-1/4, 1/16 | MOD. CLOSING | |
| 2 | 900 | 25 R&L | | 4, 5 | 0, 1/4, 1/8, 1/4 | 1-1/4, 1/4 | RUBBER IN GROOVE | |
| 3 | 3340 | 25 R&L | | | 1/4, 1/8, 1/4 | 1-1/4 | | PRIMARY TURNOFF R/W 02 |
| 4 | 4740 | 25 R&L | | 6 | 1/8, 1/4, 1/8 | 1-1/4, 1-1/4 | | PRIMARY TURNOFF R/W 20 |
| 5 | 6200 | 25 R&L | | | 3/16, 1/8, 1/4 | 1-1/4 | | |
| 6 | 7300 | 25 R&L | | | 1/4, 1/8, 3/16, 1/4 | 1-1/4 | | |
| 7 | 7300 | R/W EDGE | | | 1/4, 1/8, 1/4 | 1-1/4 | | DEPTH AT RUNWAY EDGE BELOW STANDARD |

RUNWAY GROOVE INSPECTION DATA

AIRPORT: CINCINNATI RUNWAY: 18/36 DATE: 22 MAR 78

| MAP KEY | LOCATION OF DAMAGED AREA FROM FLEET LIFT 18 END OR RIGHT OF STATION CENTER LINE | AREA DAMAGED (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS | | NATURE OF DEFECT | COMMENTS |
|---------|---|----------------------------------|--------------|---------------------|---------------|---------------------|---|
| | | | | WIDTH | SPACING | | |
| 1 | 500 25 L&R | | 1, 2 | 1/16, 1/4 | 0, 1/16 1-1/2 | | EVERY 30" ONE GROOVE WAS CUT 1/16" WIDE |
| 2 | 500 R/W EDGE | | | 1/16, 1/4 | 3/16, 1-1/2 | | |
| 3 | 1500 C/L | | 3, 4 | - | - | | TARRED AREAS NOT REGROOVED |
| 4 | 2160 25 L&R | | 5 | 1/4 | 1/16, 1-1/2 | | TURNOFF AREA (FOX TROT). UNGROOVED AREAS NEAR C/L LIGHTS |
| 5 | 5' R | 1' x FULL LENGTH OF RUNWAY | 6 | - | - | PATCH | JOINT IN PAVEMENT CRACKED & WAS PATCHED BUT NOT REGROOVED |
| 6 | 3130 25 L&R | | 8, 9 | 1/4 | 1/16, 1-1/2 | WEAR, SOME ROUNDING | TURNOFF C. DEPRESSED AREAS WITH SHALLOWER GROOVES |
| 7 | 4400 25 L&R | | 10, 11 | 1/4 | 1/8, 1-1/2 | CHIPPING, ROUNDING | |
| 8 | 4840 25 L&R | 600 | 12 | 1/4 | 1/8, 1-1/2 | | LARGE PATCHED AREA NOT REGROOVED |
| 9 | 5700 15 R | | 13 | - | - | POP-OUT | |
| 10 | 5800 25 R&L | | 14, 15 | 1/4 | 1/8, 1-1/2 | | TURNOFF E. DEEP & SHALLOW GROOVES SIDE BY SIDE |
| 11 | 9500 25 R&L | | | 1/4 | 3/16, 1-1/2 | | |

RUNWAY GROOVE INSPECTION DATA

AIRPORT: PHILADELPHIA RUNWAY: 9R/27L DATE: 29 MAR 78

| MAP KEY | LOCATION OF DAMAGED AREA FROM LEFT OR RIGHT OF 27L END STATION CENTER LINE | AREA DAMAGED (APPROX.) (Ft. Sq.) | MOTO NUMBER | GROOVE MEASUREMENTS | | NATURE OF DEFECT | COMMENTS |
|---------|--|----------------------------------|-------------|---------------------|-----------|------------------|---|
| | | | | WIDTH | DEPTH | | |
| 1 | 1200 25' L&R | | | 1/4 | 3/16 | | |
| 2 | 2000 25' L&R | | 1, 2 | 1/8-3/16 | 3/32-3/6 | RUBBER BUILDUP | SOME ROUNDED EDGES - BRAKING AREA |
| 3 | 3700 50 R | | 3, 4 | 1/4 | 3/16-1/4 | POP-OUT | TURN AREA - LITTLE WEAR |
| 4 | 5500 50 R | | 5 | 1/4 | 1/8-7/32 | | GROOVE DEPTH VARIED IN ADJACENT GROOVES DUE TO CUTTING BLADE MISALIGNMENT, NOT WEAR |
| 5 | 6800 50 R | 10 | 6 | 1/4 | 3/16-1/4 | SPALLING | TURN CC. MINOR SPALLING IN SEVERAL AREAS |
| 6 | 9300 25' L&R | | | 1/4 | 1/32-7/32 | | 9R TOUCHDOWN - VARIOUS DEPTHS IN ADJACENT GROOVES |

RUNWAY GROOVE INSPECTION DATA

AIRPORT: FT LAUDERDALE RUNWAY: 27R/9L DATE: 6 APR 1978

| MAP NO. | LOCATION OF DAMAGED AREA | | AREA DAMAGED (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS | | NATURE OF DEFECT | COMMENTS | |
|---------|--------------------------|-----------------------------------|----------------------------------|--------------|---------------------|---------------|----------------------------|---|---|
| | STATION | FELT LIFT OR RIGHT OF CENTER LINE | | | WIDTH | DEPTH/SPACING | | | |
| 1 | D-100 | 1/edge to C/L | 5000 | 1, 2, 3 | 1/8-1/4 | 1/8-1/4 | Closing & Pop-out | | |
| 2 | 1000 | 1/edge to C/L | 6000 | 4, 5, 6, 7 | 0-3/16 | 0-13/32 | 1-1-1/4 Closing | Extreme case of asphalt flowing causing distortion of pattern, cracking, etc. Area scheduled for resurfacing. | |
| 3 | 1200 | 25'L & R | | 8 | 1/16-1/8 | 7/32 | 1-1/4 Closing contaminants | Touchdown area. Rubber deposits clogging grooves | |
| 4 | 1300 | 25L & R | 10000 | 9 | - | - | - | Asphalt flowing | |
| 5 | 1400 | 25L & R | | | 1/8-3/16 | - | 1-1/4 Closing | | |
| 6 | 3000 | 15L & R | | 10 | 1/8-3/16 | - | - | Closing | |
| 7 | 4000 | 15L & R | | 11 | 0-1/4 | - | - | Closing | |
| 8 | 5500 | 25L & R | | 12 | 3/16 | 1/4 | 1-1/4 | Contaminants wavy | Rubber deposits & mod. asphalt flowing. |
| 9 | 6800 | 25L & R | | 13 | 3/16 | 3/16-9/32 | 1-1/4 | Contaminants | Heavy rubber deposits clogging curves |
| 10 | 3000 | 1/Edge to CL | | 14, 15 | 0-1/4 | 3/16-1/4 | 1-1/4 | Rounding, closing | Turn-on area |

RUNWAY GROOVE INSPECTION DATA

AIRPORT: JOHN F. KENNEDY RUNWAY: 13L/31R DATE: 13 APR 1978

| MAP BY | LOCATION OF DAMAGED AREA From 13L/31R LEFT end OR RIGHT OF STATION CENTER LINE | AREA DAMAGED (APPROX.) (FT. SQ.) | PHOTO NUMBER | GROOVE MEASUREMENTS GROOVE DEPTH SPACING | NATURE OF DEFECT | COMMENTS |
|-----------|--|---|-----------------|---|------------------------|---|
| | | | | | | |
| 1 | 0-150 Edge-Edge | 150' x 75' | 1 | 5/16 - 0 - 1/8 1 - 1/4" 3/8 | Extreme wear | TRAPEZOIDAL PATTERN INITIALLY. GROOVES NOW APPEAR RECTANGULAR. MANY SPOTS WORN COMPLETELY FLAT. DEPTH AVERAGE APPROX 1/32" |
| 2 | 1000 50L & R | 75' x 75' | 2 | 5/16 0 - 1/16 1 - 1/4" | Extreme wear | |
| 3 | 1100 50L & R | | 3 | 5/16 0 - 1/16 1 - 1/4" | Extreme wear | |
| 4 | 1200 50L & R | | 4 | 5/16 0 - 1/16 1 - 1/4" | Extreme wear | |
| 5 | 5000 50L & R | 75' x 75' | 5, 6, 7 | 5/16 0 - 1/16 1 - 1/4" | Wear & rubber paint | IN SEVERAL AREAS ADJACENT GROOVES WERE CUT TO DIFFERENT DEPTHS. BRAKING AREA BOTH DIRECTIONS, SLIGHT MIGRATING OF GROOVES. |
| 6 | 6000 25L & R | | 8, 9 | - - - | Extreme wear | TURN ECHO-GROOVES WORN FLAT NEAR CENTERLINE. |
| 7 | 7600 25L & R | | 10, 11 | 5/16 0 - 1/8 1 - 1/4" | Wear & migrating | 41/22R CROSS RUNWAY |
| 8 | 9800 - 10000 Edge-Edge | | - | 5/16 1/8 1 - 1/4" | | AVERAGE DEPTH 1/8" VERY LITTLE TRAFFIC THIS END--NO RUBBER. |

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RUNWAY GROOVE INSPECTION DATA

AIRPORT: ALLENTOWN-BETHLEHEM-EASTON RUNWAY: 24/6 DATE: 20 APR 1978

| MAP NO | LOCATION OF DAMAGED AREA | | AREA DAMAGED (APPROX.) (FT. SQ.) | PHOTO NUMBER | GROOVE MEASUREMENTS WIDTH DEPTH SPACING | NATURE OF DEFECT | COMMENTS |
|--------|------------------------------|------------------|----------------------------------|--------------|--|-----------------------------------|--|
| | LEFT OR RIGHT OF CENTER LINE | LEFT EDGE TO | | | | | |
| 1 | 0-200 | 25' L & R | | 1, 2, 3 | 0-3/16 3/32- 1/4 | CLOSING, WEAR | SLIGHT MIGRATION OF GROOVES NOTICEABLE |
| 2 | 1300 | 25' L & R | | 4 | 1/8- 1/8 - 1-1/4 | CLOSING, RUBBER | TOUCHDOWN AREA |
| 3 | 2000 | 25' L & R | | 5 | 1/4 3/8 - 1-1/4 | CLOSING | CROSS RUNWAY AREA |
| 4 | 2800 | 25' L & R | | 6, 7 | 0-3/16 0-7/32 5/32 | CLOSING, WEAR | HEAVY WEAR IN SOME AREAS |
| 5 | 3000 | 25' L & R | | 8, 9 | 0-3/16 1/8- 1-1/4 | CLOSING, WEAR | TUBN E. ALTERNATE PASSES OF DEEP-SHALLOW GROOVES APPROX 2-1/2- FEET WIDE |
| 6 | 4400 | 25' L & R | | 10 | 0-1/4 1/16- 1-1/4 | CLOSING | ALTERNATE PASSES OF DEEP-SHALLOW GROOVES AS CUT 2-1/2 FEET WIDE |
| 7 | 4800 | 25' L & R | | 11, 12 | 0-3/16 5/32- 3/8 | CLOSING, RUBBER | MINOR MIGRATING OF GROOVES CROSS RUNWAY AREA |
| 8 | 5000 | 25' L & R | | 13 | 1/16- 1/8 - 1-1/4 | ROUNDING RUBBER, ROUND-ROUGHENING | ROUGHENING FOR 6 RUNWAY |
| 9 | 5800 | LEFT EDGE TO 25R | | 14 | 0-3/16 0-5/32 1-1/4 | CLOSING, ROUNDING | |

RUNWAY GROOVE INSPECTION DATA

AIRPORT: KANAWHA (CHARLESTON, W. VA) RUNWAY: 5/23 DATE: 27 APR 1978

| M.P. BY | LOCATION OF DANGER AREA FROM LEFT 05 END STATION CENTER LINE | AREA DANGER (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS WIDTH DEPTH SPACING | NATURE OF DEFECT | C O M M E N T S | |
|------------|--|--|-----------------|--|---------------------|--|--|
| | | | | | | CENTER 60' OF RUNWAY IS CONCRETE (SEE SKETCH) | GROOVES IN BOTH ASPHALT & CONCRETE SECTION ARE IDENTICAL. |
| 1 | 0-200 EDGE TO EDGE | | 1, 2, 3 | 1/4 5/32 1" | NONE | ASPHALT & CONCRETE | |
| 2 | 1,000 EDGE TO EDGE EDGE TO EDGE | | 4, 5 | 1/4 9/32 1" 7/32 3/32 1" | NONE NONE | CONCRETE ASPHALT | |
| 3 | 3,700 EDGE TO EDGE | | 6 | 1/4 7/32 1" | CHIPPING | CONCRETE CHIPPING, ASPHALT OK. | |
| 4 | 4,500 EDGE TO EDGE | | 7 | - - - | - | VERY LITTLE RUBBER | |
| 5 | 5,100 EDGE TO EDGE | | 8, 9 | 1/4 1/4 1" | NONE | | |
| 6 | 6,100 EDGE TO EDGE EDGE TO EDGE | | - | 1/4 1/4 1" 3/16- 3/16 1" 1/4 | NONE | CONCRETE ASPHALT | |

RUNWAY GROOMING INSPECTION DATA

AIRPORT: CLEVELAND-HOPKINS INTERNATIONAL RUNWAY: 10L/28R DATE: 10 MAY 1978

| M/P NO | LOCATION OF DAMAGED AREA FROM 10' FLYT LEFT END OR RIGHT OF STATION CENTER LINE | AREA DAMAGED (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS | | NATURE OF DEFECT | COMMENTS |
|-----------|---|---|-----------------|---------------------|-----------------|----------------------------------|--|
| | | | | WIDTH | DEPTH SPACING | | |
| 1 | 0-200 25' L&R | | 1, 2, 3, 4 | 1/4 | 3/16 - 1-1/4 | CRACKING | WIDE CRACKS PROPAGATING PARALLEL TO RUNWAY & PERPENDICULAR TO RUNWAY ALONG GROOVES |
| 2 | 1,000 25' L&R | | 5 | 1/4 | 3/16 - 1-1/4 | CHIPPING | MINOR |
| 3 | 1,500 25' R | 10 | 6 | - | - | SPALLING | |
| 4 | 3,000 25' L&R | | 7 | 1/4 | 1/8 - 1/4 1-1/4 | CRACKING | |
| 5 | 3,500 25' L&R | | - | 1/4 | 0 - 3/4 1-1/4 | CRACKING | |
| 6 | 4,600 10' L | | 8, 9 | 0 - 1/4 | 1/16 - 1/4 | CLOSING WEAR | LOCALIZED CLOSING. NOT EXTENSIVE EXTENSIVE. DEEP/SHALLOW GROOVES. |
| 7 | 5,000 10' L | | 10, 11, 12 | 1/4 | 0 - 3/8 1-1/4 | MIGRATING CHIPPING, RUBBER | TOUCHDOWN AREA SURFACE COATED W/ RUBBER. LITTLE RUBBER IN GROOVES. MIGRATING 10' L FOR APPROX 50 FEET. |
| 8 | 5,800 25' L&R | | 13 | 1/4 | 1/8 - 1/4 1-1/4 | | |

RUNWAY GROOMING INSPECTION DATA

AIRPORT: CHICAGO O'HARE INTERNATIONAL RUNWAY: 14L/32R DATE: 16 MAY 1978

| MAY NOY | LOCATION OF DAMAGED AREA FROM 14L END STATION CENTER LINE | AREA DAMAGED (APPROX.) (Ft. Sq.) | PHOTO NUMBER | GROOVE MEASUREMENTS WIDTH DEPTH SPACING | NATURE OF DEFECT | COMMENTS |
|------------|--|---|-----------------|--|-----------------------------------|--|
| | | | | | | |
| 1 | 0-400 | | 1, 2, 3 | 3/16-1/4 1/8 1" | WEAR | MINOR RUBBER DEPOSITS IN GROOVES |
| 2 | 1,000 | 50' L&R | 4, 5, 6 | 3/16-1/4 3/32-1/4 | HEAVY RUBBER CRACKING | MINOR CLOSING |
| 3 | 1,500 | 25' L&R | 7 | 3/16-1/4 5/32-1/4 | HEAVY RUBBER | SOME ROUNDING & CHIPPING |
| 4 | 1,750 | 25' L&R | 8 | 3/16-1/4 1/4-1/4 | HEAVY RUBBER CLOSING RUBBER | GROOVES COMPLETELY FILLED W/RUBBER IN MANY AREAS |
| 5 | 2,000 | 25' L&R | 9 | 3/16-1/4 3/16 1" | CRACKING | |
| 6 | 2,400 | 25' L&R | - | 3/16-1/4 5/32 1" | WEAR RUBBER | |
| 7 | 3,000 | 25' L&R | 10 | 3/16-1/4 5/32 1" | CRACKING | CRACKS PERPENDICULAR TO CL ACROSS ENTIRE RUNWAY. |
| 8 | 3,500 | 25' L&R | | 3/16-1/4 5/32-1/4 | CRACKING | REFLECTION CRACKS FROM CONCRETE SUB- SURFACE |
| 9 | 4,000 | 25' L&R | 11 | 3/16-1/8 1/4-1/4 | CRACKING | REFLECTION CRACKS |
| 10 | 4,500 | 25' L&R | - | 3/16-1/4 3/16 1" | CRACKING | |
| 11 | 5,000 | 25' L&R | - | 3/16-1/8 1/4-1/4 | CRACKING | REMAINDER OF RUNWAY IS IN PROCESS OF BEING OVERLAID AND WAS UNAVAILABLE FOR INSPECTION. RUNWAY 32R IS NOT HEAVILY USED. 14L IS PRIMARY. |

APPENDIX B - INDIVIDUAL INSPECTION REPORTS SUPPLIED TO THE FAA FOLLOWING EACH AIRPORT VISIT

1. Jacksonville International Runway 7/25: Grooves in Runway 7/25 were cut in late 1974. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 2-inch center-to-center. Measurements indicate groove width and spacing conform closely to specifications while depths were somewhat shallower than called for. Minor closing of grooves was noted in the threshold areas and minor wear was evident near the centerline in touchdown and braking areas. The runway was cleaned of rubber one month before our inspection, and therefore, rubber deposits were at a minimum.

2. Ft. Lauderdale-Hollywood International Runway 9L/27R

a. Grooves in Runway 9L/27R were cut in October 1975. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. An extreme case of asphalt flowing was found at Station 1000, near turn 'M', on Runway 9L. The groove displacement approximated a sinusoidal wave form having an amplitude of 2 to 3 feet and a period of about 10 feet. The airport has already contracted to have the damaged area (approximately 6,000 square feet) repaved and regrooved. Poor asphalt mix or poor subsurface bonding appears to be the probable cause of the flowing. At the primary turnoff, farther down the runway, no such problem was evident.

b. Minor closing of grooves was noted at threshold areas and some rubber clogged grooves were noted in the touchdown areas. Flowing of asphalt (wavy grooves) was also found near the centerline at Station 1300-1400 of Runway 27. Grooved depths generally measured 5/32 inch to 7/32 inch. Spacing was constant at 1-1/4-inch and groove width varied from 3/16 inch to 7/32 inch.

3. Miami International Runway 9L/27R: Grooves in Runway 9L/27R were cut in 1972. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. Large areas of completely closed grooves were found in the 9L threshold area where aircraft turned onto the runway. Heavy rubber deposits clogged most grooves in the 9L touchdown area, Station 800 to 1300. Minor closing and rounding was evident in this area. Centerline paint was found clogging grooves in several areas. In general, grooves in threshold, touchdown, and braking areas were in poor condition either being closed together completely or clogged with rubber. In areas of no wear near runway edges, grooves measured close to specifications.

4. John F. Kennedy Runway 13L/31R: Grooves in Runway 13L/31R were cut in 1973. Specifications called for a trapezoidal pattern having nominal dimensions of 3/16-inch deep by 3/8-inch wide (top) tapering to 1/8-inch wide (bottom) with a spacing of 1-1/8 inch. The grooves are worn badly the entire length of the runway and appear rectangular in shape. In many

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areas the grooves are worn completely flat. No depths in excess of 1/8 inch were recorded. In general, groove widths measured 5/16 inch and groove spacing 1-1/4 inch.

5. LaGuardia Runway 4/22: Grooves in Runway 4/22 were initially cut in 1973, in a trapezoidal pattern identical to Kennedy Airport described above. The damaged portions of the runway have been resurfaced and regrooved with a rectangular groove measuring 1-1/4-inch (spacing) by 1/4-inch deep by 1/4-inch wide. The first 2,000 feet of Runway 22 are concrete and therefore not pertinent to this report, however, this area was inspected and found to be badly worn. Only scattered wear spots were noted near heavy braking and turning areas in the asphalt surfaced portion of the runway. The dimensions of the rectangular grooves in the resurfaced asphalt sections measured close to specification.

6. Newark International Runway 4R/22L

a. Initial plans were to inspect Runway 4L/22R which was grooved in 1970, and is 8,200 feet in length. On the day of our visit the parallel Runway 4R/22L was down for maintenance thus doubling the traffic on 4L/22R and making inspection of that runway unfeasible. Runway 4R/22L, which is an 9,800-foot asphalt runway grooved in 1973, was inspected in lieu of Runway 4L/22R.

b. Specifications for grooves in Runway 4R/22L called for a trapezoidal pattern having nominal dimensions of 3/16-inch deep by 3/8-inch wide (top) tapering to 1/8-inch wide (bottom) with a spacing between grooves of 1-1/8 inches. Grooves appeared rectangular in cross section measuring approximately 3/8-inch wide but only 3/32 to 1/8-inch deep on the average. Alternate passes of deep/shallow grooves were evident throughout the entire length of the runway. Rubber clogged grooves were noted in the touchdown areas. Damaged grooving blades cut defective grooves in several areas. Only minor migrating of grooves was evident.

7. Allentown-Bethlehem-Easton Runway 6/24: Grooves in Runway 6/24 were cut in 1973. Specifications called for a rectangular pattern having nominal dimensions of 1/4-inch deep by 1/4-inch wide with a spacing between grooves of 1-1/4 inches. Closing of grooves was noted in threshold, touchdown, and braking areas. Groove widths measured 0 to 3/16 inch, and depth measured 1/16 to 3/8 inch. Alternate passes of deep/shallow grooves were noted indicating poor control of the grooving machine cutting depth. Slight migration of grooves was found in the Runway 24 threshold.

8. Greater Pittsburgh International Runway 10R/28L: Grooves in Runway 10R/28L were cut in the Spring of 1973. Specifications called for a groove pattern having nominal dimensions of 1/4-inch deep by 1/4-inch wide with a center-to-center groove spacing of 1-3/4 inches. The runway is in poor condition with extensive cracking and spalling the entire length. The surface cracks, for the most part, propagate along the grooves occasionally jumping to adjacent grooves, and extend, in some cases, three or more inches deep. These cracks ranged up to 1/4-inch wide. Poor drainage between the asphalt surface and the concrete subsurface may have precipitated the cracks. The comparatively small size of the aggregate in the asphalt may also have had an effect. In general, groove widths measure 3/16 to 1/4 inch, groove depths 3/32 to 1/8 inch and groove spacing varied from 1-3/4 to 2-inches center-to-center. The runway was cleared of rubber five months prior to inspection and had few, if any, clogged grooves when inspected.
9. Kanawha (Charleston, West Virginia) Runway 5/23: The center 60 feet of Runway 5/23 is concrete for the full 6,300-foot length. Sections of the outer 45 feet on each side are asphalt. The entire runway was grooved in 1969. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide with a center-to-center distance of 1/4 inch for both concrete and asphalt areas. No wear and only minor rubber deposits were evident. At the high-speed turnoff station 3700 (Runway 5), some concrete chipping was found. In general, grooves measured very close to specifications.
10. Chattanooga (Lovell Field) Runway 2/20: Grooves on Runway 2/20 were cut in 1974. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch thick by 1-1/4-inch center-to-center. In general, the runway grooves were in satisfactory condition though somewhat shallower than 1/4 inch. A distorted (wavy) groove pattern was noted at the approach end of 20 where aircraft turning onto the runway have caused the asphalt to flow. Effectiveness of the grooving should not be diminished, however, since groove widths and depths remain unchanged.
11. Cincinnati (Greater Cincinnati) Runway 18/36: Grooves in Runway 18/36 were cut in 1972. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/2-inch center-to-center. Width and spacing of grooves were satisfactory; however, depths varied from 1/6 inch to 3/16 inch in most areas. Extensive patching near the centerline (bituminous cold joints and centerline light area) has effectively eliminated considerable grooved area. The patches have not been regrooved.
12. Philadelphia International Runway 9R/27L: Grooves on Runway 9R/27L were cut in 1977. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/4-inch center-to-center. The runway surface

is in excellent condition with only occasional wear spots or spalled areas. Depth ranged from 1/8 inch to 1/4 inch while width and spacing was generally to specifications.

13. Albany County Airport, Albany, NY Runway 1/19: Grooves on Runway 1/19 were cut in October 1976. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-1/4-inch center-to-center. In general, the grooves in Runway 1/19 were in excellent condition. Isolated areas of wear, erosion of filler material, and closing of grooves were noted in turn and touchdown zones. Width and center-to-center spacing of grooves measured 1/4 and 1-1/4-inch, respectively, except for the minor areas of groove closing where the width was reduced to zero. Groove depth measured generally from 3/16 to 1/4 inch.

14. Erie International Airport, Erie, PA Runway 6/24: Grooves on Runway 6/24 were cut in 1975. Specifications called for nominal dimensions of 1/4-inch wide by 1/4-inch deep by 2 inches center-to-center. Extensive cracking was found along the entire runway surface. Cracks extended both perpendicular and parallel to the runway centerline. Those running perpendicular to the centerline generally propagated along the grooves and at times widened the grooves to 1/2 inch or more. These wide cracks probably act as expansion joints, widening and closing as temperatures rise and fall. The grooves themselves are in good condition with minor wear, minimal rubber deposits, and no closing at all being noted. Groove widths measured 1/4-inch, groove center-to-center distances were constant at 2 inches, and groove depths ranged from 1/4 to 3/8 inch.

15. Chicago O'Hare International Runway 14L/32R: Runway 4L/22R was unavailable for inspection due to heavy traffic conditions. Runway 14L/32R, which was down for resurfacing, was inspected instead. Runway 14L/32R is a 10,000-foot runway grooved in October 1974. Runway 4L/22R is a 7,500-foot runway grooved in 1976. Groove specifications for runway 14L/32R called for nominal dimensions of 1/4-inch wide by 1/4-inch deep with a center-to-center distance of 1-1/4 inches. Moderate wear and cracking were found the entire length of the runway. Heavy rubber deposits clogged grooves in the touchdown zones (Station 1000 to 2000). Groove widths measured 3/16 to 1/4 inch, groove depths 1/8 to 1/4 inch (except where rubber deposits completely filled grooves) and groove center-to-center distances were constant at 1-1/4 inch.

16. Minneapolis-St. Paul International Runway 11R/29L: Runway 11R/29L is the only grooved asphalt runway in Minneapolis-St. Paul International Airport. This runway was, therefore, inspected in lieu of runway 11L/29R which is concrete. Runway 11R/29L is a 10,000-foot runway grooved in 1974. Specifications called for nominal dimensions of 1/4-inch wide by 1/4-inch deep with a center-to-center distance of 2 inches. Grooves were worn flat in many areas of both thresholds where aircraft turn onto the runway. In touchdown and braking areas heavy rubber deposits, closing of grooves, wear and cracking were found. Groove widths measured 1/8 to 1/4 inch (except

where completely closed in touchdown areas), groove depths ranged from zero to 1/4 inch and center-to-center distances were 2 inches.

17. Boston-Logan International Runway 15R/33L: Runway 4L/22R, which was grooved in 1975, was unavailable for inspection due to heavy traffic. Runway 15R/33L, which is a 10,000-foot runway grooved in 1972 and 1973, was inspected instead. Specifications called for nominal groove dimensions of 1/4-inch deep by 5/16-inch wide by 2-1/4-inch center-to-center. Migration and closing of grooves was noted in the aircraft turn-on areas of Runway 15R. Migrating, chipping, closing, and spalling were found to varying extents in the touchdown areas along with isolated areas of completely rubber clogged grooves. Groove widths ranged from 0 to 5/16 inch groove depths from 0 to 1/4 inch and center-to-center distance 2-1/4 inches.

18. Washington-National Airport Runway 15/33: Grooves on Runway 15/33 were cut in the Spring of 1976. Specifications called for nominal dimensions of 1/4-inch deep by 1/4-inch wide by 1-3/4 inches center-to-center. Isolated spots of closed grooves were found in threshold and braking areas. Erosion of filler material and spalling were evident the entire length of the runway. Only surface rubber deposits were found. Groove depth measured generally between 5/32 and 1/4 inch, groove width between 1/8 and 1/4 inch and groove center-to-center distance between 1-5/8 and 1-3/4 inches.

19. Cleveland-Hopkins International Airport, Cleveland, Ohio Runway 5R/23L: Runway 5R/23L was the runway selected for inspection at Cleveland-Hopkins, however, this runway has just been overlaid and is not yet grooved. As a substitute, Runway 16L/28R was inspected. This runway is 6,000-feet long and was grooved in 1974. Specifications called for grooves measuring 1/4-inch wide by 1/4-inch deep by 1-1/2 inches center-to-center. Extensive cracking, similar to that at Erie's Runway 6/24 was found. Minor migrating of grooves along with localized closing of grooves (10 feet left of center for 50 feet) was found in the touchdown area, Station 1400, runway 28R. Rubber deposits were limited to the surface in the touchdown area and did not clog the grooves. No appreciable chipping, rounding, or wear was noticed. Groove widths, in general, measure 1/4 inch, depths ranged from 1/8 to 1/4-inch center-to-center.