9. COMMERCIAL AIRLINES AND THE GROOVED RUNWAY CONCEPT

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SUMMARY

Early research and grooving programs undertaken by the National Aeronautics and Space Administration and the United Kingdom prompted the airline industry to develop a runway grooving program of its own over 2 years ago. Behind this decision was the airlines' desire to increase safety and to advance the state of the art in aircraft stopping capability. The airlines felt, however, that before grooving could be considered for widespread use in the United States, operational experience would be needed with grooved runways exposed to heavy use and variable weather conditions.

This experience has been provided by 15 to 19 months' use of grooved runways at three major U.S. airports. On the basis of the airlines' evaluation, the Air Transport Association of America (ATA) is actively seeking the expansion of runway grooving to other airports.

INTRODUCTION

Because heavy turbine-powered aircraft are exposed to the risk of skidding on wet, slippery runways, the airlines have followed with great interest research efforts concerned with ways to reduce such risks. Airline interest was quickly focused on the phenomenon of aircraft hydroplaning since it was found to be a contributing factor in many "off runway" type of accidents, either in which an aircraft ran off the side of a runway or off the far end of the runway following a touchdown or an aborted takeoff. It was recognized that a hydroplaning aircraft tends to weather-vane in a crosswind. If reversing were applied while the aircraft was in this cocked position on the runway, it would actually help the crosswind move the aircraft off the side of the runway. As a result, airlines developed landing techniques to cope with this effect and all pilots were well indoctrinated in the hazards of hydroplaning.

However, the possibility of skidding on wet runways was by no means eliminated, but only minimized, by using such control methods. The airlines recognized the limitations of such operational techniques and began to look into a runway grooving test program because the data expected from the government programs, by NASA and the Federal Aviation Administration (FAA), were not yet completed. It was felt the problem was serious enough and the benefits to be derived were important enough, that airlines should not wait for the outcome of these more comprehensive investigations.

DISCUSSION

During the summer of 1966, a representative of NASA Langley Research Center made a presentation on runway grooving before the ATA Flight Operations Committee. The Committee then recommended that ATA investigate the merits of an airline industry program on runway grooving in order to determine its operational benefits and future applications. The reasons for pursuing operational tests were threefold: First, the airlines were aware in the summer of 1966 that it would be at least a year before the NASA test would commence at Wallops Island using airline, military, and business aircraft on a specifically modified runway; it would probably take another year before qualitative results would become available. Second, an operational test at a heavily used airport would provide valuable information on the effectiveness of runway grooving as well as the runway's ability to withstand deterioration in heavy traffic. The United States appeared to offer a more varied climatic environment compared with that experienced in the United Kingdom during the use of grooved runways there. Third, the airlines were aware that although such an operational test would not supply an abundance of qualitative technical data, it would supplement NASA's endeavors and provide useful information at an earlier date. Also, not much was known about the possibility of increased vibration and noise which might result when an aircraft operated on grooved runways.

Following this decision by the ATA Flight Operations Committee, ATA and its member airlines began laying the groundwork for an operational evaluation of runway grooving in the U.S. In order to shed some light on the concern over the possibility of increased airframe vibration induced by grooved runways, American Airlines conducted flight tests on a grooved, dry, British runway with a newly delivered BAC 111 aircraft during the summer of 1966. No noticeable differences in vibration and noise levels between ungrooved and grooved runways were reported.

At about the same time, the airlines developed a list of preferred candidate runways for a grooving evaluation. Between the summer of 1966 and the following spring, discussions, deliberations, and studies were conducted by ATA member airlines and airport authorities to determine which runway or runways should receive priority consideration for a test grooving program. By early 1967 airline financial participation in the grooved runway test effort was fairly well assured.

The program that resulted represented a cooperative effort between the airlines serving Kansas City, Missouri, and the Kansas City Municipal Airport Authority and a similar joint effort by the airlines serving New York's John F. Kennedy International Airport (JFK) and the Port of New York Authority.

In May 1967, Kansas City Municipal's instrument runway 18-36, made up of both concrete and asphalt sections, was grooved for over 130 feet of its 150-foot width and for over 4500 feet of its 7000-foot length. The groove pattern was transverse, measuring 1/8 inch wide and 1/4 inch deep with 1 inch between centers. In early August 1967, the main instrument runway at JFK, concrete runway 4R-22L, was grooved from end to end and side to side. The transverse groove pattern was 3/8 inch wide by 1/8 inch deep on a $1\frac{3}{8}$-inch pitch. At Kansas City the grooves were rectangular in cross section, but at JFK they had 45° sloping sides with a groove width of 3/8 inch at the top and 5/32 inch at the bottom. These and similar data for the two airports are summarized in table 1.

These runways and Washington National Airport's runway 18-36, which was completed April 25, 1967, were selected for grooving tests by the airlines out of 40 potential candidates and proposed to the airport authorities. The airlines paid for the grooving operation at both Kansas City ($87 000) and JFK ($178 500), but the grooving operation at Washington National was paid for by FAA.

In order to determine the effects of runway grooving on aircraft landing performance during wet conditions, ATA sent questionnaires to the airlines for use by their pilots immediately following a wet-runway landing on any of the three grooved runways. Pilots were asked to describe the precipitation, the amount of standing water on the runway, crosswind component, aircraft touchdown speed, and the number of times they had landed on the particular runway, both before and after grooving. The pilots were also asked to comment on the degree of improved lateral stability and to estimate the number of feet that stopping distance was reduced by grooving the runway.

Table 2 briefly summarizes some of the more pertinent factors which were considered significant in determining the effectiveness of runway grooving. Four different precipitation conditions were experienced during the period of the evaluation. More than 80 percent of landings reported were made when the rain had stopped before landing or when a light rain was falling during the actual touchdown and braking phase of the landing. The runway surface condition which generally resulted from these types of weather conditions was reported to vary from a thin film of moisture up to and including the condition in which pools of collected water formed over most of the used runway surface. The average touchdown speed of each type of aircraft used appeared to be within the approximate range experienced during normal operations. The reported stopping distance reduction attributable to grooving averaged better than 1000 feet. Pilots generally included in the comment section of their report statements to the effect that they strongly endorsed the concept. Directional-control capability was considered greatly improved by 86 percent of the pilots; 7 percent felt that it was not improved, and 7 percent offered no comment.

Once the pilot operational evaluation produced such a favorable reaction, it appeared prudent and timely to determine whether grooving had produced any detrimental effects on the runway surface and whether any complaints had developed regarding increased vibration or abnormal tire wear. With close to a year's operations at both Washington National and Kansas City and 9 months at JFK, including a full winter's operations at all three, the ATA sought comments from representatives of these three airports on the following four areas:

(1) The changes, if any, observed in rate of pavement deterioration resulting from normal aircraft use and use of ground equipment (for example, snow removal)

(2) Increased drainage rate observed (spraying effects reduced during landing and runout)

(3) Maintenance problems reported by airlines (tire wear, nose wheel vibrations, etc.)

(4) Other problems experienced or anticipated as a result of grooving

Based on the responses by these airports, the outlook for operational use of the grooving concept grew even more encouraging. A consolidation of these responses is presented in table 3. Although two of these airports indicated no noticeable increase in the rate of pavement deterioration, Kansas City Municipal has stated that there is some deterioration in the surface of the concrete, but it has been difficult to determine how much of this is the result of grooving. Kansas City Municipal also stated that there has been a noticeable increase in aggregate pop outs, which is not considered serious. Spalling has also taken place around cracked areas but it cannot be determined if this is the result of grooving. It is understood by ATA that the FAA made a walkover inspection of the Kansas City runway and considered that the noticeable pop outs and joint deteriorations were typical of this type of aged concrete paving. Figures 1 to 4 are recent photographs of airline aircraft on the grooved runways at Kansas City and JFK airports. Figures 1 and 2 show the landing gear of an aircraft on runway 18-36 at Kansas City Municipal after more than 150 000 landings have been completed since it was grooved. Figures 3 and 4 show an aircraft on runway 4R-22L at JFK, which has experienced more than 72 000 landings on its grooves.

The results of year-long tests at these three airports were reviewed by the ATA Flight Operations Committee during June 1968, and a decision was made to seek an expansion of runway grooving at U.S. airports served by the airlines. The Air Transport Association of America, on behalf of its member airlines, is in the process of preparing a list of candidate airports for runway grooving based on recommendations of member airlines.

Specific proposals for grooving will be made from this list of candidates by the airlines working through ATA Regional Operations Managers. Runways proposed for grooving and the priority they should receive will be shown in the airlines' Airport Survey which is prepared and revised regularly by the airlines through ATA.

Since runway grooving must compete with other airport surface improvements for funding and since there is some merit in picking optimum times for grooving (from the standpoint of runway use and other runway improvements), the airlines recognize that the expansion of the runway grooving program will be a gradual process. Nevertheless, the airlines are encouraged by the progress that has already been made since the June 1968 decision to seek more grooved runways.

The grooving of runways 13R-31L and 4R-22L at Chicago's Midway Airport, which was completed last September, represents the first time Federal Aid to Airports Program (FAAP) funds were used to help defray the cost of grooving. Figures 5 and 6 show an aircraft on the grooved Midway runways.

Late in October, grooving was completed on Charleston, West Virginia's Kanamha County Airport runway 5-23. Grooving recently started on Atlanta Airport runway 9R-27L should be completed around early 1969. The next runway to be grooved could well be 4R-22L at Boston's Logan International Airport. This is now under consideration by the airlines and the Massachusetts Port Authority.

CONCLUDING REMARKS

The airlines are convinced that runway grooving is an effective aid in overcoming hydroplaning. Grooving also helps to increase the stopping capability of large turbine-powered aircraft when landing on wet runways or runways with standing water. Airline operational evaluation of grooving during a period of 15 to 19 months at three U.S. airports not only demonstrated in an operational environment the conclusions reached as a result of NASA research but also dispelled earlier fears that grooving might damage runways or aircraft. The airlines believe the evidence to date shows that (1) grooving has produced no increased rate of runway deterioration, (2) runway drainage has been improved by grooving, and (3) there are no aircraft maintenance problems that appear related to operations on grooved runways.

In conclusion, the airlines have tried grooving and found that it works. They are now engaged in bringing this new safety aid into widespread operational use by working with airport authorities and the FAA to have more runways grooved. Finally, the airlines have asked me to express their appreciation to NASA for the research which made this evaluation possible. ATA will continue to work closely with NASA's pavement grooving and runway traction research program.

TABLE 1.- AIRLINE RUNWAY GROOVING EVALUATION DATA FOR JOHN F. KENNEDY INTERNATIONAL AIRPORT AND KANSAS CITY MUNICIPAL AIRPORT

	JFK	KC
Cost per square foot, dollars	0.13	0.14
Cost to airlines, dollars	178 500	87 000
Material	Concrete	Concrete and asphalt
Daily grooving time	6 a.m. to 3 p.m.	12 p.m. to 7 a.m.
Runway use during grooving operations	Closed	15 min open 15 min closed
Groove pattern:		
Width, in.	3/8	1/8
Depth, in.	1/8	1/4
Pitch, in.	$1\frac{3}{8}$	1
Shape		
Completed	Aug. 1967	May 1967

TABLE 2.- AIRLINE RUNWAY GROOVING EVALUATION

Summary of Airline Pilot Survey
August-September 1967

[Airports: Washington National, Kansas City Municipal, and John F. Kennedy International. Airplanes: DC-8, DC-9, 707, 720, 727, and 188]

Percent of landings with following conditions:	
Rain stopped just before landing	34
Light rain during landing	47
Showers during landing	9
Heavy rain during landing	10
Touchdown speed, knots:	
Maximum	135
Minimum	105
Average	118
Comments on directional control, percent of pilots questioned:	
Improved	86
Not improved	7
No comment	7
Reduction of stopping distance, feet:	
Maximum	3000
Minimum	500
Average	1081

TABLE 3.- AIRLINE RUNWAY GROOVING EVALUATION

Summary of Airport Survey
May 1968

	JFK	WN	KC
Changes in rate of pavement deterioration	None indicated	None indicated	Slight increase for concrete; none for asphalt
Drainage rate	Increased – absence of spray in front of airplane	Increased – no reports of spraying	Increased – difference in spray pattern normally experienced
Maintenance problems reported by airlines	None	None	None
Other problem areas	Accumulation of rubber deposits anticipated, but none formed	Rubber deposits filling grooves anticipated, but none formed	None except for increased deterioration of concrete pavement

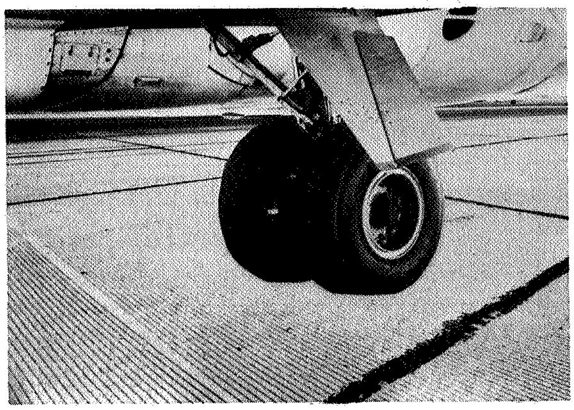

Figure 1

Figure 2

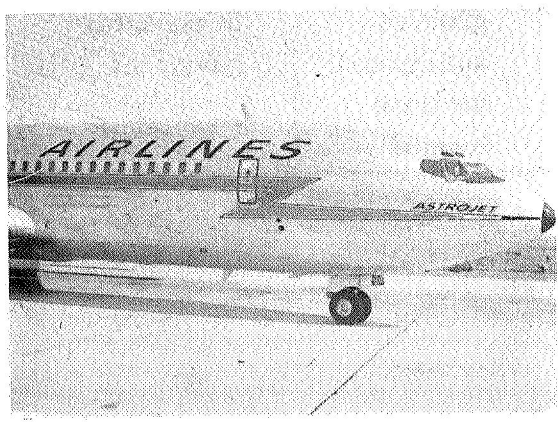

Figure 3

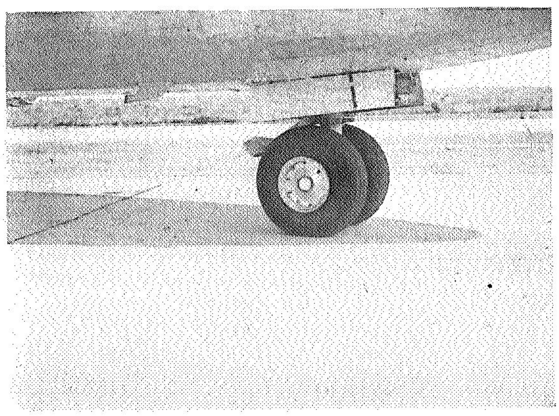

Figure 4

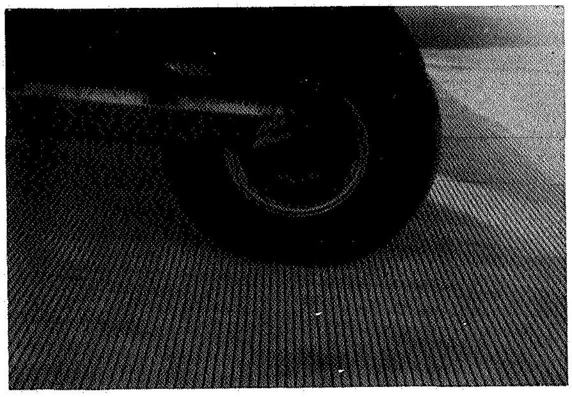

Figure 5

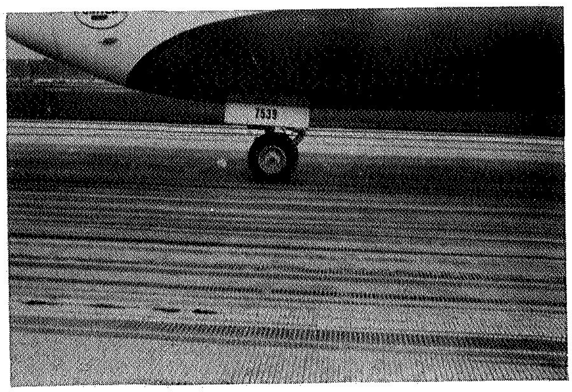

Figure 6