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THE FRICTION CLASSIFICATION OF RUNWAYS.(U)
DEC 79 R W SUGG, I BEATY, R J NICHOLLS
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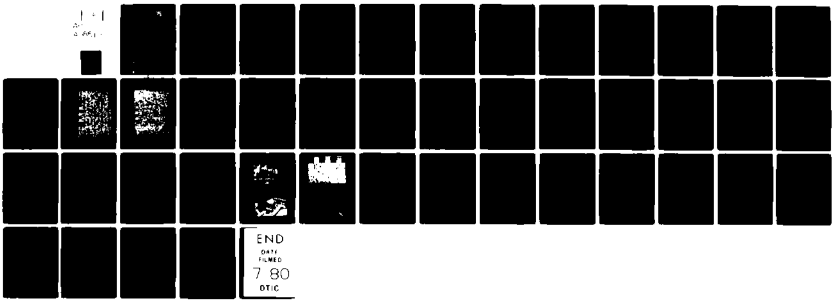

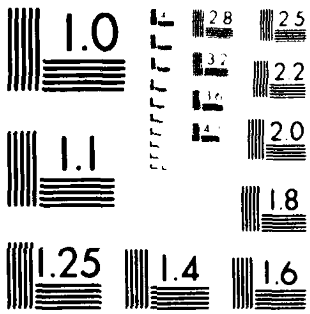
1.0
2.8
2.5
3.2
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2.0
1.1
1.8
1.25
1.4
1.6

S&T-MEMO- 6 -79

PROCUREMENT EXECUTIVE MINISTRY OF DEFENCE

THE FRICTION CLASSIFICATION OF RUNWAYS

R W SUGG, I BEATY AND R J NICHOLLS

ISSUED BY:
DEFENCE RESEARCH INFORMATION CENTRE
Station Square House, St. Mary Cray, Orpington, Kent, BR5 3RE

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(6) THE FRICTION CLASSIFICATION OF RUNWAYS,

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SUMMARY

The fundamental principles regarding the design of runway surfaces to provide high friction under wet conditions are well known and have been put into practice for some time. In the past a locked wheel trailer has been used to assess the relative friction of runways by making measurements at a number of isolated points on the surface. With the development of the Continuous Recording Runway Friction Meter (Mu-Meter) and a runway self wetting system contained in the tow vehicle, it has been possible to obtain a permanent record showing the friction reading along the entire length of a runway. This S&T Memo describes the method developed to carry out such a trial together with its associated Standard Friction Classification Table.

Use of the Mu-Meter under natural rain conditions has demonstrated that aircraft aquaplaning could sometimes occur in local areas. A method is described how these areas can be identified and how it is combined with the self wetting trial to give a proper friction evaluation of a runway.

The relationship in Mu-Meter readings when using the US Federal Aviation Administration and UK Ministry of Defence methods of runway friction classification, have been determined.

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TABLES

FIGURES

FIGURES (Contd)

APPENDIX

1. Introduction

1.1 One of the operational problems that was created when aircraft landing speeds started to increase was the ability to stop within the confines of the runway, particularly when wet. The most immediate outcome was the introduction of runway grooving (Fig 1) and later the development of the Porous Friction Course (Fig 2). The grooves which were ¼" wide, ⅛" deep of 1" centres, improved the mecrotexture of the surface and as explained in Ref 1, increased the friction level at high speeds. The Porous Friction Course consists of a layer of aggregate between 1" and 2" thick which is so graded when it is laid there are interconnecting drainage holes. These holes first allow the water to drain in a vertical direction until it meets the impervious surface on which the PFC is laid, then sideways down the crossfall. Provided the runway is correctly profiled no water collects on the surface.

1.2 A high speed trailer developed by the Transport and Road Research Laboratory was used to measure runway friction. This trailer could be towed at speeds up to 100 mph and measured friction by locking the test wheel for a short distance and it was established the results did bear some relation to pilots opinion. The test method was to select several small areas on the runway which were wetted by a water bowser. Runs were then made at speeds between 20 and 100 mph and runways compared by the friction value at 80 mph. Additional water was applied when the surface condition was considered to have changed sufficiently to affect friction.

1.3 Since the test areas were relatively small and the water depth a matter of opinion, the equipment was limited in its accuracy and the extent of its survey. With the development of a Continuous Measuring Runway Friction Meter (Mu-Meter) (Ref 2) for use in the Royal Air Force, the situation changed considerably since a self-wetting system was also developed which could be carried in the towing vehicle to deposit a standard quantity of water ahead of each test wheel as well as provide a continuous record of friction from end-to-end of the runway. It was now possible to create a more scientific method by which runway friction could be judged. The result of trials using several different types of aircraft under differing runway conditions demonstrated that a relationship could be established between aircraft stop distance and average Mu-Meter reading. See Fig 3 and Ref 3 Fig 9. Consequently the Mu-Meter could be used with confidence to compare runway friction.

1.4 The initial Service requirement for the Mu-Meter was to provide a daily indication of the runway state under natural rain conditions. When these recordings became available it was found that the variations in friction along the runway could be very different from those in its self-wetting mode, see Figs 4, 5, 6 and 7. It was found that these variations were due, almost entirely, to changes in water depth caused by the slight uneveness of the runways.

1.5 Tests with aircraft at the Cranfield Institute of Technology (Ref 4) established the following table which gives the depth of water needed to cause acuaplaning on different types of runway surface.

Table 1 - Critical Water Depths which will Initiate Acuaplaning

Surface	Percentage Velocity is above Acuaplaning Speed	
	10%	40%
Brushed Concrete	.08	.04
Scored Concrete	.18	.06
⅛" Grooved Concrete	-	.18
⅛" Grooved Asphalt	-	.15
Marshal Asphalt	-	.04
¼" Grooved Concrete	.23	.13

1.6 Tests in the "critical water depths" of Table 1 gave Mu-Meter readings of between .3 and .4. Some Mu-meter recordings of runways under natural rain conditions gave readings, in some areas, below this figure (see Figs 4, 5, 6 and 7). Although the length of these potential acuaplaning areas was often short, a succession of such areas could cause the aircraft wheels to spin down resulting in a dangerous condition where a type of aquaplaning could continue down to a very low speed. It was clear that an important part of a test to determine the classification of a runway would have to be a check if such conditions existed.

1.7 The classification had therefore to consist of 2 separate and distinct parts. Firstly the general friction level measured at a standard speed under standard wetness conditions where it can be compared with other known surfaces and be related to a table giving recommended actions. Secondly, tests under natural rain conditions over the full length and width of runway where the presence and location of low friction areas caused by ponding can be established.

2. Self-Wetting Trials

2.1 The self-wetting system used by the Ministry of Defence consists of a 70 Imperial gallon rigid tank fitted behind the driving seat of a 3 litre Ford Capri and a 12 volt motor driven pump which can be regulated to deliver up to a maximum of 50 gallons of water per minute. The water is discharged just ahead of each test wheel through brushes in contact with the runway. The brushes reduce the dispersion of the water when the equipment is used at high speed. See Appendix A Plates A1 and A2. In addition to the trace recorder in the Mu-Meter itself, the vehicle contains a repeater in the instrument panel so that the readings can be seen in the driving position during test runs.

2.2 After carrying out the standard calibration checks called for in Ref 2, runs are made down the runway at speeds of 20, 40, 60 and 80 mph along a track approximately 5 metres from the centre-line, discharging water ahead of the test wheels at the rate of 10, 20, 30 and 40 Imperial gallons per minute respectively. The object of changing the water discharge rate with speed is to maintain a standard water depth under the test wheels, this depth has been calculated as approximately .015".

2.3 The shape of the speed/friction curve obtained by plotting the test data from these runs, shows how much friction drops with speed and is a factor that must be taken into account in the final report. The runway itself is classified in accordance with the following table using the average reading at 80 mph obtained from the Mu-Meter recorder trace.

Table 2 - Runway Classification Table - NATO Stanag 3811

Average Mu-Meter Reading at 80 mph	Classification Standard	Action
.6 and above	Acceptable	None
.59 to .4	Marginal	Inspect and rectify as necessary
.39 and below	Unacceptable	Corrective action required

2.4 There will be occasions when the average of the end-to-end friction value will be in the "acceptable" category, but certain areas may give low readings due to rubber deposits or other reasons. Where these readings fall below .39 in the braking area, rectification action should be taken if the contaminated area is long enough to affect stop distance in such a way as to constitute a hazard.

2.5 The use of a high speed for this type of work is favoured since it gives a clearer indication of the relative merits of different surfaces particularly when they are at approximately the same friction level. However, tests have shown that provided a correction is made it is possible though less accurate, to use the same Classification Standard in Table 2 by running the Mu-Meter at a lower speed. See Fig. 8. The relationship between the

Mu-Meter readings using the US Federal Aviation Administration and UK Ministry of Defence test speeds and self wetting discharge rates is at Fig. 9.

2.6 A typical report of a high speed friction trial is at Part 1 of Appendix A. This shows the standard pro forma used for the results, how friction is plotted against speed and the type of photographs taken to describe the test surface. To serve as a comparison for test results, Fig 10 is a list of some runways that have been tested and placed in their friction order together with the NATO Stanag 3011 Classification Standard.

3. Natural Rain Trials

3.1 As explained in paras 1.6 and 1.7 this part of the runway friction classification trial is to determine if there are areas where a potential aircraft aquaplaning risk exists. Where these areas are present, they are frequently caused by undulations in the runway, allowing water to collect. For this trial a Mu-Meter has to be positioned at the airfield ready for it to rain. Because vehicles used on airfields cannot be expected to have the performance to pull a Mu-Meter at 80 mph, a speed of 40 mph has been used as the standard for this part of the classification trial. To make a survey of the whole runway width, the test tracks are specified together with their sequence. See Fig 11.

3.2 Using the event bulb in the vehicle cab each run is identified as follows:

2 squeezes at the start threshold

1 squeeze as soon as 40 mph is reached

1 squeeze just before decelerating

2 squeezes at the finish threshold.

The Remote Read-out Unit (if fitted) is operated in the normal manner ie switched on when 40 mph is reached, changing channels at each third of the runway and switching off before decelerating. In addition the following are observed.

3.2.1 At regular intervals the trace is to be marked with the run number. At this point check to ensure sufficient recording roll remains to continue the operation and that the Mu-Meter is functioning correctly.

3.2.2 The test wheels are splayed out at all times, even if the vehicle is temporarily cleared from the runway.

3.2.3 The Wet Test Log at Fig 12 is used to keep a record of all runs.

3.2.4 At the end of the runs a copy of the rainfall trace for the day (if available) is attached to the Wet Test Log.

3.2.5 To confirm the calibration of the Mu-Meter, a run is made in dry conditions as soon as possible after the wet runs at a position 2 metres to one side of the centre-line. The result should be recorded in the Wet Test Log.

3.3 Since the traces have all been marked to show the beginning and end of the runway, an inspection of the trace can show where areas of low friction occur on the actual runway along each track. By associating the readings of one track with another it is possible to show how areas of low friction occur across the runway as well as along its length. See Fig 13.

3.4 The following friction table from Stanag 3634 is used to judge the runway condition.

Table 3 - Extract from NATO Stanag 3634 - Braking Action Table

Mu-Meter Reading at 40 mph	Verbal Description
.5 and above	Good
.49 to .35	Medium
.34 and below	Poor

3.5 As shown in para 1.6 a potential aquaplaning condition can exist when the Mu-Meter reading is below .4 and this figure is now used when indicating when and where the runway surface is below standard. See Fig 13.

4. Trials Report

4.1 Appendix A is an example of a final test report where the results of both the self-wetting and natural rain trials form Parts 1 and 2 of a combined document. Part 1 contains a standard test proforma for use at the classification speed of 80 mph whilst at Table 1A is a record of Mu-Meter readings at speeds of 20, 40, 60 and 80 mph which are plotted at Fig 7A and in this case shows a small drop off at high speed. Figs 2A to 6A are typical Mu-Meter traces along different tracks and show an inherently high friction reading.

4.2 Part 2 of Appendix A describes the test under natural rain conditions with a typical trace marked with the danger areas. Fig 2B has been constructed using the method described in paras 3.3 and 3.5 to show the areas with a potential aquaplaning risk. Another example of a combined report is at Appendix C of Ref 3.

5. Discussion

5.1 As the result of trials with a number of aircraft it has been demonstrated that a relationship can be established between Mu-Meter reading and aircraft stop distances under wet conditions. This fact gives confidence that the equipment can be used to conduct a runway friction survey which is meaningful to aircraft performance. A set of standard conditions and a Friction Table have therefore been developed so that the measured friction can be compared with other known runways and a decision made if and what remedial action to take.

5.2 It has been demonstrated that whilst self-watering trials will measure the inherent friction they do not always represent the friction under natural rain conditions. This is partly due to variations in water depth along the runway which may get worse with time.

5.3 Since aircraft trials have demonstrated that it only requires a water depth of .04 inches on some surfaces to cause aquaplaning, it can be seen that only a small change in runway slope is required to create a low friction area. It is therefore not surprising that results from runways under natural rain conditions have introduced an additional and vital condition which must be considered in the friction classification of runways.

5.4 Fortunately tests already conducted with the Mu-Meter in water depths which had been shown to cause aircraft aquaplaning, demonstrated that a dangerous condition could exist below a reading of 0.4. This figure is now used in runway classification work to indicate the areas where potential aquaplaning conditions exist.

6. Conclusion

6.1 Equipment used for this type of work must have been demonstrated as giving friction readings which can be related to the stop distances of different types of aircraft. It must also have been tested to determine the readings at which it will indicate potential aquaplaning conditions exist.

6.2 The friction classification of runways under wet conditions must consist of two parts. First, a survey from end to end using a self-wetting system to measure inherent friction. Second, a series of runs along defined tracks under natural rain to provide the data to determine the extent and position of possible aquaplaning areas.

6.3 This S & T Memo describes a satisfactory method now being used to conduct a runway friction classification using the Mu-Meter.

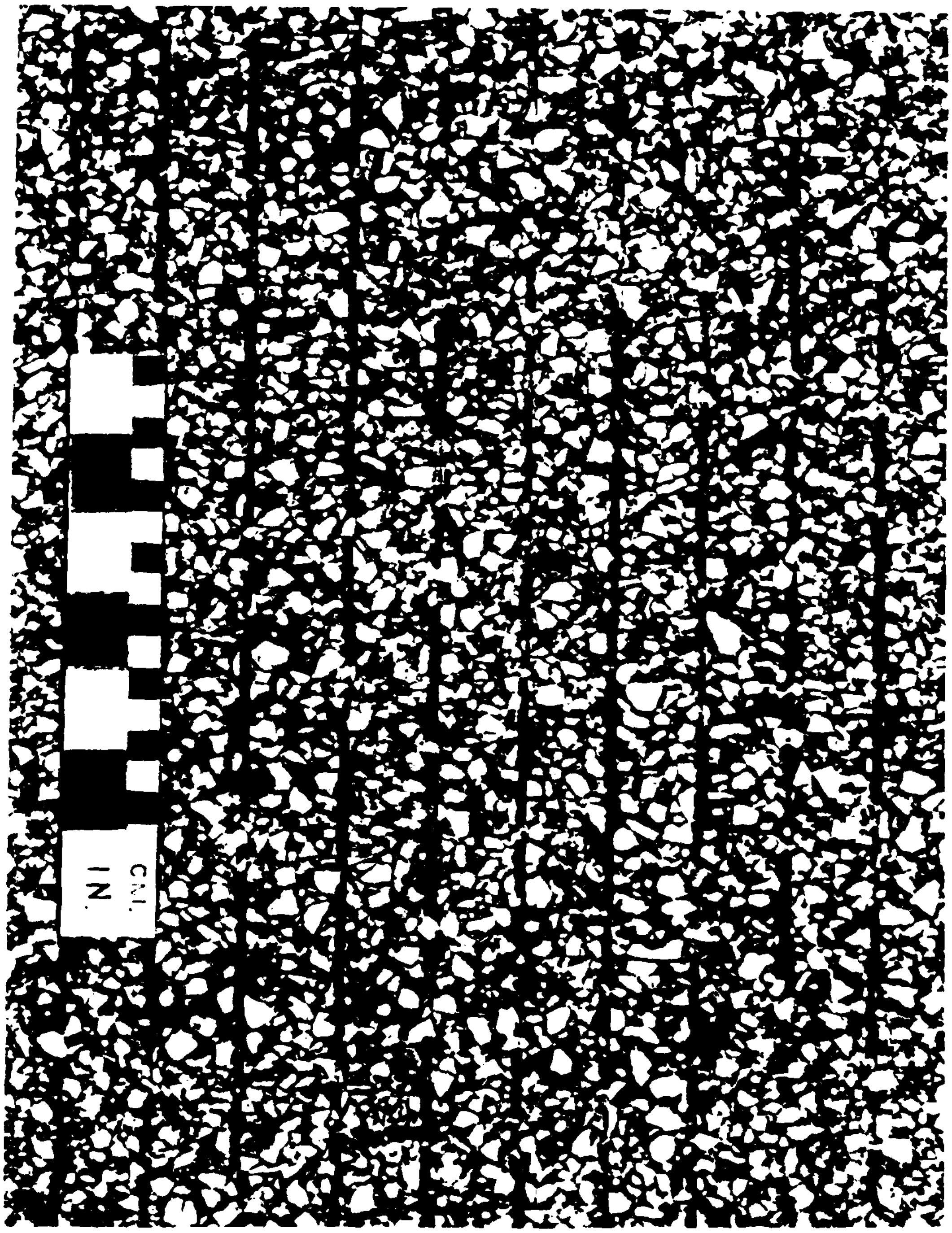
7. References

(1) R W Sugg - An Investigation into Measuring Runway Surface Texture by the Grease Patch and Outflow Meter Methods. Ministry of Defence S&T Memo 2/79.

(2) Continuous Recording Runway Friction Meter - Ministry of Defence Air Publication AP 11QJ-1001-126A.

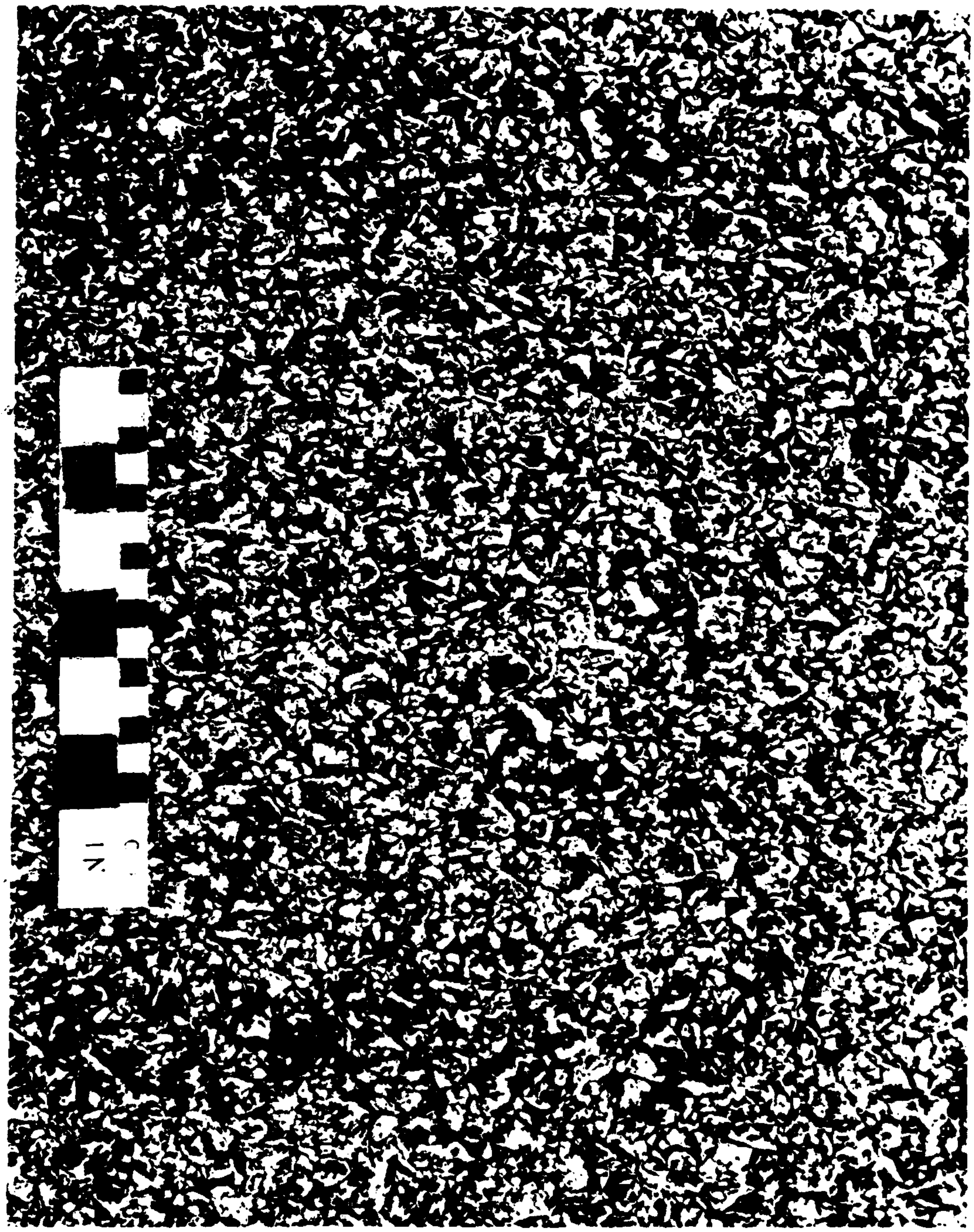
(3) I Beaty and R W Sugg - Trials to compare the stopped performance of three anti-skid systems and to demonstrate methods of determining aircraft stop distances on the Standard Military Reference Wet Surface, Ministry of Defence S&T Memo 3/79. AO78533

(4) J R Williams - The Effects of Runway Surface Texture on Aquaplaning - Ministry of Defence S&T Memo 11/71.



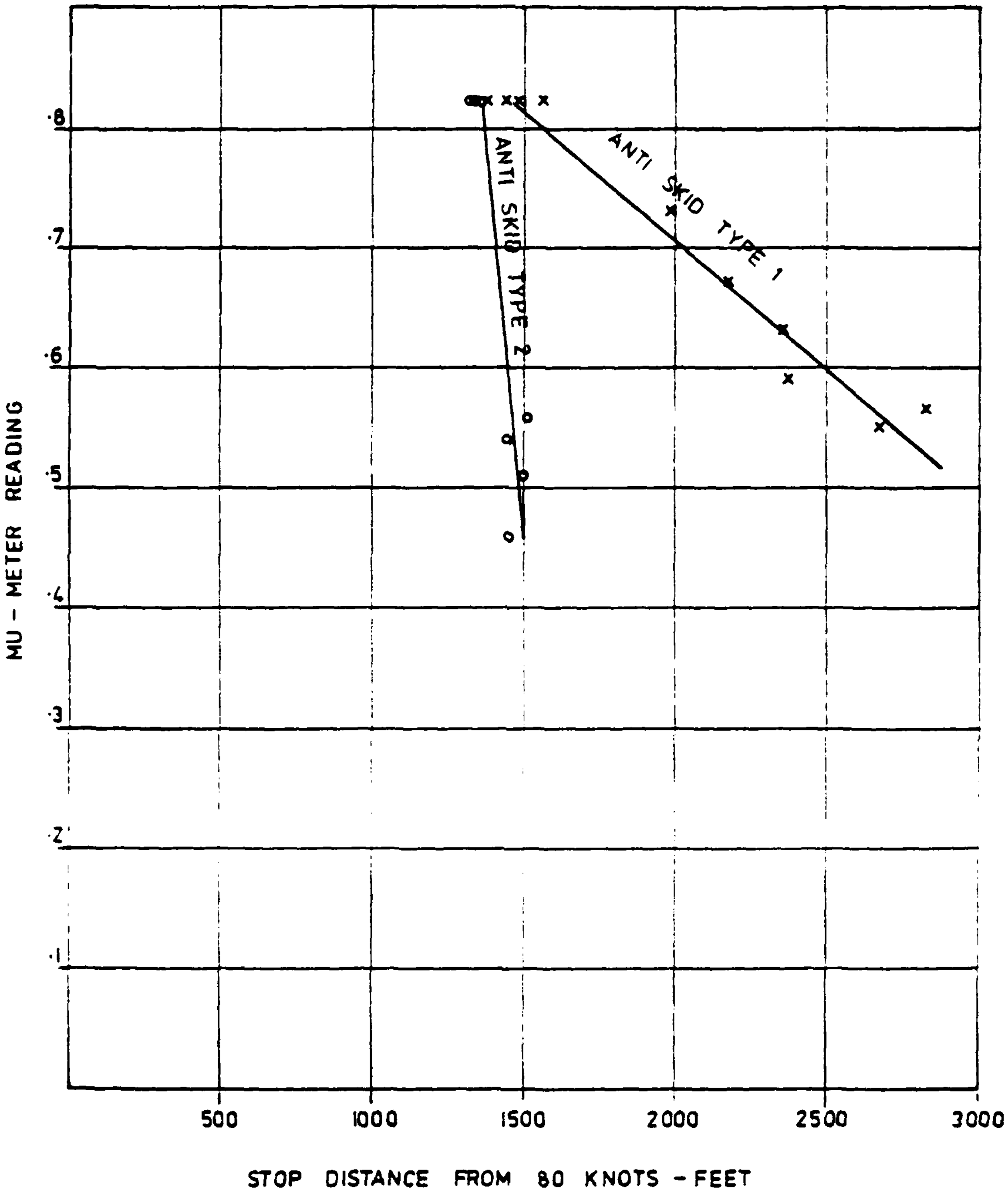
1/8" x 1/8" x 1" GROOVED ASPHALT

FIG. 1



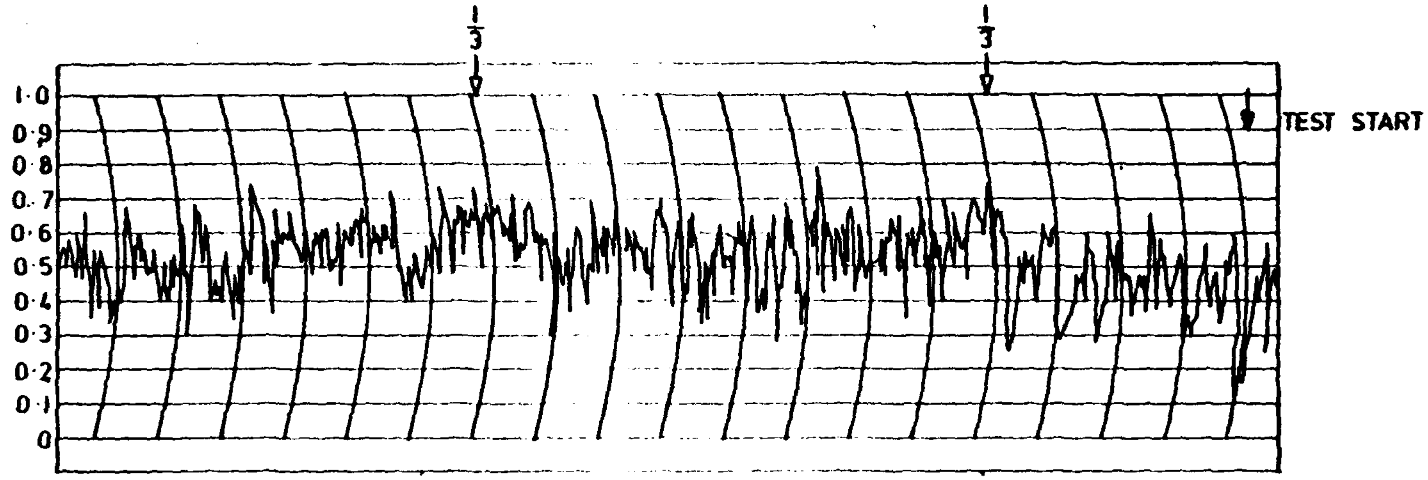
POROUS FRICTION COURSE

FIG. 2

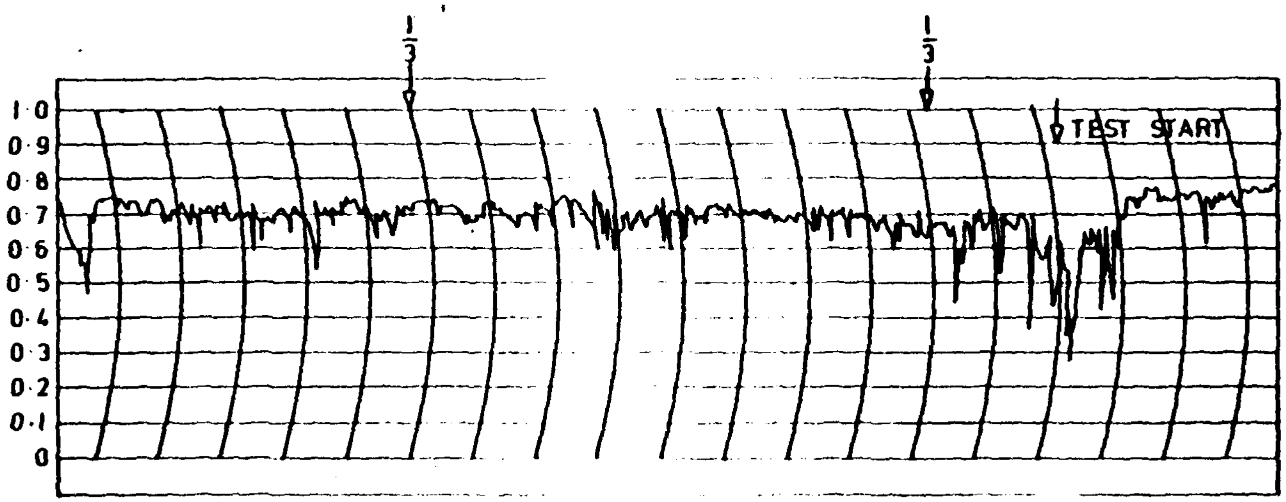


RELATIONSHIP BETWEEN MU-METER READINGS AND AIRCRAFT STOP DISTANCES FROM RECENT TRIALS

FIG. 3



MU-METER TRACE UNDER NATURAL RAIN CONDITIONS



MU-METER TRACE UNDER SELF WETTING CONDITIONS

A COMPARISON BETWEEN MU-METER TRACES UNDER NATURAL RAIN AND SELF WETTING CONDITIONS ON A MILITARY RUNWAY SURFACED WITH 1/8" PRE COATED GRIT

FIG. 4

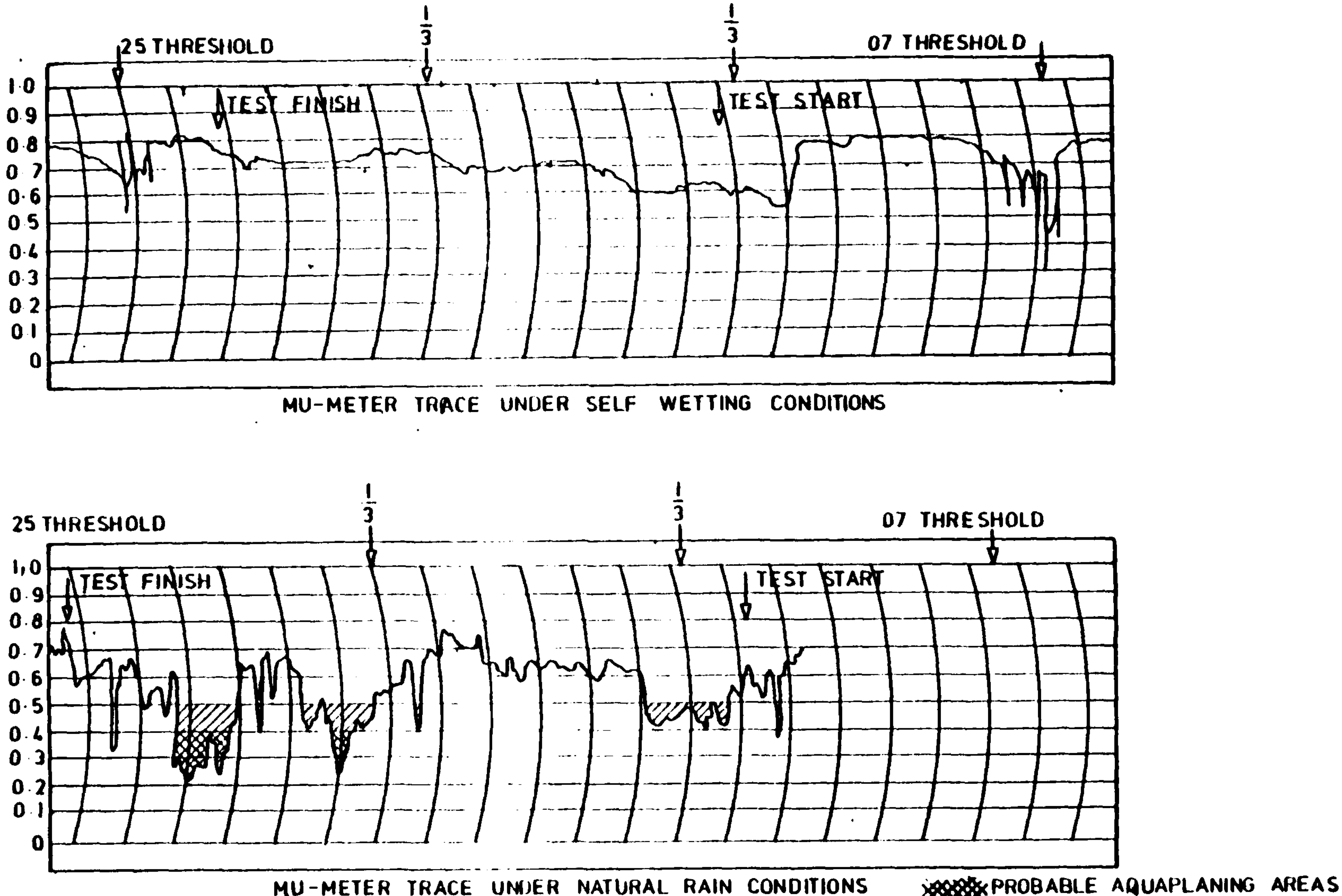
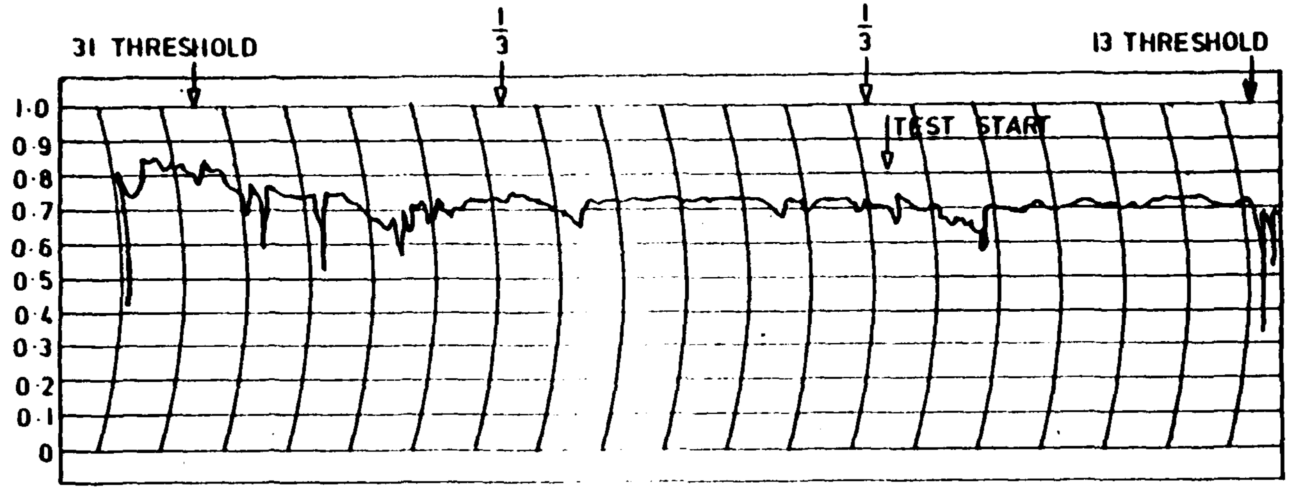
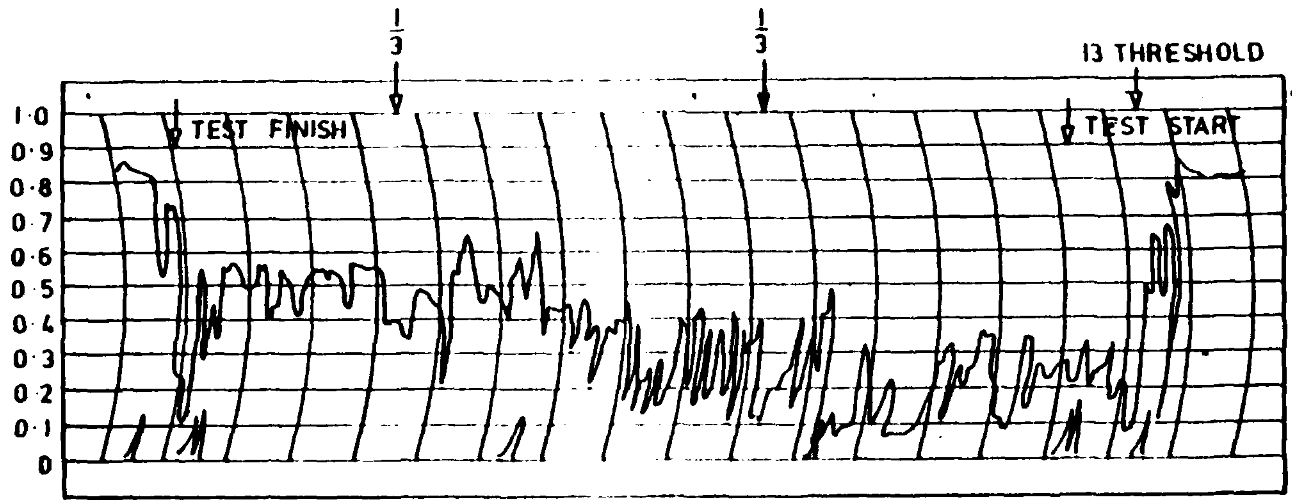


FIG. 5

A COMPARISON BETWEEN MU-METER TRACES UNDER NATURAL RAIN AND SELF WETTING CONDITIONS ON AN ASPHALT MILITARY RUNWAY



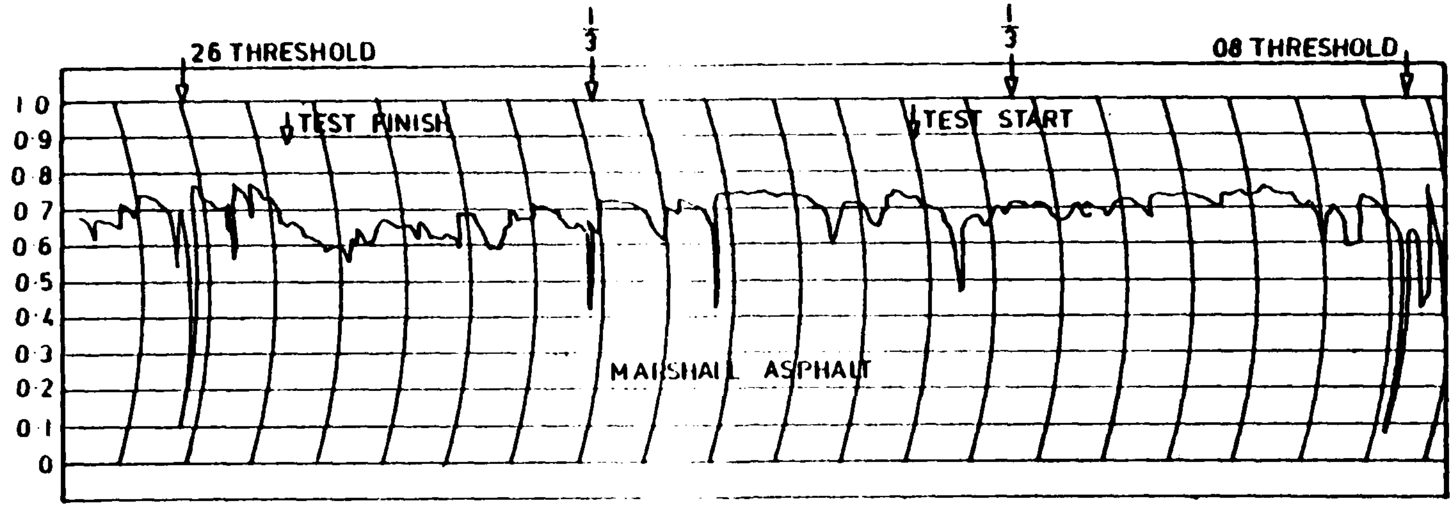
MU-METER TRACE UNDER SELF WETTING CONDITIONS



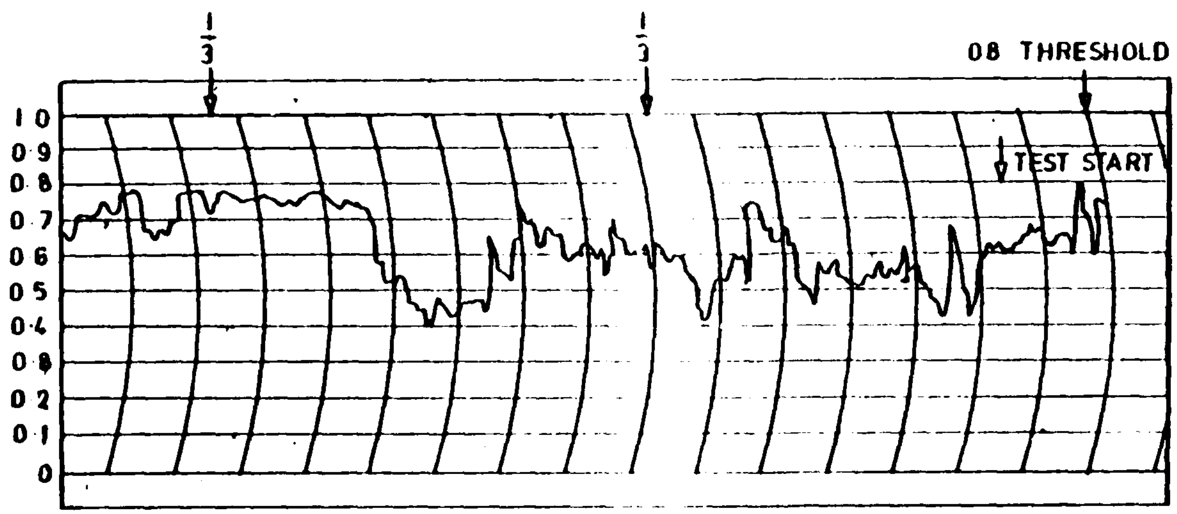
MU-METER TRACE UNDER NATURAL RAIN CONDITIONS

A COMPARISON BETWEEN MU-METER TRACES UNDER NATURAL RAIN AND SELF WETTING CONDITIONS ON A CIVIL RUNWAY SURFACED WITH $\frac{1}{8}$ PRE COATED GRIT

FIG. 6



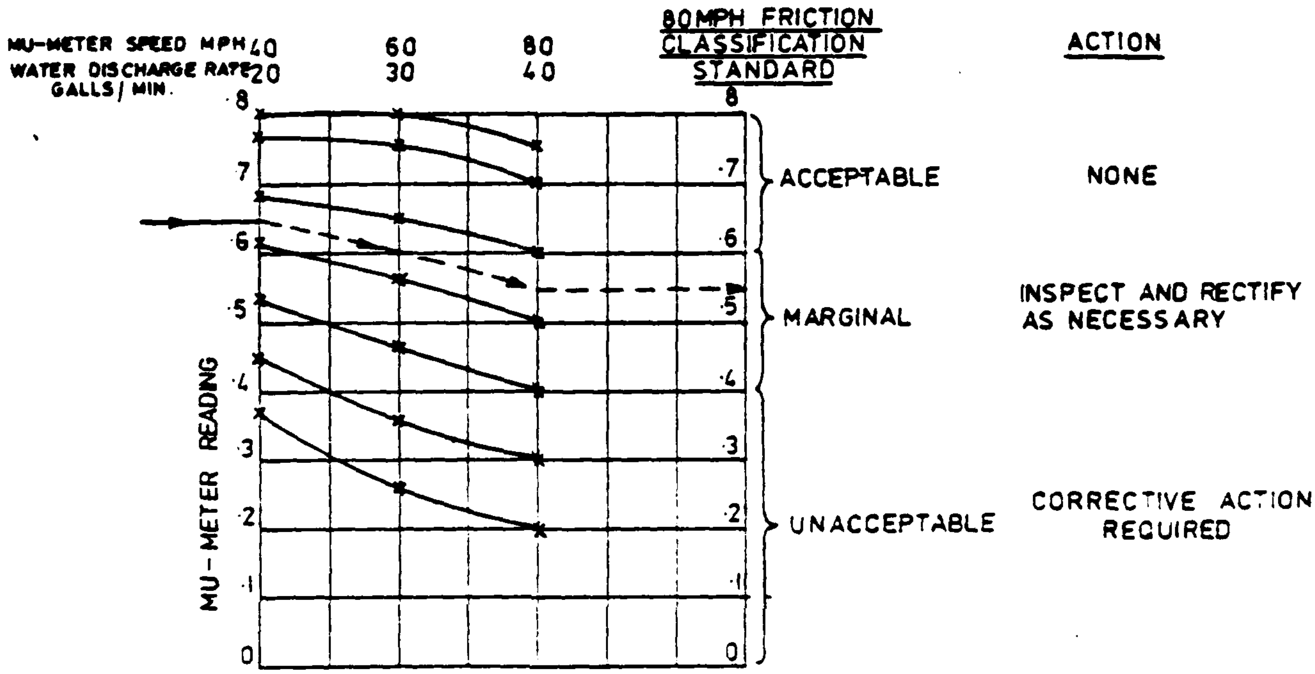
MU-METER TRACE UNDER SELF WETTING CONDITIONS



MU-METER TRACE UNDER NATURAL RAIN CONDITIONS

A COMPARISON BETWEEN MU-METER TRACES UNDER NATURAL RAIN AND SELF WETTING CONDITIONS ON A CIVIL MARSHALL ASPHALT RUNWAY

FIG. 7



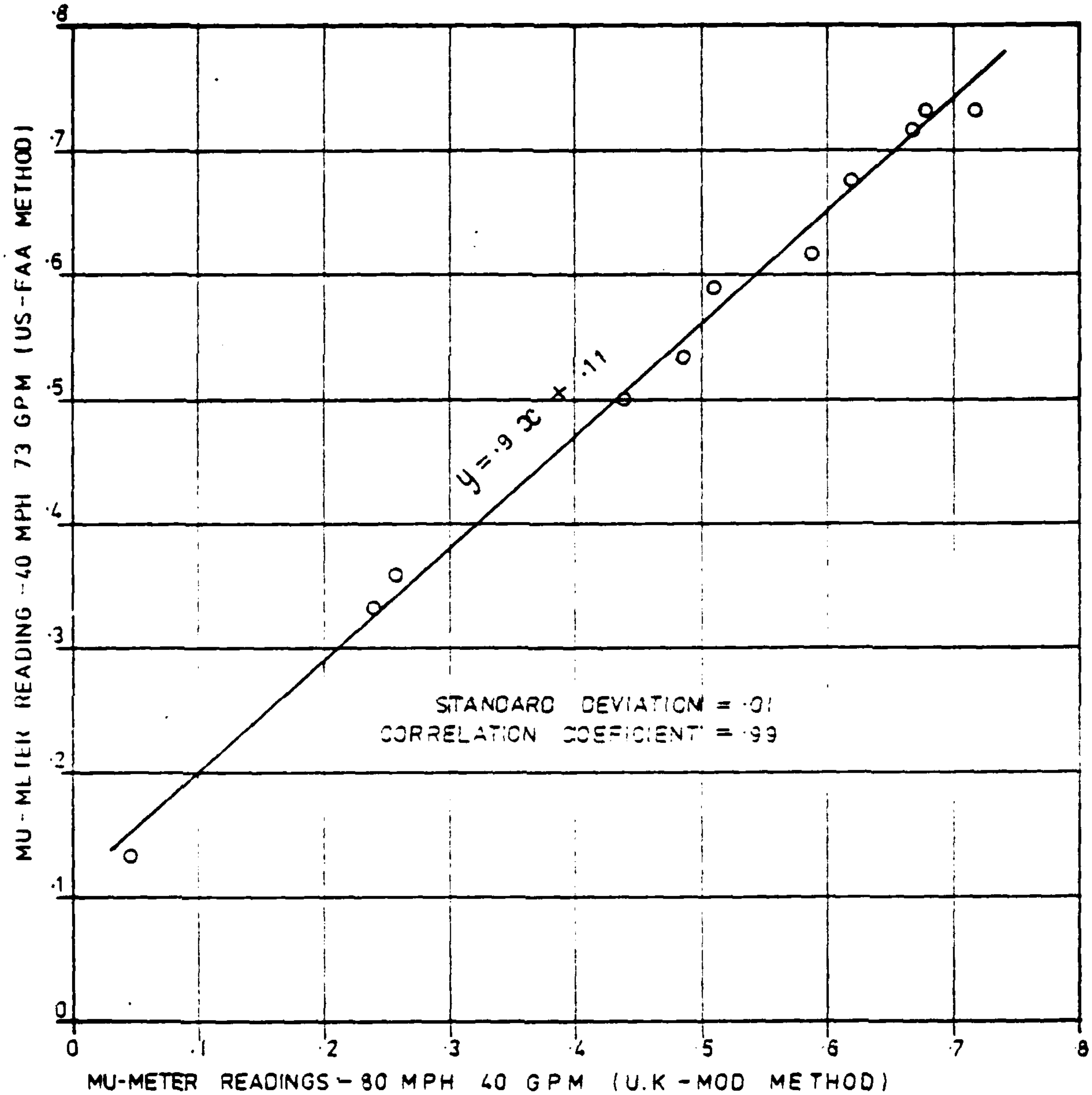
NOTE 1 THE SPEED RELATIONSHIP IS TAKEN FROM S & T MEMO 2/79

NOTE 2 THE CLASSIFICATION STANDARD AND ACTION IS FROM STANAG 3811

RELATIONSHIP BETWEEN MU-METER READINGS AT DIFFERENT SPEEDS UNDER SELF WETTING CONDITIONS

EXAMPLE – A READING OF ·65 AT 40 MPH USING A WATER DISCHARGE RATE OF 20 GAL/MIN IS THE EQUIVALANT OF ·55 AT 80 MPH USING A DISCHARGE RATE OF 40/GALL MIN AND GIVES A FRICTION CLASSIFICATION STANDARD OF 'MARGINAL'

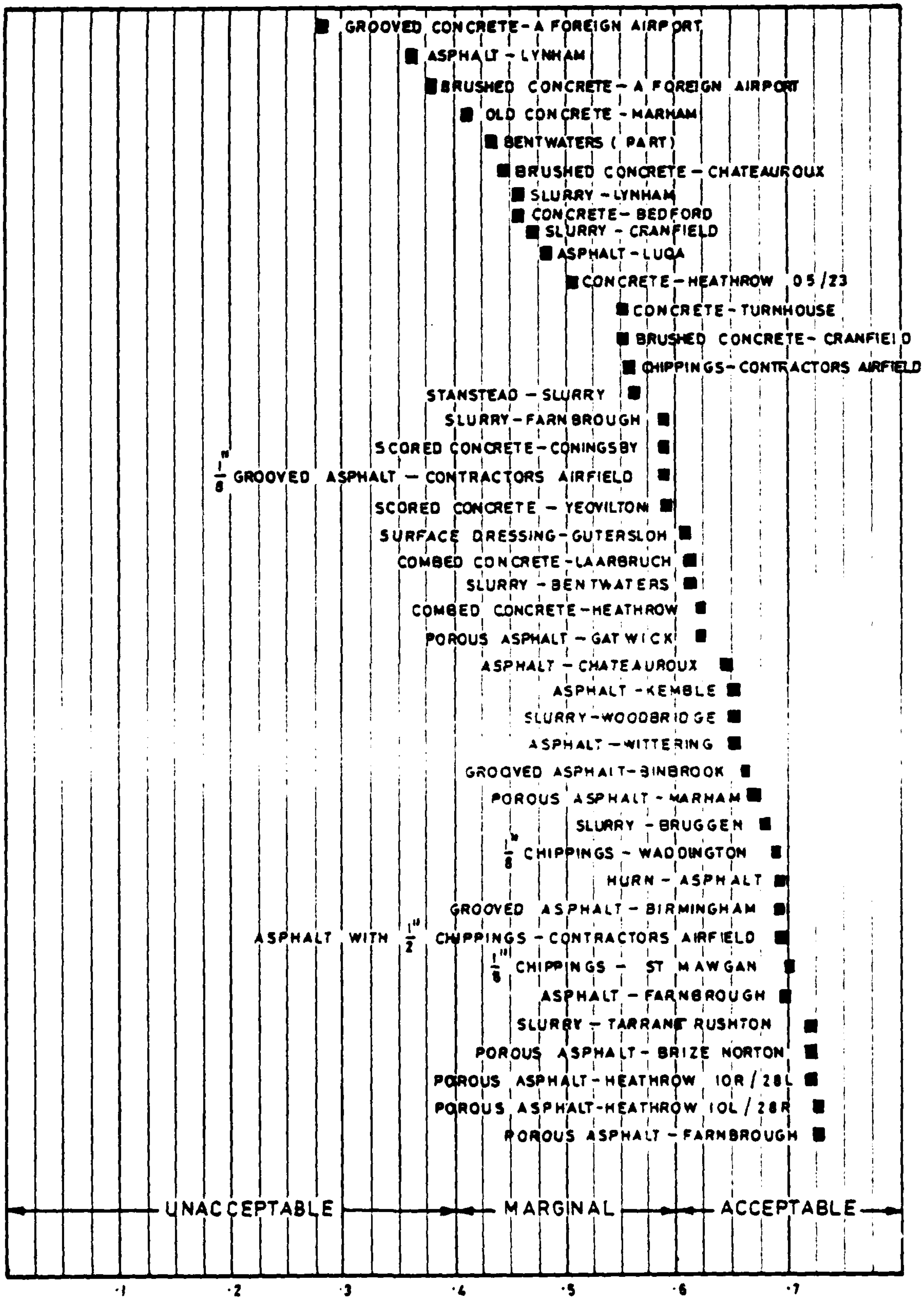
FIG. 8



RELATIONSHIP BETWEEN MU-METER READINGS USING U.S FEDERAL AVIATION ADMINISTRATION AND U.K. MINISTRY OF DEFENCE SELF WETTING METHODS.

FIG. 9

MU-METER RUNWAY FRICTION CLASSIFICATION TO DRAFT STANAG 3811 FS

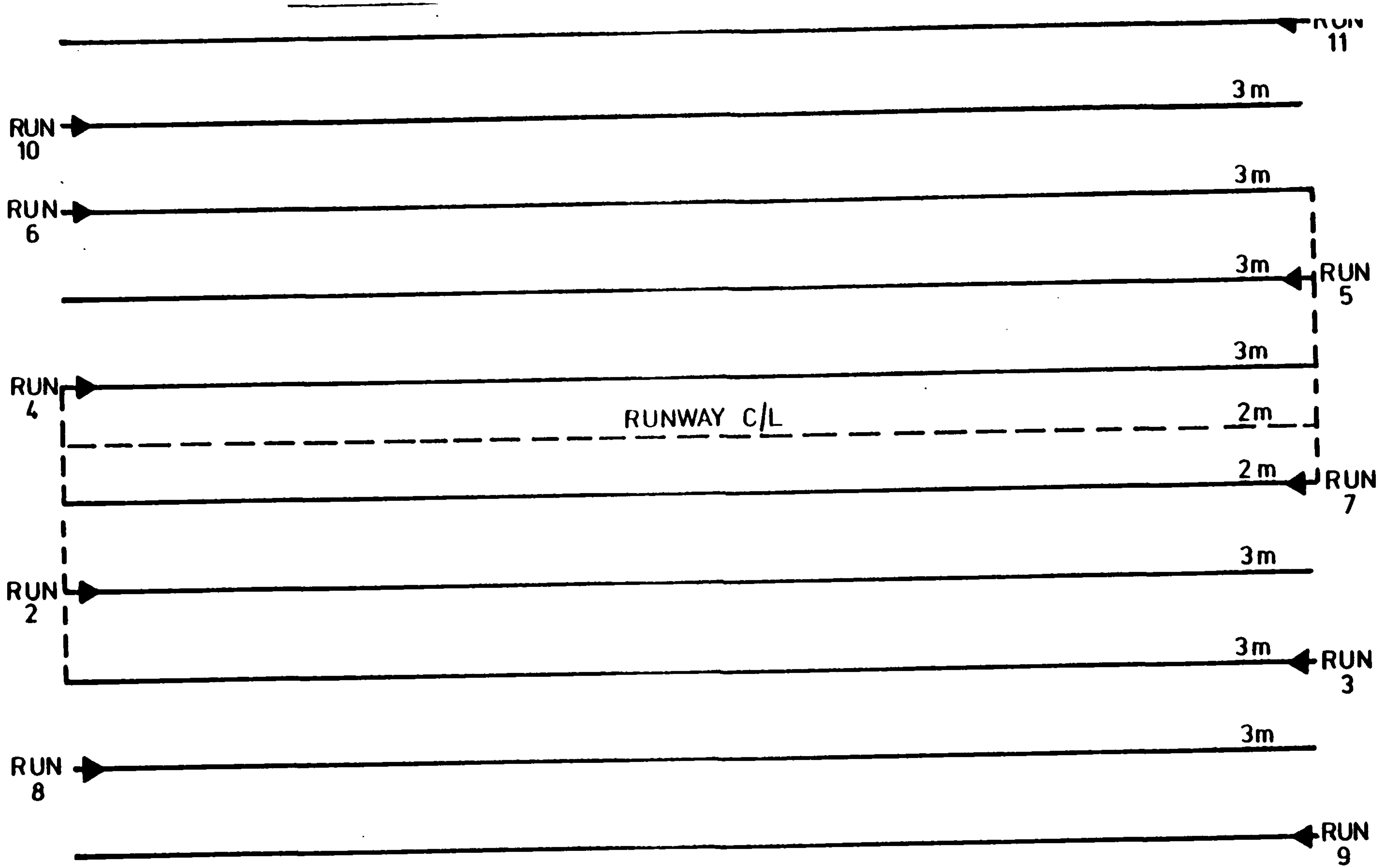


MU-METER SELF WETTING READING AT 80 M P H

NOTE 1 - SOME OF THESE RUNWAYS HAVE BEEN RESURFACED SINCE TESTING

NOTE 2 - THE READINGS RECORDED ARE FOR THE MAIN PORTION OF THE RUNWAY

FIG.10



* RUN 1 IS RECHECKED AT RUN 7 TO ASSESS ANY CHANGES IN CONDITIONS. RUN 8 ONWARDS DEPENDS ON THE WIDTH OF RUNWAY BEING ASSESSED

FIG.11

1/DW

WET TEST AND INCIDENT LOG

RAF STATION............................

DATE ....

OPERATORS...............................

....

RECORD OF LAST DRY CONDITION CHECK RUN

DATE

RRO READING (Mu)

TRACE READING (Mu)

TEST BOARD READING   DATE

TOW VEHICLE

REGISTRATION

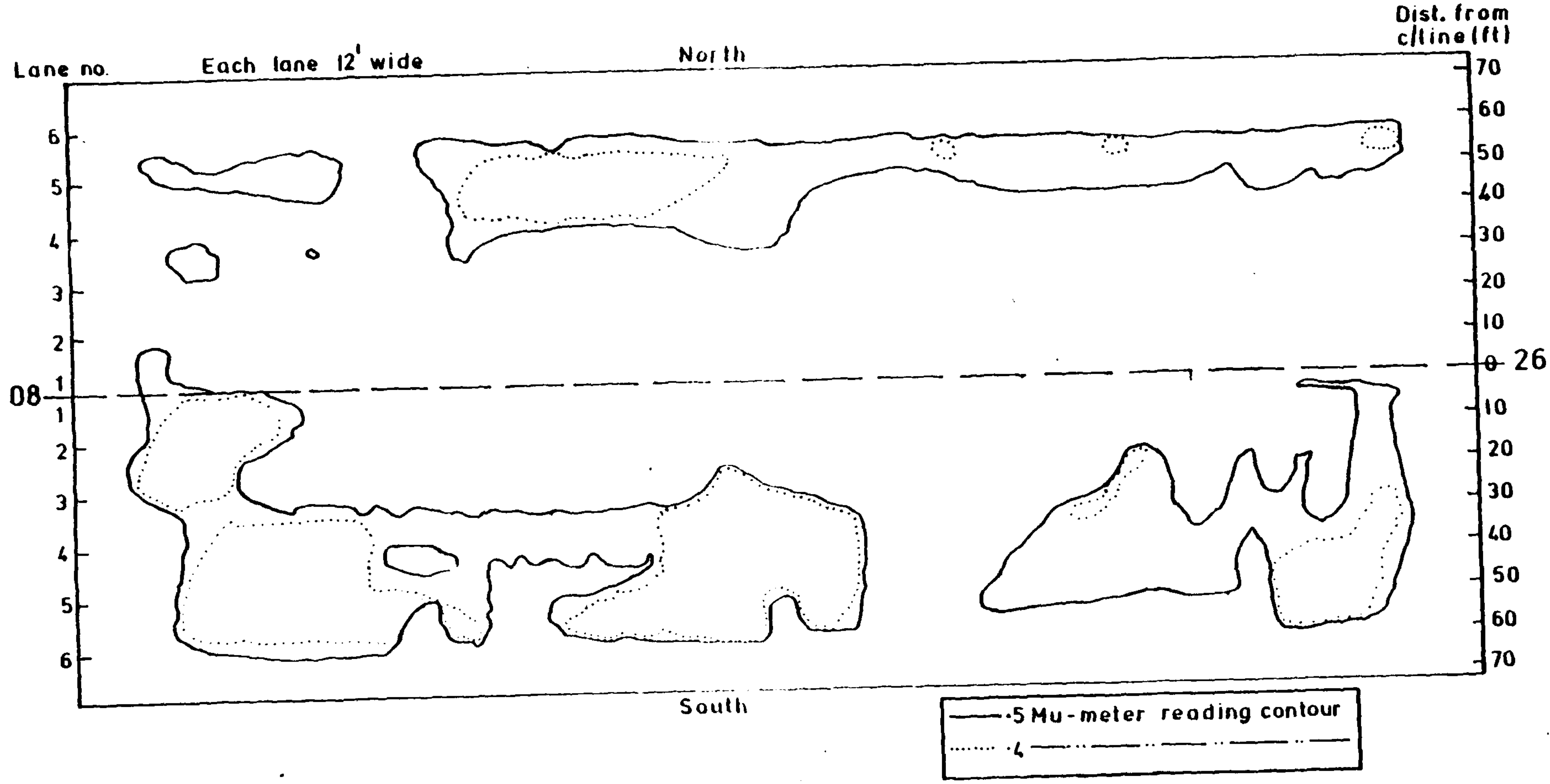
RAINFALL

COMMENT

(eg Rainfall during hour prior to test)

COL 1	COL 2	COL 3	COL 4	COL 5		COL 6									COL 7			COL 8
Run No	Dirn	Dist from C/L (M)	Time	Wind		Remote Readout 1	2	3	4	5	6	7	8	9	Trace			Remarks
				Dir	Velocity	C_1	B_1	C_2	B_2	C_3	B_3	Mu_1	Mu_2	Mu_3	Mu_1	Mu_2	Mu_3	

FIG. 12



FRICTION CONTOURS ON A CIVIL RUNWAY

FIG.13

APPENDIX A

Runway Friction Classification

RAE West Freugh
Parts 1 & 2

by I Beaty
R J Nicholls

Cranfield Institute of Technology

Issue 2
November 1978

RAE WEST FREUGH

Part 1 - High Speed Tests.

INTRODUCTION

Part 1 of this note describes a runway friction classification carried out on 6th November 1978 at RAE West Freugh by Cranfield Institute of Technology.

RUNWAY DESCRIPTION

Fig.A1 is a schematic diagram of runway 07/25 which is 6023 ft. long and 150 ft.wide. The surface is of rolled asphalt with ½-inch chippings. The surface texture varies along the runway, depending on the proportion of these chippings which appear above the general asphalt surface (see Plate 3). Approximately 500 ft. at each threshold is concrete.

TEST EQUIPMENT

Mu-Meter MLE 374 towed by a Ford Capri incorporating a self-wetting device capable of depositing approximately .015 inches of water beneath the Mu-Meter measuring wheels was used for the tests (Plates 1 and 2).

RESULTS

The results are shown in Table A1, the attached proforma, and in the traces of the five runs made at 80 mph (Figs.A2-A6) Two runs (Nos.9 and 10) were made at 40 mph with the water flow adjusted to give the same depth as at 80 mph. Two short runs (Nos.7 and 8) of approximately 1000 ft. each were made at 20 mph and 60 mph, once again with standard water depth so that, together with an average of the 80 mph runs and an average of the 40 mph runs, a speed/friction curve could be plotted as shown in Figure A7. The resultant curve shows a Mu-Meter value which decreased only slightly with speed indicating that this surface has good friction properties over a wide range of speeds.

Rubber deposits at both ends are light.

DISCUSSION

The traces give an average friction reading at 80 mph of .72 which is classified as good. The reading along the runway edge (Fig.A6 run 6) at .70 shows that trafficking has raised the adjacent to centreline readings slightly.

CONCLUSIONS

1. With an average Mu-Meter reading of .72 with self-wetting at 80 mph, this runway is classified as good.

RAE WEST FREUGH

DETAILS OF MU-METER RUNS ON RUNWAY 07/25.

Run No	Direction	Speed mph	Self Wetting	Distance from C_L	μ_{07}	μ_c	μ_{25}
1	25	40	Off	5'S	.77	.77	.77
2	07	80	On	10'S	*	.67	.73
3	25	80	On	15'S	.72	.71	*
4	07	80	On	10'N	*	.75	.77
5	25	80	On	15'N	.71	.72	*
6	07	80	On	50'S	*	.70	.70
7	25	20	On	5'N	-	-	.77
8	25	60	On	5'N	.77	-	-
9	07	40	On	20'S	.74	.76	.77
10	25	40	On	20'N	.77	.79	.76
11	07	40	Off	5'S	.83	.825	.81
12	25	40	Off	5'S	.79	.79	.795

TABLE A 1

* No reading - vehicle accelerating.

μ_{07} Friction reading for 1/3rd of runway at 07 end.

μ_c Friction reading for 1/3rd of runway central.

μ_{25} Friction reading for 1/3rd of runway at 25 end.

RUNWAY CLASSIFICATION PROGRAMME PROFORMA

Report on test at ....RAE WEST FREUCH........ Aerodrome

SECTION 1

Date of test: 6-11-78 | Time: 17·30

Weather: CLOUDY DAY | Wind: 20KTS | Direction: 180°

Runway direction: 07/25 | Length: 6023' | Width: 150'

Runway surface description: ASPHALT

Runway surface condition (swept/unswept etc): SWEPT

Runway rubber deposits (location and approx extent) LIGHT

Confirm runway DRY before tests: ✓

SECTION 2

Tests conducted by: Cranfield Institute of Technology. Towing vehicle: Ford Capri

Mu-Meter calibrated on test board before beginning test. Value was:- ·77

Confirm self-wetting device set at 40 galls per minute: ✓

Confirm test speed of 30 mph: ✓

SECTION 3 - Friction Measurements (Wet)

Note: Measurements to be made in both directions along tracks spaced 15 feet each side of centreline and in one direction along a track 20 feet from runway edge (middle third only).

15' South of centreline		
	Runway Hdg 07	Reciprocal Hdg. 25...
1st third	*	*
2nd third	·67	·71
3rd third	·73	·72
Trace	2	3

15' North of centreline		
	Runway Hdg 07	Reciprocal Hdg. 25...
1st third	*	*
2nd third	·75	·72
3rd third	·77	·71
Trace	4	5

20' from N/S edge	
	Runway Heading ...07...
Middle third	·70

Length covered by traces.

Trace No...2... Starting at.2143..ft from t/hold r/way.07....and ending.620..ft from t/hold..25...

Trace No...3... Starting at.2179.ft from t/hold r/way..25...and ending..620.ft from t/hold..07..

Trace No...4... Starting at.2267.ft from t/hold r/way..07..and ending..584.ft from t/hold..25..

Trace No...5... Starting at.2338.ft from t/hold r/way..25...and ending..762.ft from t/hold..07..

The original traces, annotated to give reasons for any significant variations in Mu-Meter values, must be attached to this form.

SECTION 4 Remarks

* Vehicle accelerating - No reading

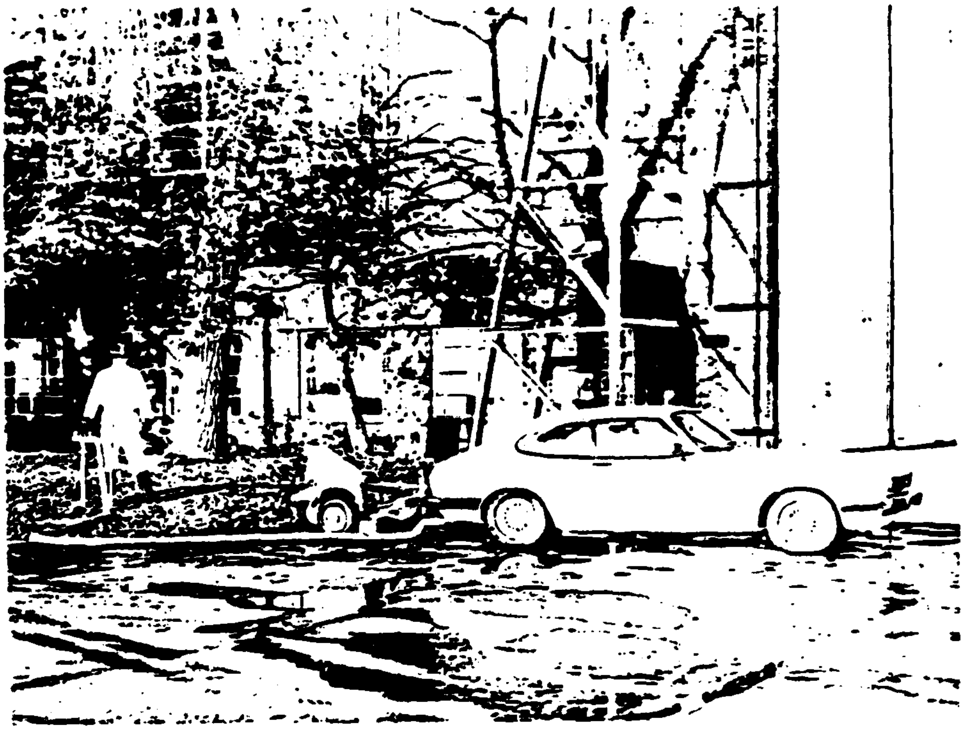


Plate 1 Mu-meter and tow vehicle

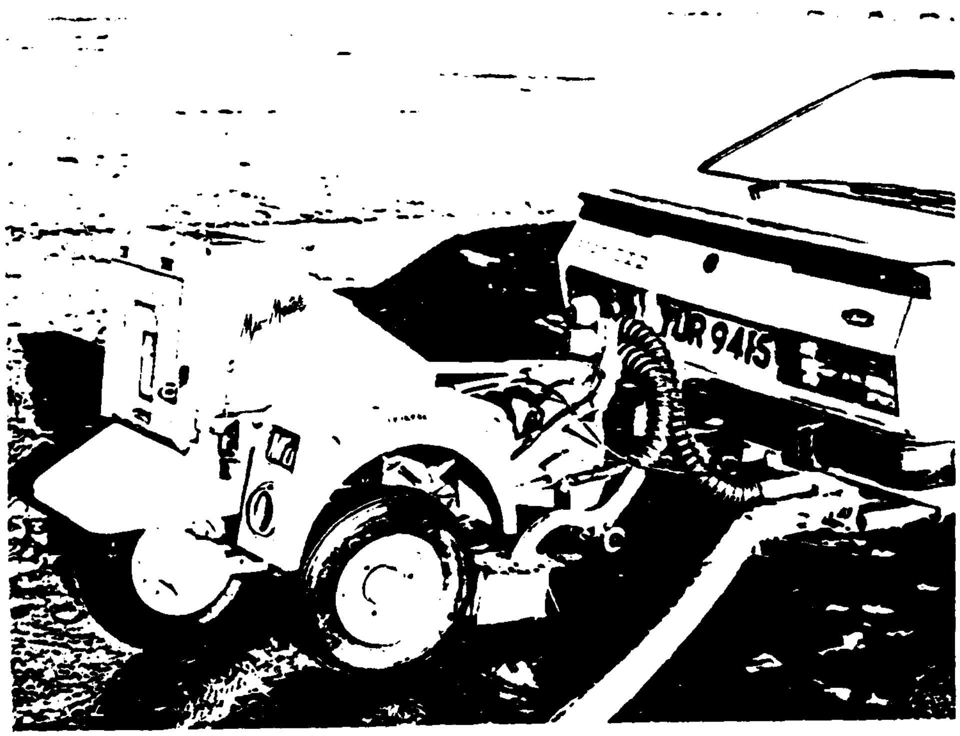


Plate 2 Self-wetting system

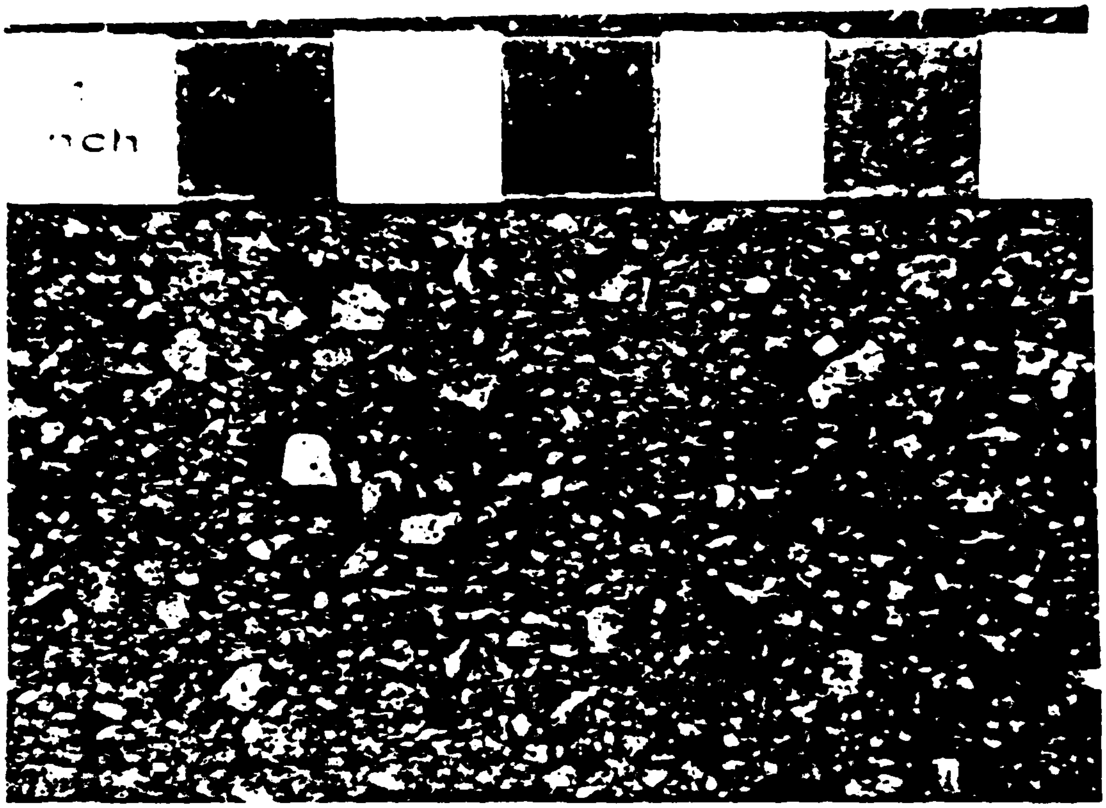


Plate 3 Asphalt

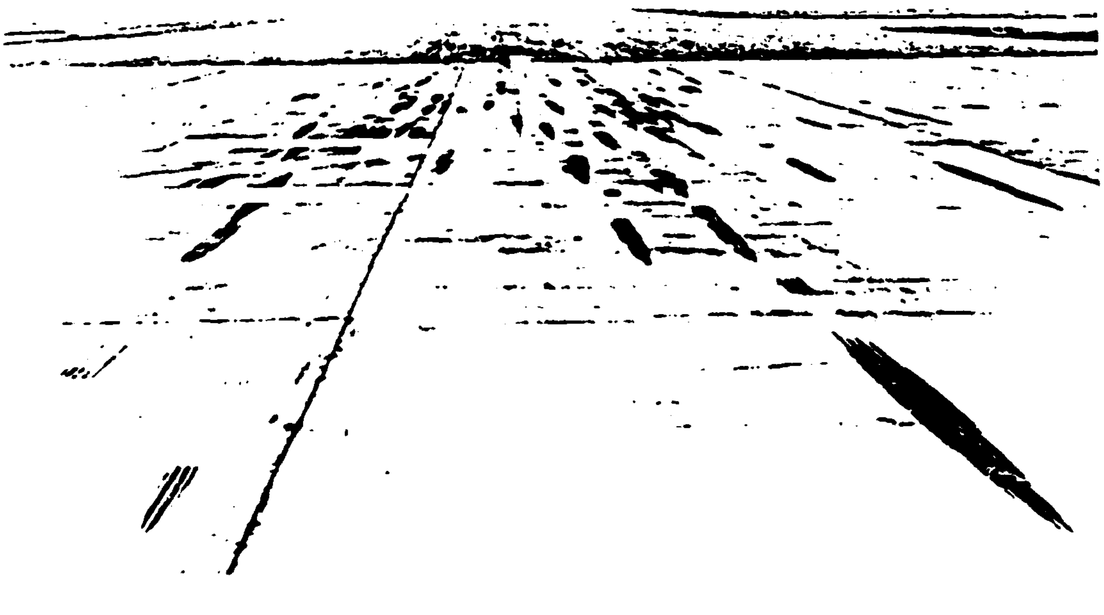


Plate 4 Rubber deposits 25 threshold

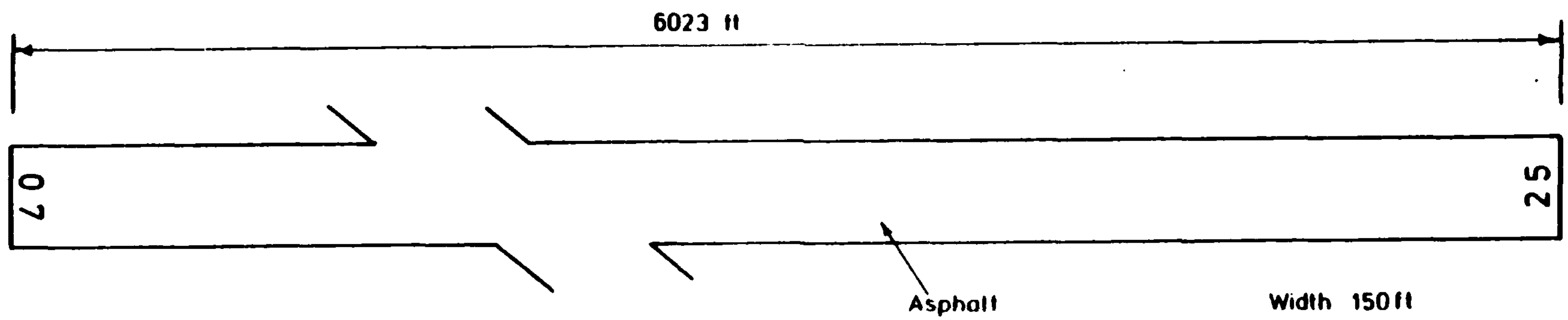


Fig A1 RAE West Freugh. Schematic diagram of runway 07/25

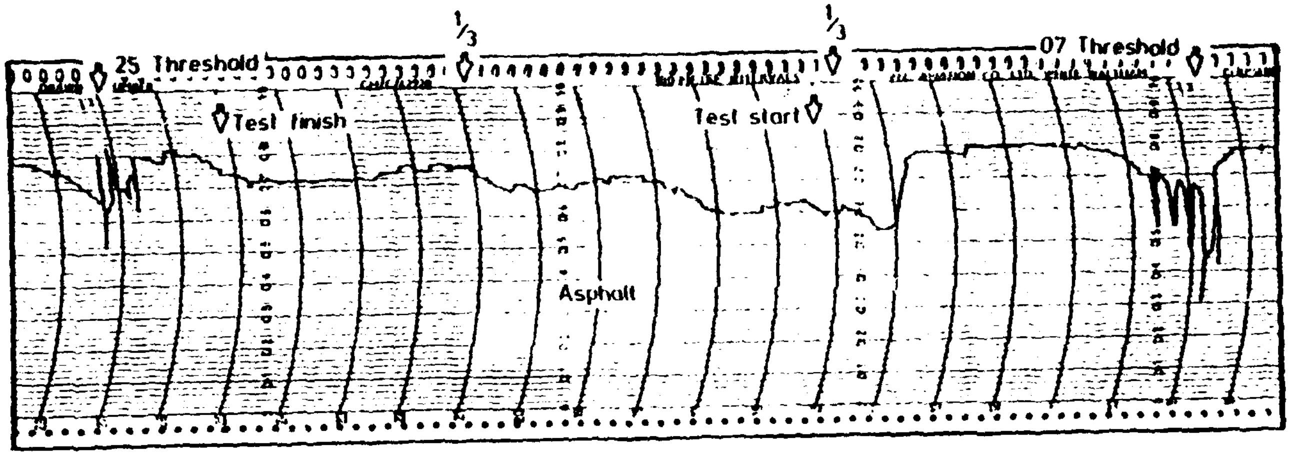


Fig A2 Run 2 *Runway 07* 10'S of centreline

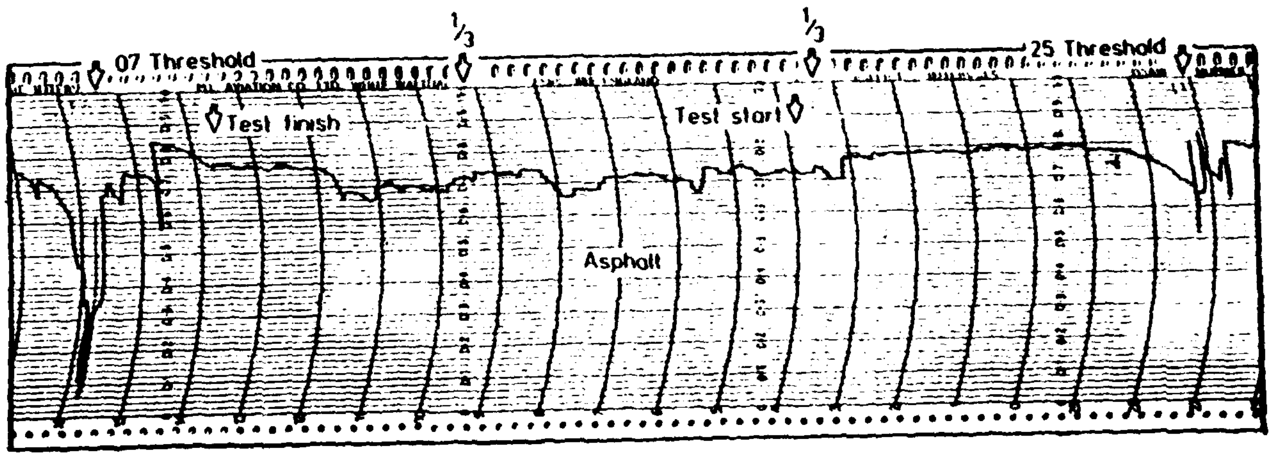


Fig A3 Run 3 Runway 25 15'S of centreline

Scale 1:2

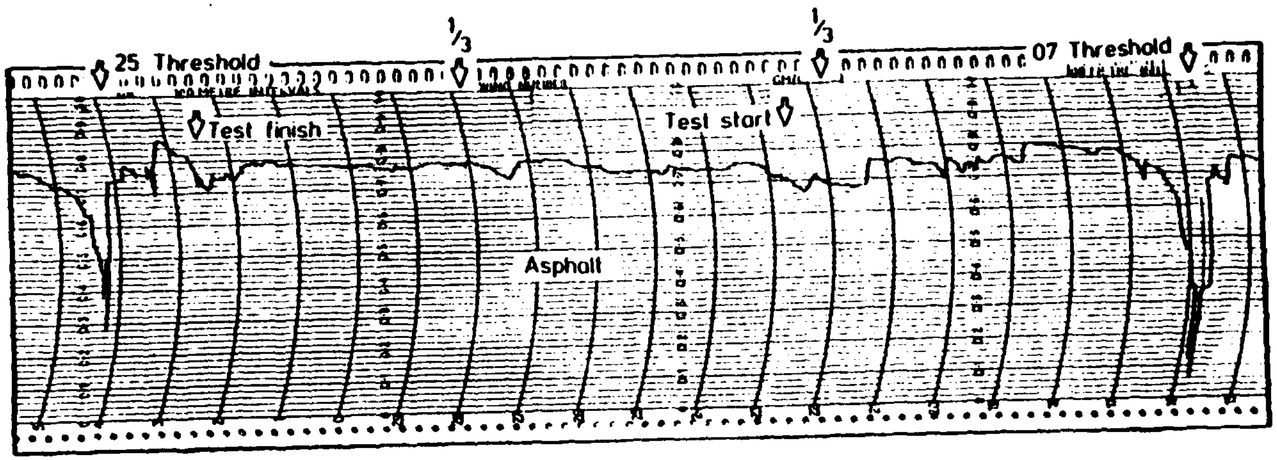


Fig A4 Run 4 Runway 07 10'N of centreline

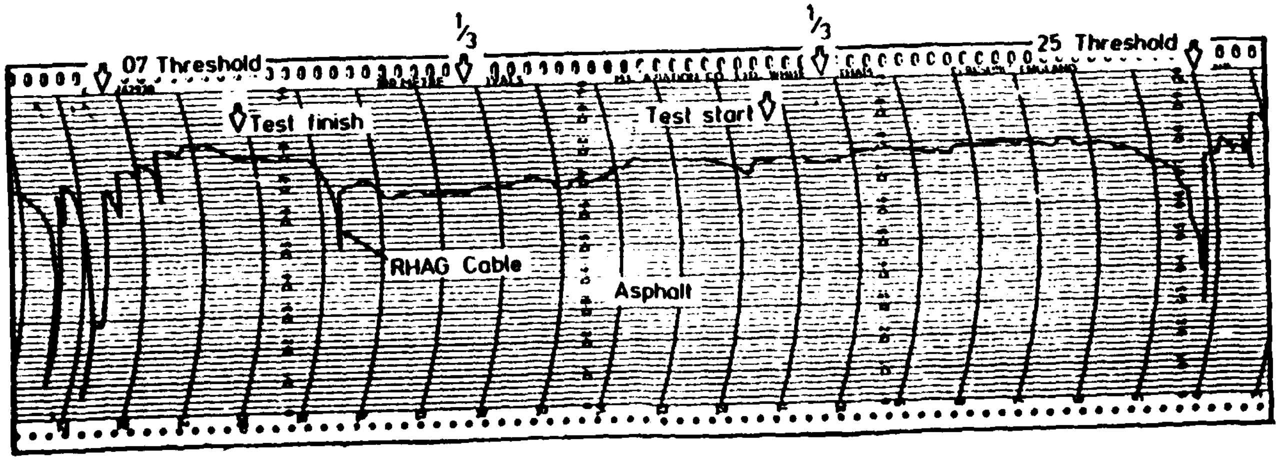


Fig A5 Run 5 Runway 25 15'N of centreline

Scale 1:2

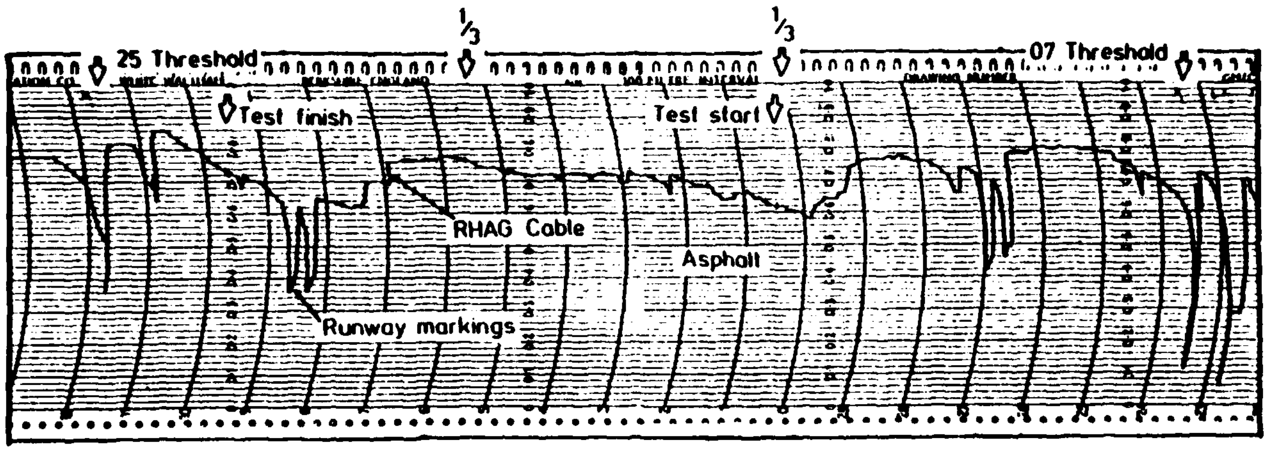


Fig A6 Run 6 Runway 07 50'S of centreline

Scale 1.2

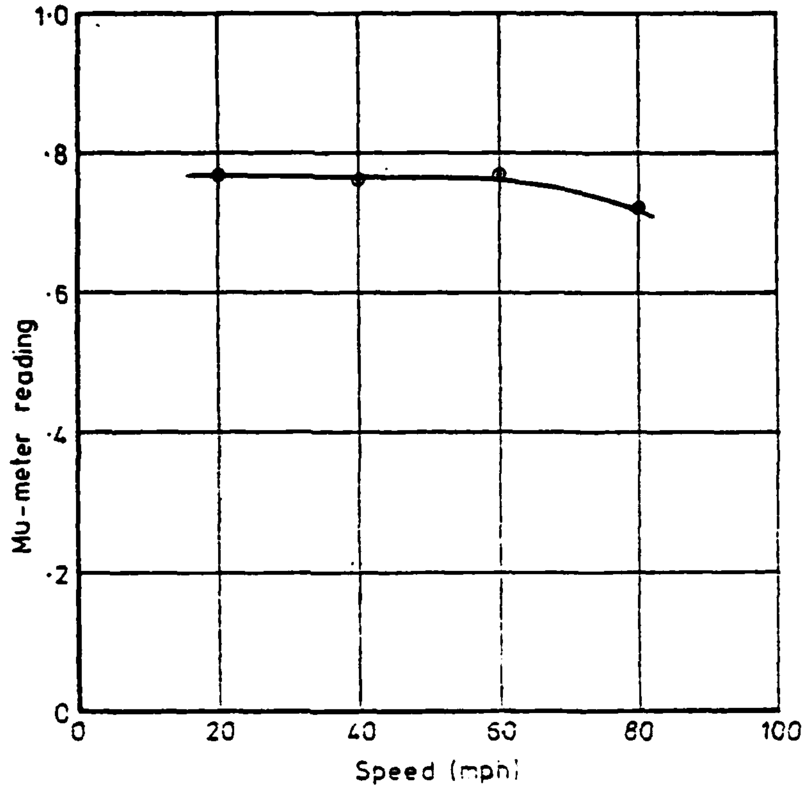


Fig A7 Mu-meter reading v Speed

RAE WEST FREUGH

Part 2 - Low Speed Tests

INTRODUCTION

Part 1 of this classification report dealt with the friction qualities of the West Freugh 07/25 runway under controlled wetting conditions (constant water depth) at a Mu-Meter speed of 80 mph. Part 2 considers the friction qualities under natural rainfall conditions which, unlike Part 1, will identify any areas of low friction caused by standing water or ponding. Part 1 measured the friction within 15 ft.(4.5m) of the centreline and along one edge, whilst Part 2 covers measurements over the central 60 ft. (18m) of the runway.

These trials were conducted by airfield personnel in accordance with NATS document 8K/182/115. The Mu-Meter traces were subsequently analysed by CIT Cranfield.

RESULTS

It must be noted that no record of actual rainfall amounts was made. Consequently, whilst these results show what occurred at the time of the trial, they may only be used as a guide to potential low friction areas.

Table A2 gives a breakdown of the results averaged over every third of the runway. It can be seen that in general the further from the centreline, the lower the Mu-Meter reading. Fig.A8 is a copy of a typical Mu-Meter trace (Run 3, 26 ft.(8m) from the centreline).

Fig.A9 shows a friction contour map of the 07/25 runway obtained by isolating from the Mu-Meter traces the low friction areas (below .5 and .4 Mu-Meter reading) detected during each run. These areas have been transferred on to a scaled diagram of the runway and then linked by contour lines to show potential low friction areas.

Two major low friction areas are identified.

1. North of centreline extending from 600 ft. to 2000 ft. from the 07 threshold and 30 ft. wide.

2. South of centreline extending from 3200 ft. to 5500 ft. from the 07 threshold 30 ft. wide.

Other smaller areas of low friction can also be seen.

The low friction must be caused by depth of water since Phase 1 has shown that, under constant water depth, the Mu-Meter value is reasonably constant.

Run No.	Direction	Distance from Centreline	Mu-Meter Reading		
			μ_{07}	μ_c	μ_{25}
1	07	2m S	.73	.75	.67
2	25	5m S	.66	.64	.51
3	07	8m S	.56	.60	.48
4	25	2m N	.59	.61	.68
5	07	5m N	.62	.64	.60
6	25	8m N	.57	.56	.51

Table A2 Details of 40 mph Mu-Meter runs during moderate continuous rainfall.

CONCLUSIONS

1. Part 1 has shown that under controlled wetting conditions, the Mu-Meter readings on runway 07/25 at West Freugh are good.

2. Part 2 identifies a number of areas of low Mu-Meter readings which are probably due to areas of standing water or ponding.

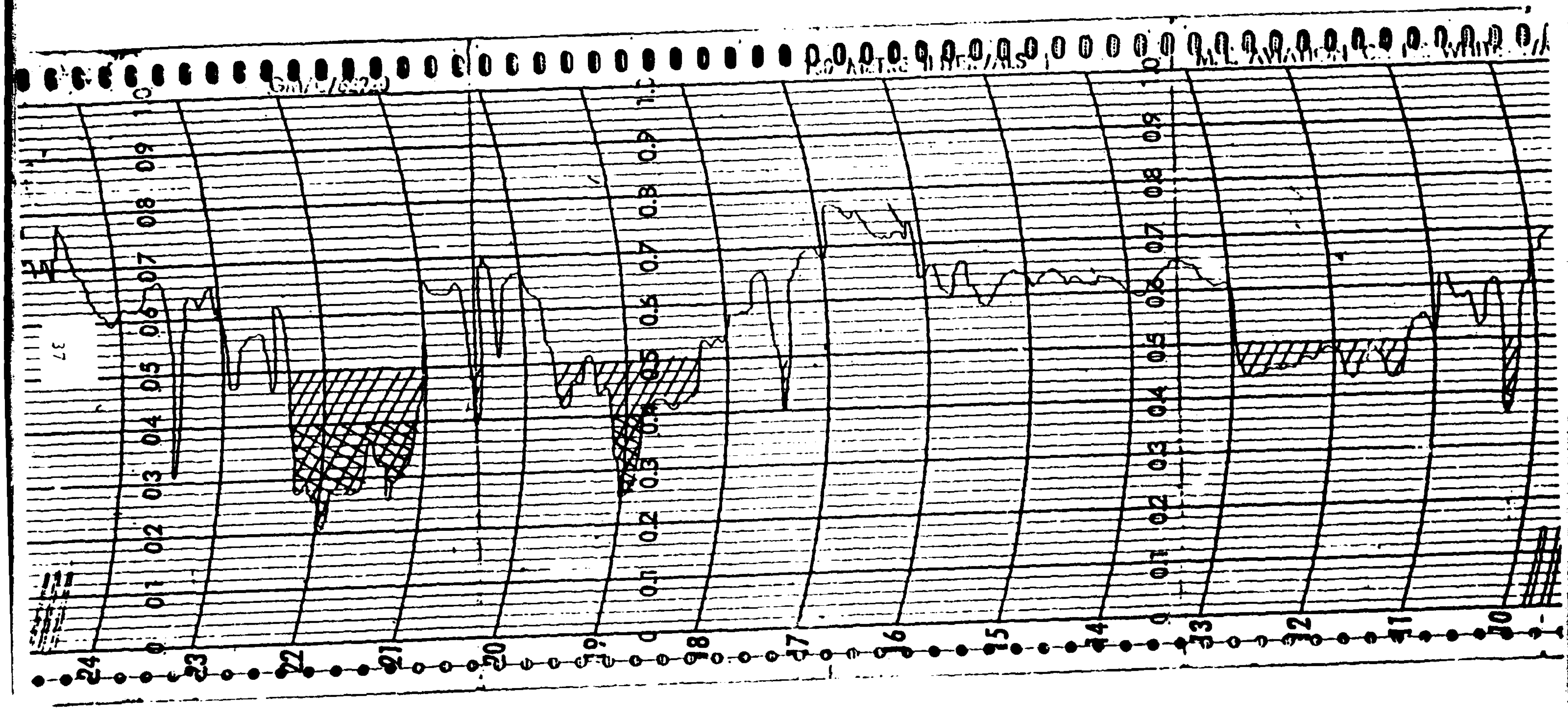


Fig A8 Typical Mu-meter trace during rainfall showing low friction areas caused by ponding

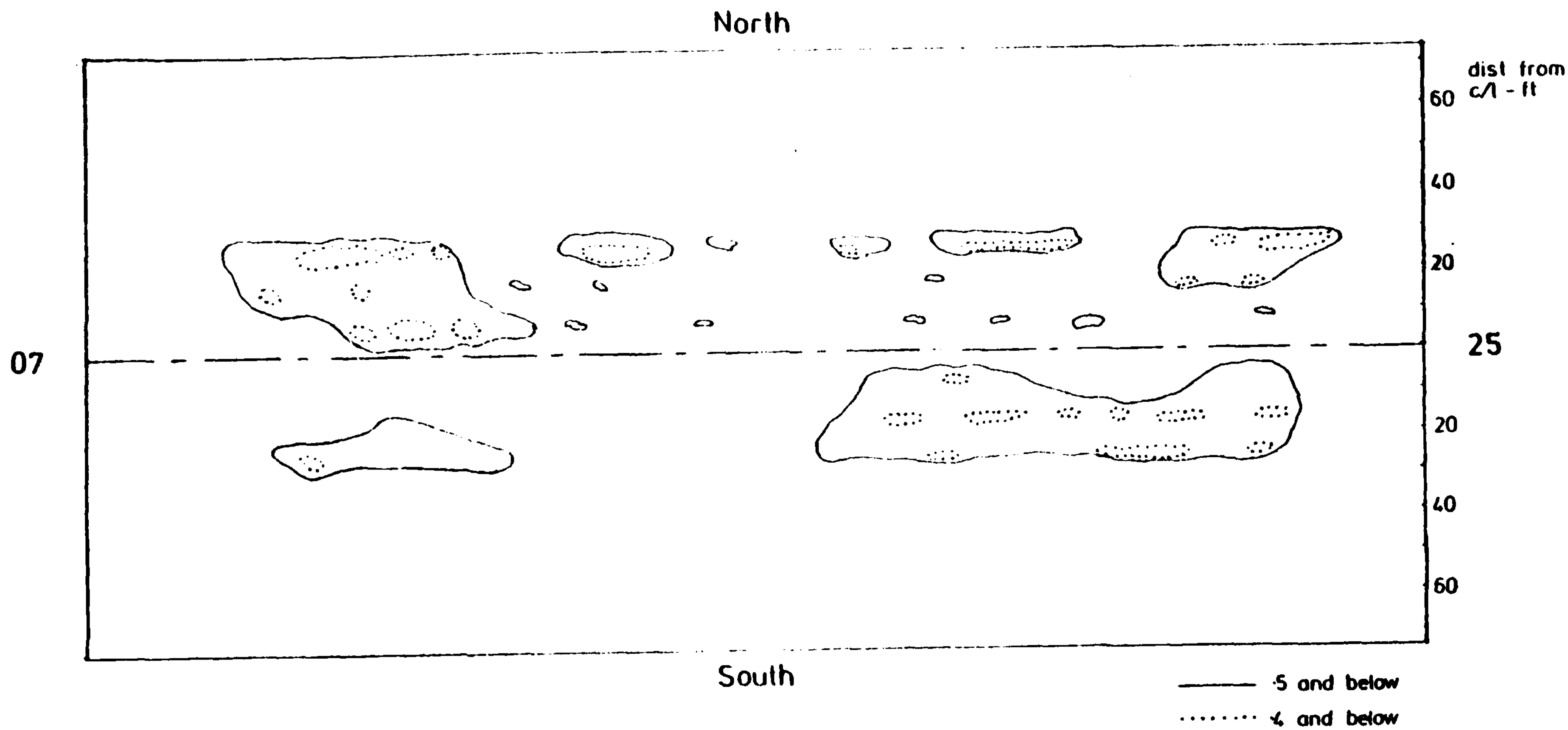


Fig A9 Friction contour map of RAE West Freugh runway

REPORT DOCUMENTATION PAGE

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		S&T-MEMO-6-79	UNLIMITED

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15. Distribution statement

Descriptors (or keywords)

*Aircraft landing, *Aquaplaning, *Friction, *Runways, *Surface waters, Measuring instruments, Standards, Surface properties, Wettability.

Abstract The fundamental principles regarding the design of runway surfaces to provide high friction under wet conditions are well known and have been put into practice for some time. In the past a locked wheel trailer has been used to assess the relative friction of runways by making measurements at a number of isolated points on the surface. With the development of the Continuous Recording Runway Friction Meter (Mu-Meter) and a runway self wetting system contained in the tow vehicle, it has been possible to obtain a permanent record showing the friction reading along the entire length of a runway. This S&T Memo describes the method developed to carry out such a trial together with its associated Standard Friction Classification Table. Use of the Mu-Meter under natural rain conditions has demonstrated that aircraft aquaplaning

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could sometimes occur in local areas. A method is described how these areas can be identified and how it is combined with the self wetting trial to give a proper friction evaluation of a runway.

The relationship in Mu-Meter readings when using the US Federal Aviation Administration and UK Ministry of Defence methods of runway friction classification, have been determined.