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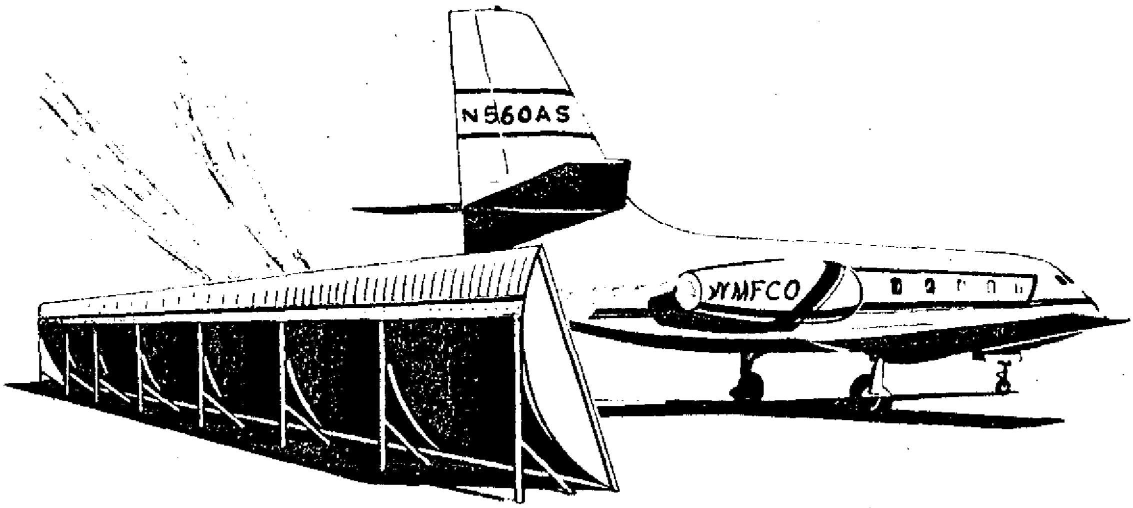

AIRPORT DESIGN STANDARDS - EFFECTS AND TREATMENT OF JET BLAST

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Initiated by: AAS-560

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FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRPORT DESIGN STANDARDS - EFFECTS AND TREATMENT OF JET BLAST

1. PURPOSE. This circular presents criteria on the jet engine blast velocities associated with aircraft in common use in air carrier service, the effects of these blast velocities during ground operations, and suggested means to counteract or minimize these effects.

2. CANCELLATION. Information in this circular replaces material in the Advisory Circular 150/5325-6, Effects of Jet Blast, dated 15 April 1965.

3. REFERENCES. The publications listed in Appendix 1, Bibliography, provide further guidance and detailed information.

4. HOW TO GET THIS PUBLICATION. Additional copies of this advisory circular can be obtained without charge from the Department of Transportation, **Distribution Unit,** TAD-484.3, Washington, D.C. 20590.

Clyde W. Pace Jr

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Initiated by: AAS-560

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CHAPTER 1. INTRODUCTION

1. GENERAL. The continued advance in airplane design has created new requirements which have been met by the airport designer. As examples, it has been necessary to provide longer and stronger runways, larger terminals, and better fuel handling facilities. The change in design from piston to jet engines has required an increased emphasis on the resolution of the problems associated with the velocities of air movement behind airplanes during ground operations.

2. JET BLAST. In the period of general use of the small piston engine transport, propwash was considered disagreeable but not dangerous. As the large four engine airplane came into use, it was found that its propwash could be tolerated if reasonable separation distances were used to dissipate the wind force created. With the advent of large jet airplanes, it was soon realized that jet blast velocities far exceeded those of propwash in the same ground operations. These increased velocities were capable of causing injury to personnel and damage to equipment and facilities. Various studies and tests have been made to analyze these high-energy jet blasts and to determine how best to minimize their detrimental effects.

CHAPTER 2. BLAST

3. BLAST CONSIDERATIONS.

a. Personnel and Equipment Operations. Velocities above 35 miles per hour are undesirable for personal comfort and equipment operations in the terminal area. Jet aircraft exhaust may cause velocities many times greater than 35 miles per hour at considerable distances from the operating aircraft. To diminish the velocity effects created by jet thrust, the erection of blast fences or increased spacing between aircraft parked in the terminal area should be considered.

b. Taxiways. With the present criteria of 100-foot-wide taxiways, the outboard engines of wide-bodied jets extend outward from 20 feet to as much as 54 feet beyond the edge of the pavement. For this reason, treatment of taxiway shoulders is recommended to prevent their erosion and the blowing of debris or loose material into following aircraft.

c. Pavement Edge. On the holding apron and at runway ends, the jet blast approaches thrust conditions of 40 to 60 percent of maximum continuous thrust (MCT). This much thrust is necessary to start the aircraft moving, and it subjects the surrounding areas to critical velocities. Blast fences and surface stabilization may be used to protect these areas. Runway shoulders in most instances will also require a stabilized surface.

d. Cargo and Maintenance Areas. Varied thrust conditions may be encountered in other places, such as the cargo area and the aircraft maintenance apron, depending on operating requirements. In these areas, blast velocities may become critical where high thrust levels are required to initiate movement of the aircraft.

e. Terminal Areas. Blast effects of jet engines in terminal facilities must be considered in the design of airports. Structural design factors should incorporate wind loads commensurate with the airplane ground operating practices anticipated in the vicinity of the terminal.

f. Jet Blast Pressure. Jet blast velocities are irregular and turbulent in nature. For very small areas of 10 to 15 square feet, they should be assumed to be periodic in their cycles and the vibrations should be considered in building design. Such assumptions are not necessary in design of large sections. When necessary, the pressure of a jet blast on a surface perpendicular to it may be computed from the expression:

$$P = 0.00255V^2$$

where V = the velocity in miles per hour normal to the surface, and P = pounds per square foot

4. BLAST VELOCITIES.

a. General. Figures 1 through 4 (pages 5 through 8) show the velocity versus distance from the rear of aircraft for the Douglas DC-8, Boeing 727, Boeing 747, and Douglas DC-10 at various thrust levels. These aircraft are representative of the types common in air carrier use. For specific velocity data on other aircraft, including lateral and vertical contours, the manufacturer should be consulted.

b. Velocity Peaks. It has been determined from various studies that blast velocities are cyclical. Velocity peaks can be expected to occur 2 to 6 times per second. These peaks are not continuous laterally or vertically and cover relatively small areas. The maximum velocities shown in all figures are an average of the peaks.

c. Heat Effects. A detailed study of the heat effects associated with jet blast has not been included because the areas where the upper limits of heat are generated are unoccupied due to blast velocity tolerance limits.

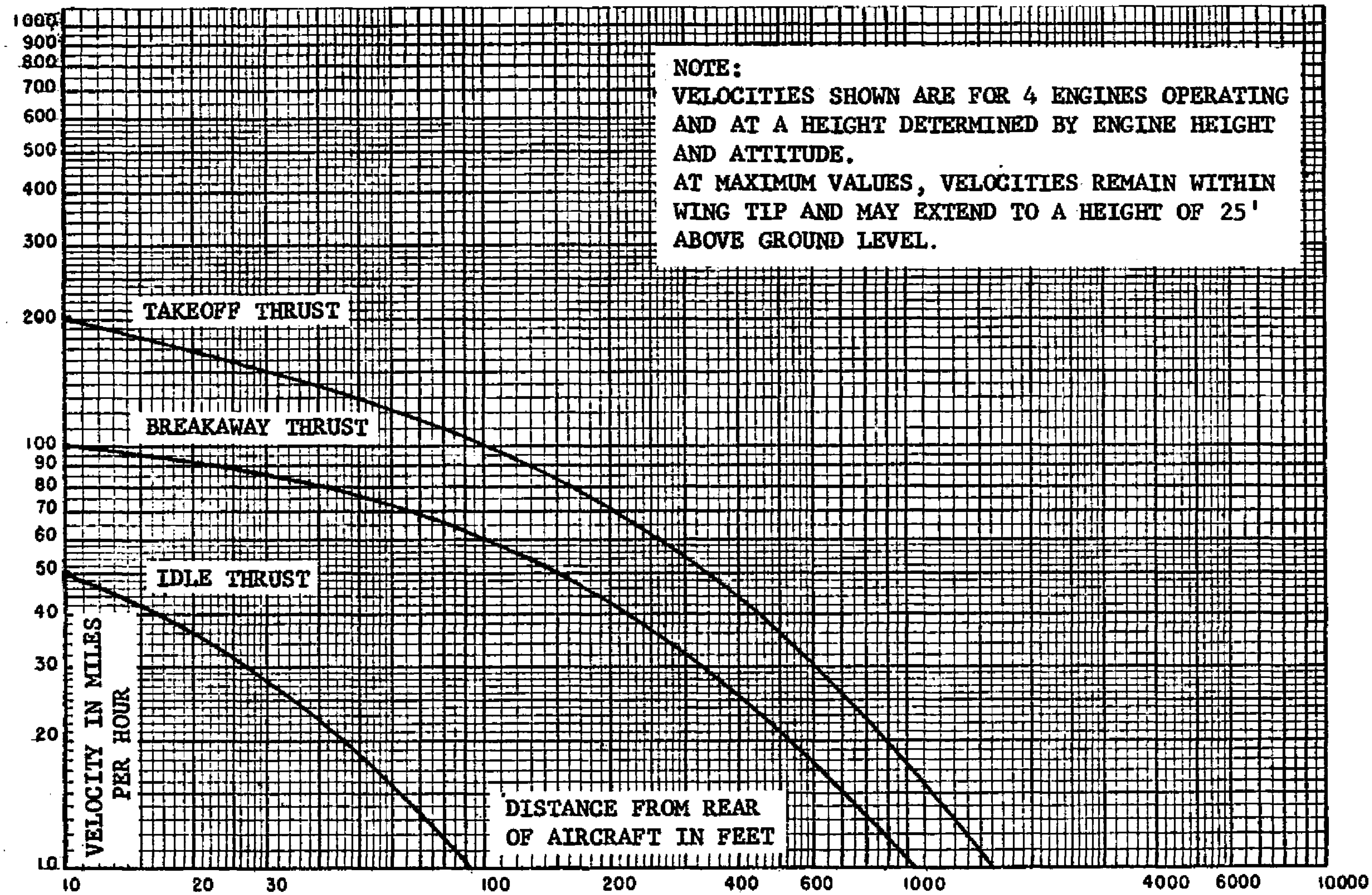


FIGURE 1. MAXIMUM VELOCITY CURVES (DC-8)

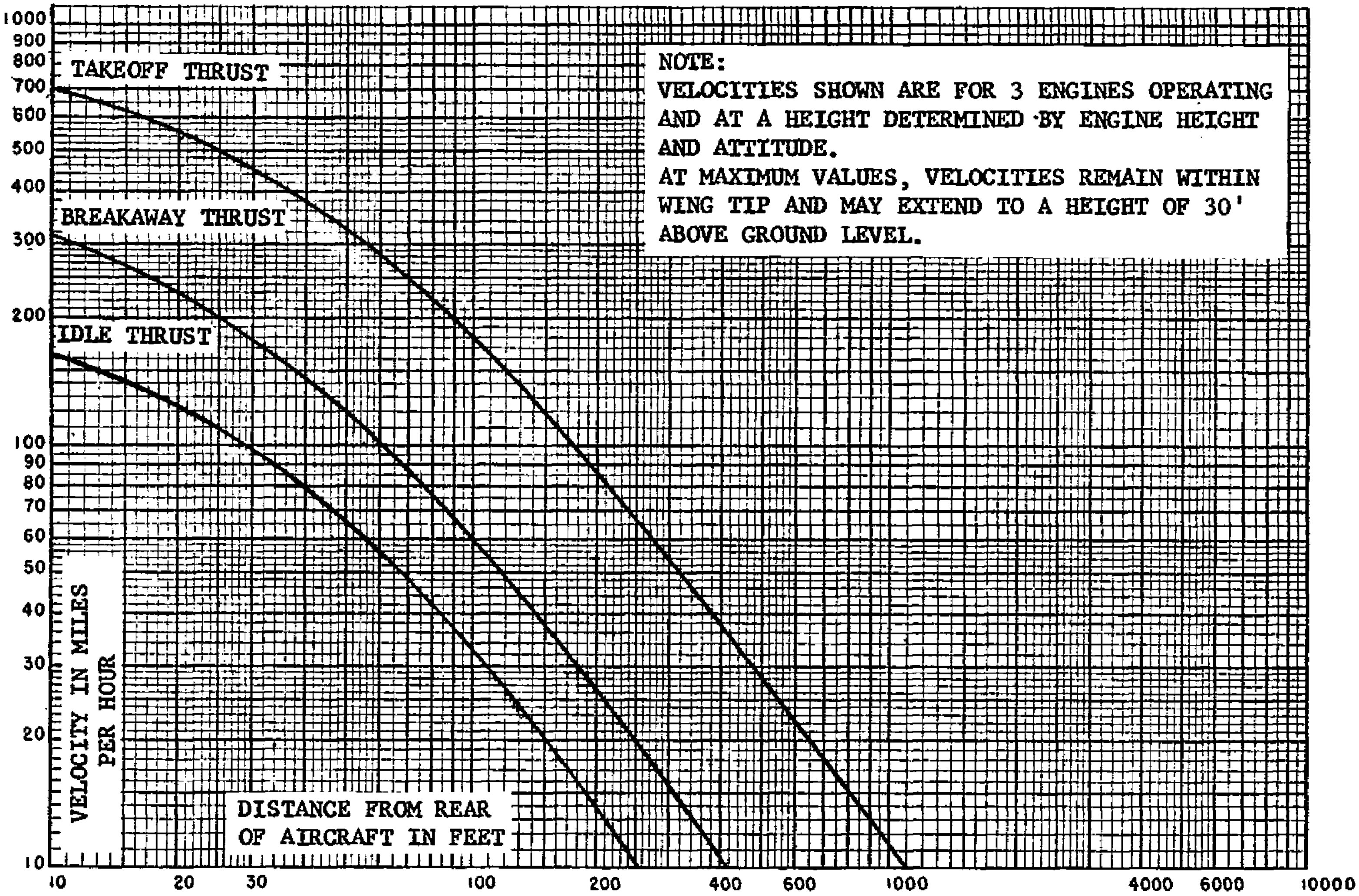


FIGURE 2. MAXIMUM VELOCITY CURVES (BOEING 727)

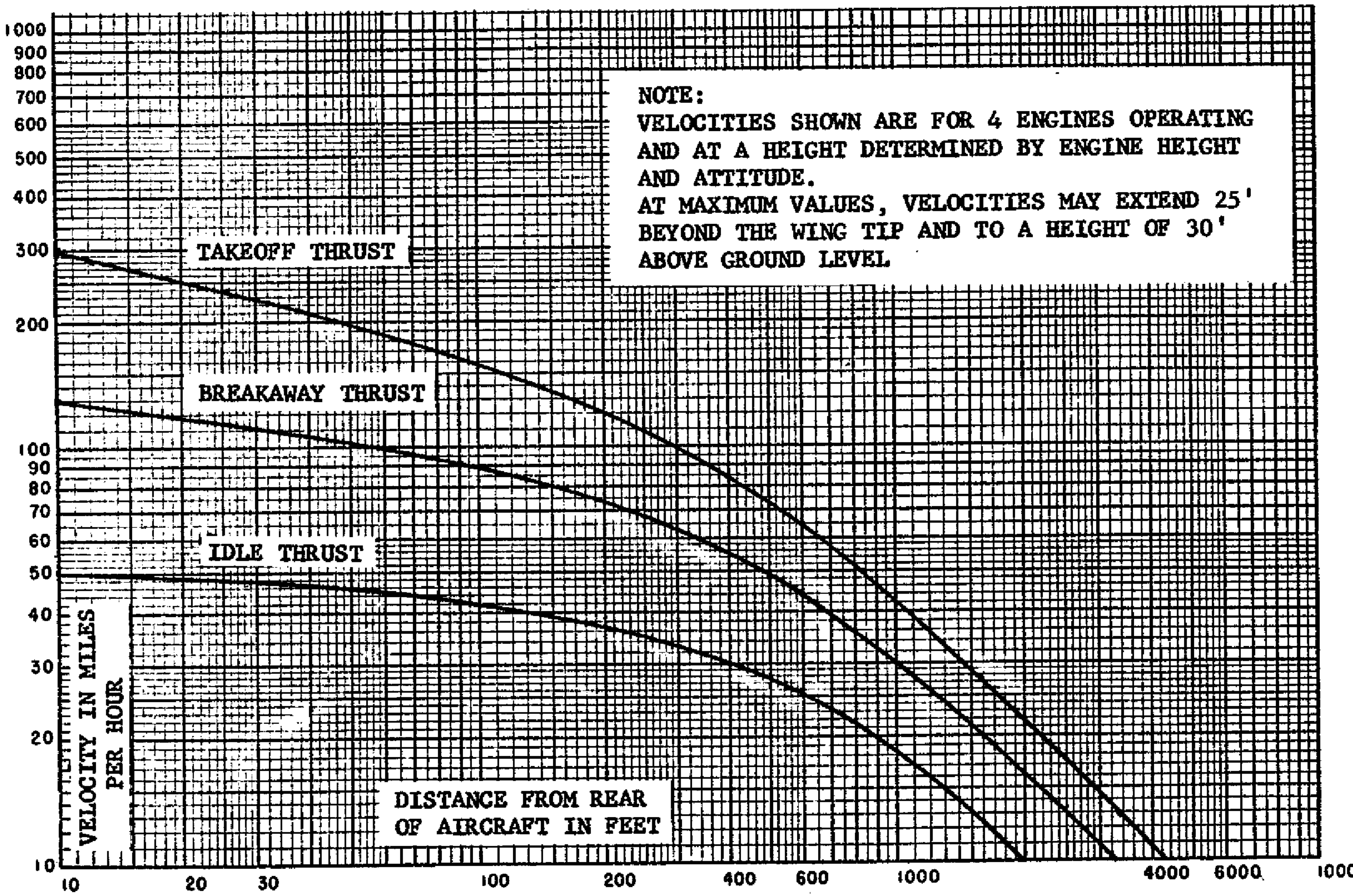


FIGURE 3. MAXIMUM VELOCITY CURVES (BOEING 747)

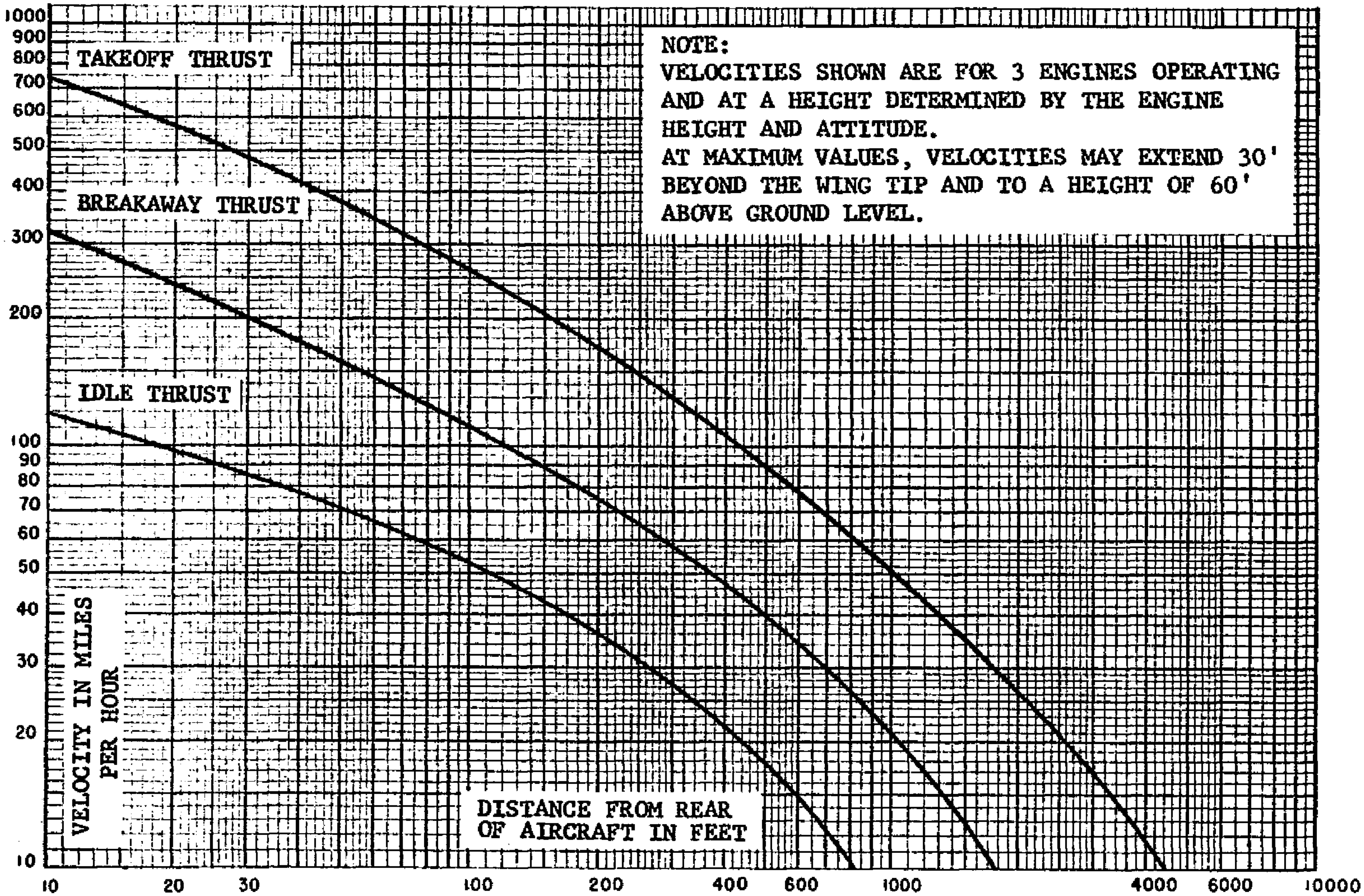


FIGURE 4. MAXIMUM VELOCITY CURVES (DC-10)

CHAPTER 3. BLAST FENCES

5. GENERAL. It has been found that the detrimental effects of blast, such as erosion, hazards of high velocities to personnel and equipment, and related fumes and noise resulting from the energy of high velocity wakes of both propeller and jet aircraft, can be substantially reduced or eliminated by properly designed blast fences. Their application was primarily limited to service and maintenance areas before jet aircraft became widely employed. Jet aircraft operations have emphasized the need for a suitable means of deflecting and controlling the engine blast in other areas.

6. BLAST FENCE CONSIDERATIONS.

a. Design. Several types of blast fences are fabricated (see Figures 5 and 6 on pages 10 and 11), the design of which are readily available from the various manufacturers. It should be realized that the effectiveness of any blast fence depends upon local conditions, and custom design will usually be required to meet any special requirements.

b. Function. Consideration must be given to the location of runway ends and holding aprons with respect to landing thresholds of other runways, roads, structures, or other facilities in determining whether blast fences are required. Sudden gust velocities striking moving vehicles and aircraft are more dangerous than continous velocities of the same magnitude. Crosswind gusts averaging more than 20 miles per hour on a moving vehicle are considered hazardous. In the case of wide-bodied aircraft, this velocity can occur over 2000 feet from the rear of the aircraft at takeoff.

c. Location. The location of the blast fence has an important bearing on its effectiveness, and is determined by its design and function. Generally, the closer the fence is to the source of blast, the better it performs, provided the extended centerline of the blast falls below the top of the fence. It should not be placed where it creates a hazard to aircraft approaches or departures.

d. Other Types of Blast Protection. Although the use of fences has been effective, blast protection may be gained by other methods and materials. Any obstruction, natural or manmade, will afford some measure of protection. Hedges, bushes, and trees can also help attenuate sound to some extent. Tall hedges especially may be used to advantage in some cases (e.g., around engine run-up areas).

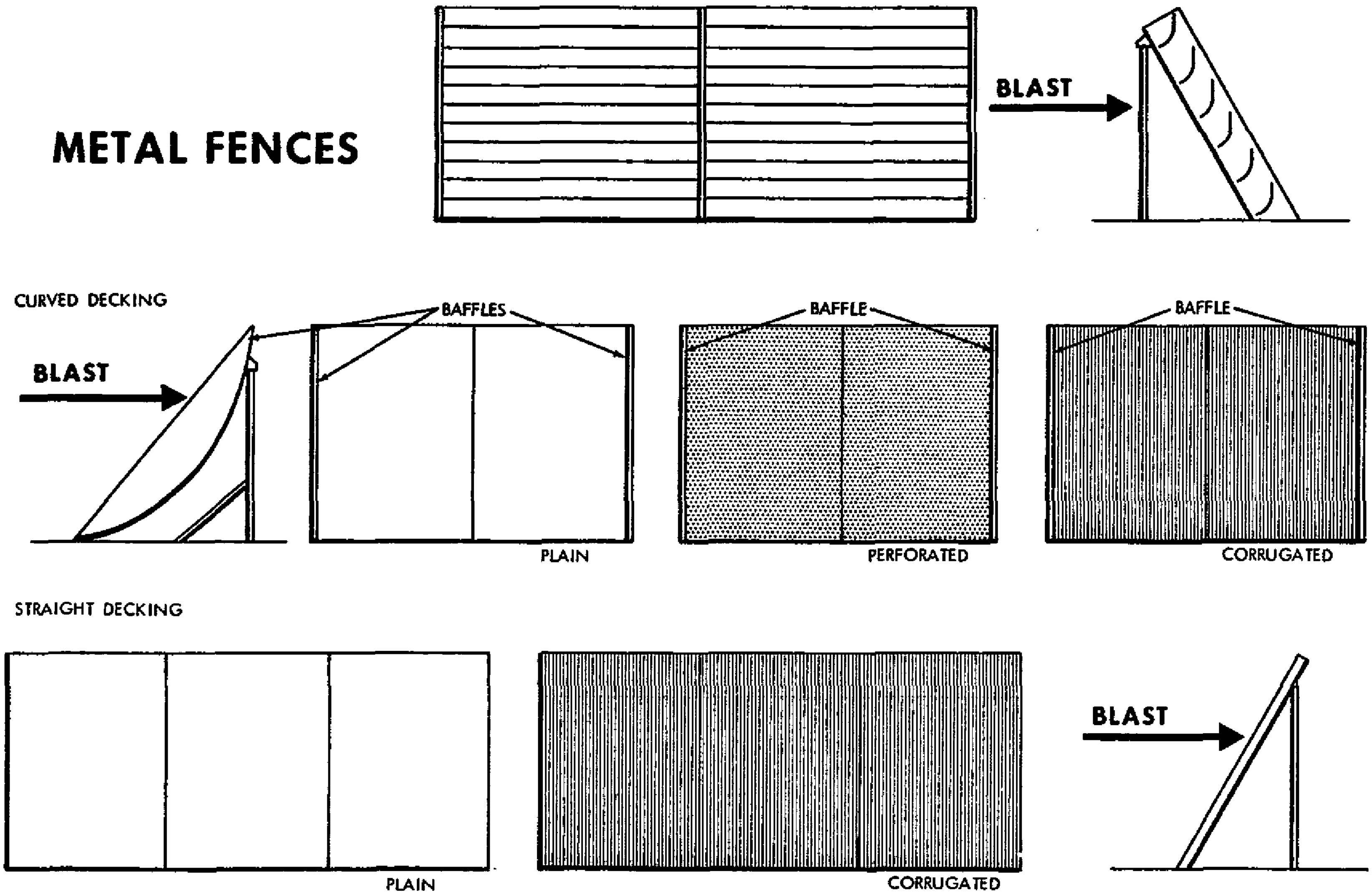
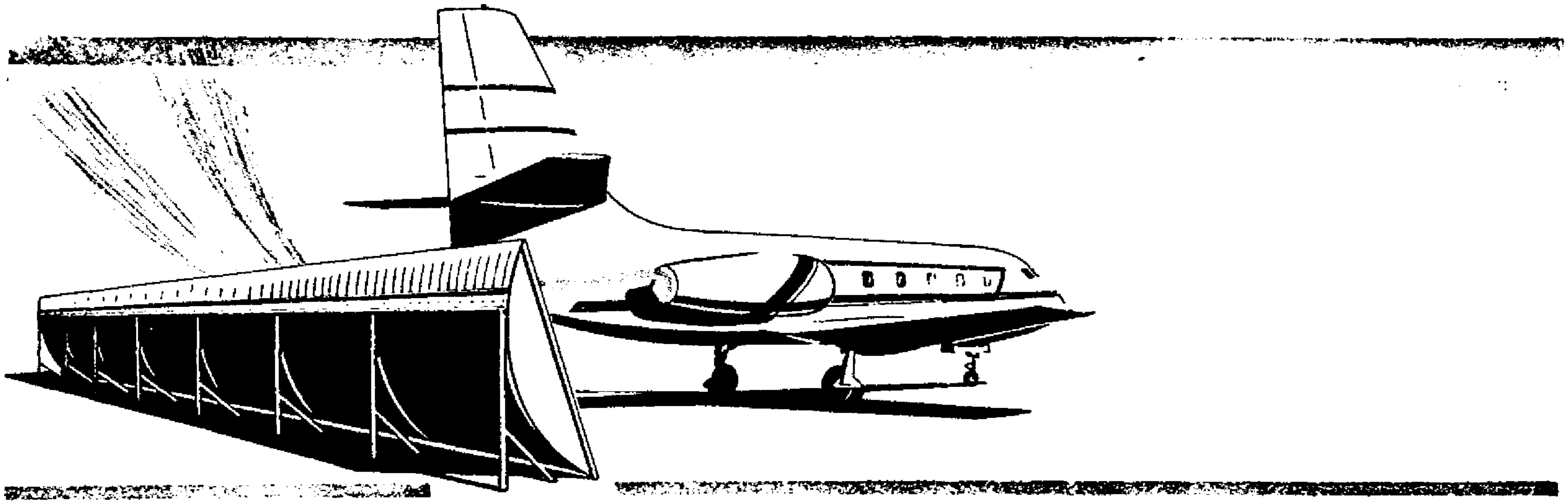
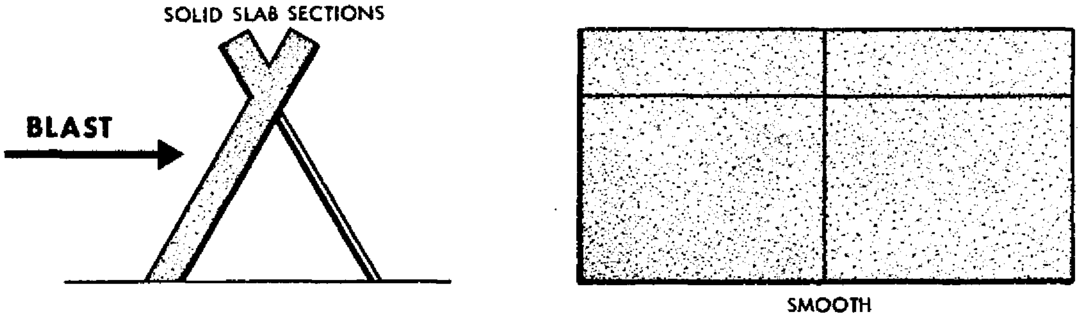


FIGURE 5. TYPICAL BLAST DEFLECTOR FENCES (METAL)



CONCRETE FENCES



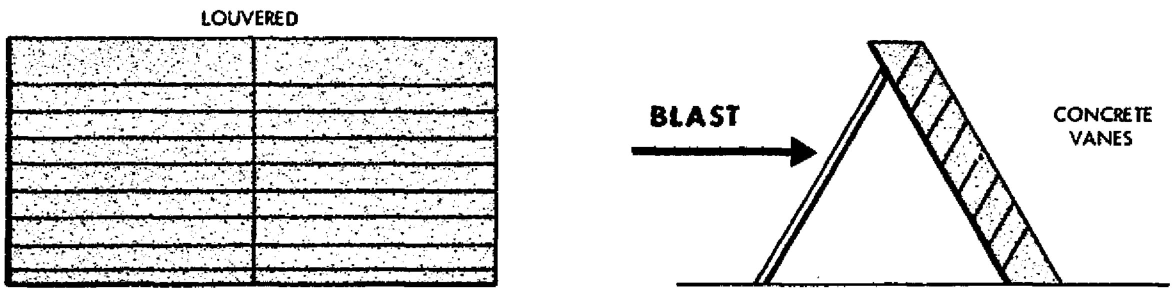


FIGURE 6. TYPICAL BLAST DEFLECTOR FENCES (CONCRETE)

e. <u>Other Considerations</u>. In service, parking, and other areas, the foregoing considerations may be used as a guide in establishing the need for and design of blast fences. In terminal areas, passenger comfort becomes the controlling factor, since blast velocities greater than 35 miles per hour become intolerable. Further, loose objects on the pavement become potential missiles in the wake of a jet at this velocity and may be thrown considerable distances.

CHAPTER 4. BLAST EROSION OF OFF-PAVEMENT AREAS

7. GENERAL. Drag and uplift forces caused by high-energy jet exhaust from present day jet aircraft may move boulders several feet thick and, at 35 feet behind the exhaust nozzle of an engine operating at maximum thrust, can raise boulders 2 feet in diameter completely off the ground. The forces causing such erosion decrease rapidly with distance, and beyond about 1200 feet from the engine of a wide-bodied aircraft they affect only sand and finer cohesionless soils. The shoulder and blast pad protection criteria contained in this chapter relate to the airplane design groups specified in Figure 4 on page 7 of AC 150/5335-1A, Airport Design Standards - Airports Served by Air Carriers - Taxiways.

8. SHOULDER AND BLAST PAD WIDTHS.

a. Where paved runway and taxiway shoulders are required for erosion protection or the operation of maintenance vehicles, provision of the following shoulder widths on new and existing taxiways is recommended.

(1) Runways.

(a) On 150-foot runways, which are not planned to accommodate aircraft above Design Group II, a 25-foot wide shoulder is recommended.

(b) On 150-foot runways, where airplanes in Design Group III are planned to be accommodated, the recommended shoulder width is 50 feet, with 35 feet an acceptable minimum.

(c) On 200-foot runways, a 25-foot wide shoulder is recommended.

(2) Taxiways.

(a) For Design Group I aircraft, a 20-foot shoulder is recommended.

(b) For Design Group II aircraft, a 25-foot shoulder is recommended.

(c) For Design Group III aircraft, a 35-foot shoulder is recommended.

b. Where blast pads are required for erosion protection, they should have a width equal to the width of runway plus shoulders. The length of blast pads may be determined as follows:

(1) For aircraft in Design Group II and below, a blast pad length of 200 feet is recommended.

(2) For aircraft in Design Group III, a blast pad length of 400 feet is recommended.

9. SHOULDER AND BLAST PAD DESIGN THICKNESS. The thicknesses of shoulders and blast areas should be such as to accommodate an occasional passage of the critical aircraft for runway pavement design, and the critical axle load of the emergency or maintenance vehicle which may pass over the area. In addition, the following criteria should be applied:

a. The critical axle load of the emergency or maintenance vehicle should be considered to be on single wheels. The thickness should be determined by using the critical load and the procedures of AC 150/5320-6A, Airport Paving. If this thickness is greater than that based on paragraph 8b below, then this design thickness should be used for shoulder and blast areas.

b. The design thickness required for shoulder and blast areas to accommodate the critical aircraft should be established by using one half of the total thickness determined by using the procedures of AC 150/5320-6A, Airport Paving.

c. For Design Group II aircraft and below, the recommended minimum surface thickness, if bituminous concrete on an aggregate base, is 2 inches on shoulders and 3 inches on blast areas. For service by Design Group III aircraft, an increase of 1 inch in these thicknesses is recommended.

d. The use of stabilized bases in shoulders and blast areas is recommended. They should be built to the standards of AC 150/5370-1A, Standard Specifications for Construction of Airports, including the 1½ to 1 equivalency and the minimum thickness noted in AC 150/5320-6A. A 2-inch bituminous concrete surface is the recommended minimum on a bituminous stabilized base.

e. If it is advantageous to use portland cement concrete and a granular subbase for shoulder and blast areas, the 6-inch minimum thickness standards of AC 150/5320-6A should be applied.

f. The same compaction and construction criteria for subgrade and pavement courses in shoulder and blast areas should be used as for full strength pavement areas, except the design should be based on 50-blow laboratory samples. A Marshall stability of 500 minimum and flow of 20 maximum should be adequate. It is recommended that approximately a 1-inch drop-off be considered at the edge of the full strength pavement, shoulders, and blast areas to provide a definite line of demarcation.

10. DRAINAGE. Drainage capability should be maintained or improved in the affected areas. Where pavement edge drop-off and 5 percent transverse slope are present in existing turf areas, they may be retained in the paved surface details. It is recommended that courses of sufficient depth to maintain the positive drainage of granular base or subbase courses under the runway pavement be provided. An alternative is the provision of subdrains at the pavement edge. A sufficient number of manholes should be provided in the subdrains to permit observation and flushing of the subdrain system.

11. SPECIAL CONDITIONS. It is recognized that local conditions at some airport sites may require surface protection from erosion in addition to that recommended in paragraph 8. In such circumstances, it is recommended that the additional pavement be provided. The pavement section and surface material to be used should be governed by previous satisfactory local experience. In approving low cost materials and procedures, maintenance time should be considered, particularly for areas adjacent to time-critical runways.

12. APRON EDGE TAXIWAYS. When apron edges are designated as taxi routes, a taxiway shoulder should be provided.

13. PAVEMENT MARKING. Where blast protection pavement is provided, the edge of the full strength pavement should be identified and blast pads and runway shoulder areas marked in accordance with AC 150/5340-1C, Marking of Paved Areas on Airports.

14. RUNWAY/TAXIWAY EDGE LIGHTING SYSTEM. Where shoulders are added to an existing runway or taxiway, the edge lighting system may require modification. In new construction, edge lights should be base mounted and the cable under the pavement installed in conduit to permit maintenance of the lighting circuits without cutting of the pavement.

APPENDIX 1. BIBLIOGRAPHY

1. The following advisory circulars may be obtained from the Department of Transportation, **Distribution Unit,** TAD-434.3, Washington, D.C. 20590.

   a. AC 150/5335-1A, Airport Design Standards - Airports Served by Air Carriers - Taxiways.

   b. AC 150/5320-6A, (Changes 1, 2 and 3), Airport Paving.

   c. AC 150/5340-1C, Marking of Paved Areas on Airports.

2. The following advisory circular may be obtained from the Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402. Make check or money order payable to the Superintendent of Documents. No C.O.D. orders are accepted.

   AC 150/5370-1A, Standard Specifications for Construction of Airports. ($3.50)

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