DOT/FAA/EE/93-03
DOT-VNTSC-FAA-93-XX

# INM
# Integrated Noise Model Version 4.11

Office of Environment and Energy

Washington DC 20591

# User's Guide - Supplement

Gregg G. Fleming
Edward J. Rickley
Joseph Burstein
John R. D'Aprile

Volpe National Transportation Systems Center
Acoustics Facility
Cambridge MA 02142-1093

Final Report
December 1993

Supplement to
Report No. DOT/FAA/EE/92/02



U.S. Department of Transportation

**Federal Aviation Administration**

# REPORT DOCUMENTATION PAGE

*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the t instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing information. Send comments regarding this burden estimate or any other aspect of this collection of information, inclu for reducing this burden, to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project Washington, DC 20503.

| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | December 1993 | Final Report<br>June 1992-December 1993 |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>INM, Integrated Noise Model Version 4.11,<br>User's Guide - Supplement | 5. FUNDING NUMBERS<br>FA465/A4012 |
| 6. AUTHOR(S)<br>Gregg G. Fleming, Edward J. Rickley[1], Joseph Burstein[2],<br>John R. D'Aprile | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>U.S. Department of Transportation<br>Research and Special Programs Administration<br>Volpe National Transportation Systems Center<br>Cambridge, MA 02142 | 8. PERFORMING ORGANIZATION REPORT NUMBER<br>DOT-VNTSC-FAA-93-XX |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br>U.S. Department of Transportation<br>Federal Aviation Administration<br>Office of Environment and Energy<br>800 Independence Avenue, S.W.<br>Washington, DC 20591 | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER<br>DOT/FAA/EE/93-03 |

11. SUPPLEMENTARY NOTES

[1] Technology & Management Systems, Inc. 99 South Bedford Street, Suite 211 Burlington, MA 01803-5128

[2] Unisys Corporation Kendall Square Cambridge, MA 02142

| 12a. DISTRIBUTION/AVAILABILITY STATEMENT | 12b. DISTRIBUTION CODE |
|---|---|
| This document is available to the public through the National Technical Information Service, Springfield, VA 22161 | |

13. ABSTRACT (Maximum 200 words)

The John A. Volpe National Transportation Systems Center (Volpe Center), in support of the Federal Aviation Administration, Office of Environment and Energy, has developed Version 4.11 of the Integrated Noise Model (INM). The User's Guide for the Version 4.11 computer software is a supplement to INM, Version 3, User's Guide - Revision 1 for the Version 3.10 computer software released in June, 1992. The Version 4.11 supplement, prepared by the Volpe Center's Acoustics Facility, presents computer system requirements as well as installation procedures and enhancements. Specific enhancements discussed include: (1) the introduction of a takeoff profile generator; (2) the ability to account for terrain elevation around a specified airport; (3) the ability to compute the CNEL, WECPNL, LEQDAY, and LEQNIGHT noise metrics; (4) the ability to account for airplane runup operations; (5) the ability to account for displaced runway thresholds during approach operations; (6) an enhancement to the noise contour computations; (7) an increase in the number of takeoff profile segments; and (8) enhancements to the echo file.

| 14. SUBJECT TERMS | 15. NUMBER OF PAGES |
|---|---|
| Airport Noise, Computer Model, Noise Contours, Integrated Noise Model, Noise Level Prediction, FAR Part 150 | 80 |
| | 16. PRICE CODE |

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | |

## PREFACE

This document was prepared by the John A. Volpe National Transportation Systems Center (Volpe Center), in support of the Federal Aviation Administration, Office of Environment and Energy. It is a User's Guide for the Integrated Noise Model (INM) Version 4.11 computer software used to predict noise impact around airports. This User's Guide is a supplement to INM, Version 3, User's Guide - Revision 1, which was released in June, 1992, along with the INM Version 3.10 computer software. The Version 4.11 supplement, prepared by the Volpe Center's Acoustics Facility, presents computer system requirements as well as installation procedures and INM Version 4.11 enhancements.

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# 1. INTRODUCTION

During June, 1992, through December, 1993, the John A. Volpe National Transportation Systems Center (Volpe Center), in support of the Federal Aviation Administration, Office of Environment and Energy, developed Version 4.11 of the Integrated Noise Model (INM). The User's Guide for the Version 4.11 computer software, prepared by the Volpe Center's Acoustics Facility, is a supplement to the Integrated Noise Model (INM), Version 3, User's Guide - Revision 1[1] for the Version 3.10 computer software released in June, 1992. Section 1.0 of the supplementary document presents computer system requirements and installation procedures for INM Version 4.11. Section 2.0 describes the user's implementation of several new capabilities, including descriptive examples. Appendix A describes the technical revisions made to several internal algorithms - primarily revisions which are transparent to INM users. Appendices B and C, respectively, present a technical discussion of two new capabilities, the takeoff profile generator and the capability to account for airplane runup operations. Appendix D presents a copy of the INM Input Testcase, revised to reflect INM Version 4.11 enhancements. Appendix E contains a copy of the User's Manual for the WINM computer software, an INM Version 4.11 plotting program for use with Microsoft Windows.

## 1.1 Computer System Requirements

INM Version 4.11 operates on an IBM Personal Computer (PC)-Compatible platform with the following minimum configuration:

- IBM PC-AT or compatible, Series 286 microprocessor;
- 3 MB of available hard disk space;
- 590 KB of Random Access Memory (RAM) or 3 MB of RAM, if operating the INM from a RAM disk, as discussed in Section 1.2.1 below;
- Math co-processor, Series 80287; and
- Microsoft-compatible Disk Operating System (MSDOS) Version 3.3.

In addition, the CONFIG.SYS file on the PC slated for INM Version 4.11 installation must contain the following lines: BUFFERS=30; and FILES=30.

## 1.2 Installation

The files on the INM Version 4.11 system diskette have been stored in a compressed format using the PKZIP Version 1.1 utility software [Copyright (c) 1990 PKWare, Inc.]. With the source drive prompt displayed on the screen, execute the UNPACK batch file to install INM Version 4.11 on your PC:

- **UNPACK <SOURCE DRIVE> <TARGET DRIVE>**

For example, the command UNPACK A C will install, from the A drive, INM Version 4.11 on the C drive in a subdirectory called INM411. Note: The UNPACK batch file will, without prompting, overwrite the contents of subdirectory INM411, if one exists on the user-specified target drive.

### 1.2.1 RAM Disk Installation

Operation of INM Version 4.11 on a RAM disk will improve computation time by an estimated 5 to 15 percent, as compared to operating it from a hard-disk drive. RAMDRIVE.SYS, an installable device driver supplied with Microsoft-compatible DOS, allows a user to configure part of the PC's RAM as if it were a hard disk (i.e., a RAM disk, sometimes referred to as a virtual disk). The following is an example installation of INM Version 4.11 onto a RAM disk. The user is referred to the DOS manual and/or the manual supplied with any memory management software being used if difficulties should occur.

To install RAMDRIVE.SYS for use with INM Version 4.11, the following command line should be included in the CONFIG.SYS file:

- **DEVICE=C:\DOS\RAMDRIVE.SYS 3000/E**

Upon including the above command line in the CONFIG.SYS file, the PC must be rebooted. After rebooting, the PC will have a 3 MB RAM drive located in extended memory. The RAM drive's logical, alphabetical drive designation will be one letter higher than the highest current physical drive on the PC (e.g., if a PC has a 5¼ inch A-drive, a 3½ inch B-drive, and a hard-disk C-drive, upon rebooting, the RAM drive will be designated the D-drive). The user may now install the INM software on the RAM drive by designating it as the target drive for installation. For example:

- **A:\UNPACK A D**

The above command will automatically install the INM from the A-drive onto a subdirectory (INM411) on the RAM drive (i.e., in this example the D-drive). The RAM drive must now be logically connected to the hard drive using DOS's JOIN command. To accomplish this, an empty subdirectory, e.g., C:\RAM, must be created on the hard drive. From within that subdirectory execute the following command:

- **C:\RAM\JOIN D: C:**

This will assign the RAM drive, i.e., the D-drive, to operate within the subdirectory C:\RAM on the hard drive. Note: It is extremely important to remember that each time the PC is reset or its power is turned off, the information stored on the RAM drive will be lost. As a result, if the INM is run from the RAM drive, all files must be copied to a physical drive, e.g., a floppy drive, prior to powering-off the PC.

## 2. IMPLEMENTATION OF INM VERSION 4.11 ENHANCEMENTS

This Section of the document describes the methodology for implementing INM Version 4.11 enhancements. It includes a background discussion of the enhancements, a brief discussion of the need for the enhancements, and example implementation of the enhancements. The following enhancements are discussed: (1) the takeoff profile generator; (2) the ability to account for terrain elevation around a specified airport; (3) the ability to compute the CNEL, WECPNL, LEQDAY, and LEQNIGHT noise metrics; (4) the ability to account for airplane runup operations; (5) the ability to account for runway thresholds during approach operations; (6) an enhancement to the noise contour computations; (7) an increase in the number of takeoff profile segments; and (8) enhancements to the echo file.

### 2.1 Takeoff Profile Generator

This enhancement allows for the computation of airplane takeoff profiles based on the user-supplied airport elevation and temperature entry in the SETUP section of the INM input file. The takeoff profiles are utilized by the INM in the computation of all noise metrics. Previous versions of the INM utilize takeoff profiles which were based on standard-day conditions, i.e., temperature of 59°F and airport elevation of zero ft Above Mean Sea Level (MSL). Previously, the user-supplied airport elevation (altitude) and temperature were only used to compute an atmospheric acoustic impedance correction.

The takeoff profile generator is made possible by the inclusion of standardized airplane operating procedures and performance coefficients in Data Base Number 11. These procedures and coefficients are presented in References 2, 3, and 4, and accessible from the Data Base using the ACDB11.EXE computer program, supplied with the Version 4.11 release. With the exception of INM airplane numbers 1, 6, 7, 8, 10, 24, 56, 100, 101, and four of the new airplanes (INM airplane numbers 104 to 107) discussed further in Appendix A, the operating procedures and performance coefficients required for takeoff profile computation are included in Data Base Number 11. For the airplanes without standard procedures and coefficients the takeoff profile for standard conditions is assumed regardless of the airport elevation and temperature. Note: The incorporation of the takeoff profile generator will not affect the standard approach profiles. The approach profiles are the same as employed in INM Version 3.10.

Operation of the profile generator is time-efficient and entirely transparent to the user. If other than standard-day conditions are specified by the user in the SETUP portion of the input file, the profile generator automatically computes the takeoff profiles using the airplane performance coefficients in Data Base Number 11 and the equations in the Society of Automotive Engineers Aerospace Information Report 1845[5] (SAE/AIR 1845). When an airport elevation and temperature is not specified, the INM assumes standard conditions and utilizes the standard profiles included with Data Base Number 11, i.e., the internal profile generator will not be exercised.

To insure the takeoff profiles and resultant noise metrics computed by INM Version 4.11 are reasonable for the user-defined input case, a runway length check has been instituted. When the computed ground roll segment of the takeoff profile exceeds the user-specified runway length, the user is notified of the discrepancy. A message similar to the following is included in the echo file.

! **WARNING: COMPUTED GROUND ROLL ERROR FOR INM AIRPLANE 747200, STAGE WEIGHT 7, -- EXCEEDS USER-DEFINED RUNWAY LENGTH BY X PERCENT FOR THE TAKEOFF ON TRACK TR1,RUNWAY 09L.**

In many cases this warning will indicate to the user that there is an error in the input file, possibly in the user-defined average yearly temperature, airport elevation, airport runway length, or airplane stage weight. In cases where the computed ground roll segment exceeds the runway length by more than 10 percent, the above message will be included in the echo file as a fatal error rather than a warning and the user will not be permitted to continue processing of the input case.

There may be instances where the user has correctly defined the input case and the computed ground roll segment exceeds the runway length by more than 10 percent. This apparent anomaly may be the result of using the average yearly temperature at the airport as an input. For example, a particular airport may be capable of operating a high stage- weight B747 airplane in the early evening or during winter months only, when the temperature is significantly lower than the average yearly temperature. In such cases it is suggested that a user-defined profile be included in the input file.

In addition, there may be instances (e.g., high stage weights, high temperatures, and high airport elevations combined) where a negative rate-of-climb is computed. Consequently, a fatal error will occur and a profile will not be generated. In such instances, the user will be notified with a message similar to that below; it is suggested that a user-defined profile be included in the input file.

! **FATAL: PROFILE FOR INM AIRPLANE 747200, STAGE WEIGHT 7 CANNOT BE COMPUTED.**

A technical discussion of the takeoff profile generator is presented in Appendix B. In addition, Appendix B presents tables which summarize the runway requirements and operational boundaries of the profile generator. These tables are presented for various combinations of airport elevation and temperature intended to cover the range of average yearly conditions at airports across the United States.

## 2.2 Terrain Elevation

This user-selectable enhancement included with INM Version 4.11 allows for the computation of source-to-receiver slant range, i.e., propagation distance, based upon actual terrain elevation at receiver locations around a specified airport. The implementation of this enhancement can result in a vast improvement in the accuracy of the noise computations at airports located near hilly terrain, however its implementation will result in an increase in computation time by an estimated 50 to 100 percent. To utilize this enhancement, INM Version 4.11 users must have the United States Geological Survey (USGS) 3 Arc Second Elevation Data on CD-ROM, available from:

Rocky Mountain Communications, Inc. (RMC)
2023 Montane Drive East
Golden, CO 80401
(303) 526-5454
(303) 526-2662 (FAX)

The USGS data are available for the entire United States or parts thereof.

Prior to implementing the elevation enhancement within INM Version 4.11, the preprocessing program, MAKEFILE.EXE, which is included with the Version 4.11 distribution package, must be run on the RMC Digital Elevation Model (DEM) files. MAKEFILE.EXE constructs a 2.8 MB, one-degree by one-degree, geodetic data file with the user-specified airport located at the geographic center of the file. The file generated by MAKEFILE.EXE, which has a three-letter user-defined prefix and a .3CD extension (e.g., Boston's Logan International Airport might be designated BOS.3CD), will be used by INM Version 4.11 to compute the source-to-receiver slant range. Use of the MAKEFILE.EXE program is described below.

With the drive prompt displayed on the screen, type MAKEFILE to invoke the program.

! **C:\INM411\ <u>MAKEFILE</u>**

MAKEFILE.EXE will then prompt the user to enter a three-letter airport identification, e.g., BOS, and the latitude and longitude of a reference point at the airport (e.g., the beginning of the primary runway). In the following example the latitude and longitude are for the start of Runway 09L at Boston-Logan.

- **ENTER 3 LETTER AIRPORT IDENTIFIER (EX. BOS): BOS**
- **ENTER RUNWAY LAT COORD. DEGS MINS SECS (EX. 42 21 20): 42 21 20**
- **ENTER RUNWAY LON COORD. DEGS MINS SECS (EX. 71 00 48): 71 00 48**

The MAKEFILE.EXE program then computes the coordinates of the southeast corner of a one-degree by one-degree data-block based upon the start of the airport's primary runway being at the geographic center of the block. The computed southeast corner is displayed along with the four RMC DEM files required to construct the one-degree by one-degree data-block around the airport. The user is also given the option to overwrite an existing or create a new BOS.3CD file, where BOS is the three-letter airport identifier.

- **THE SE CORNER OF THE REQUIRED (1X1 DEG) DATA BLOCK IS: 41 52 70 31**
- **THE REQUIRED DEM FILES ARE: NW FN=42071.3CD NE FN=42070.3CD SW FN=41071.3CD SE FN=41070.3CD**
- **DO YOU WISH TO CREATE A NEW BOS.3CD FILE (Y/N) ? Y**

The user should type **Y** to overwrite/create a new file. If the four DEM files exist in the current directory, the program will create the BOS.3CD file without further prompting. If MAKEFILE.EXE cannot find the required DEM files, it will request that the user enter the drive where the DEM files are resident. In addition, MAKEFILE.EXE will ask if the data are on the RMC CD-ROM and, if so, copy them into the current directory. If the four DEM files are not on the CD-ROM drive, MAKEFILE.EXE will request the path where the files can be found. The program will then construct the required one-degree by one-degree data-file, with the airport's primary runway at its approximate geographic center. The user will be informed that the file has been constructed, and the minimum and maximum elevation within the constructed one-degree by one-degree block will be provided.

- **WRITING OF BOS.3CD IS COMPLETE**

The example BOS.3CD file is now ready for implementation by the INM. To utilize the elevation data in the BOS.3CD file in the computation of source-to-receiver slant range, the user must specify, in the SETUP portion of the INM input file: (1) the three-letter airport code which identifies the specific user pre-processed .3CD file; (2) the disk-drive location of the .3CD file (Note: It is not necessary to specify the location of the .3CD file if it is in the current directory; also, if the .3CD file resides in a subdirectory, the path to that subdirectory must be created prior to running INM.); and (3) the latitude and longitude of a user-defined reference point at the airport, where the X and

Y coordinates of all defined runways must be referenced to this point. To insure that the user has identified the appropriate .3CD file, the INPUT.EXE program will test the user-defined reference point at the airport against the stored reference in the .3CD file.

In the following example the user has: (1) specified Boston's Logan International Airport; (2) identified the C-drive as the location for the BOS.3CD file; and (3) specified the latitude and longitude of a reference point at Boston-Logan.

```
!    SETUP:

     TITLE <EXAMPLE IMPLEMENTATION OF ELEVATION ENHANCEMENT>
     AIRPORT <ELEVATION EXAMPLE>

     CODE BOS
     DRIVE C
     LATITUDE 42 21 20
     LONGITUDE 71 00 48
```

With the elevation enhancement invoked as described above, all noise-level computations are performed based upon the actual source-to-receiver slant range, rather than assuming a flat terrain as was the case in previous versions of the INM.

In addition, the data in the BOS.3CD file are used to compute the slope of a three-by-three arc-second tangential ground plane, with the receiver at its physical center. This ground plane is used in the computation of the source-to-receiver elevation-angle, beta, required by the lateral attenuation algorithm in the INM. The beta angle is defined as the angle subtended by the propagation path from the airplane to the receiver and the three-by-three arc-second ground plane. Figures 2-1 and 2-2, respectively, depict the beta angle for two scenarios: (1) previous versions of the INM (i.e., flat terrain); and (2) INM Version 4.11.

## 2.3 CNEL, WECPNL, LEQDAY, and LEQNIGHT Noise Metrics

The capability to compute four additional noise metrics has been included in INM Version 4.11. They are the Community Noise Equivalent Level (CNEL), Weighted Equivalent Continuous Perceived Noise Level (WECPNL), Equivalent Sound Level During Daytime Hours (LEQDAY), and Equivalent Sound Level During Nighttime Hours (LEQNIGHT). The addition of these four metrics brings the total number of metrics available for computation by the INM to eight (NEF, LEQ, LDN, TA, CNEL, WECPNL, LEQDAY, and LEQNIGHT). As was the case in previous

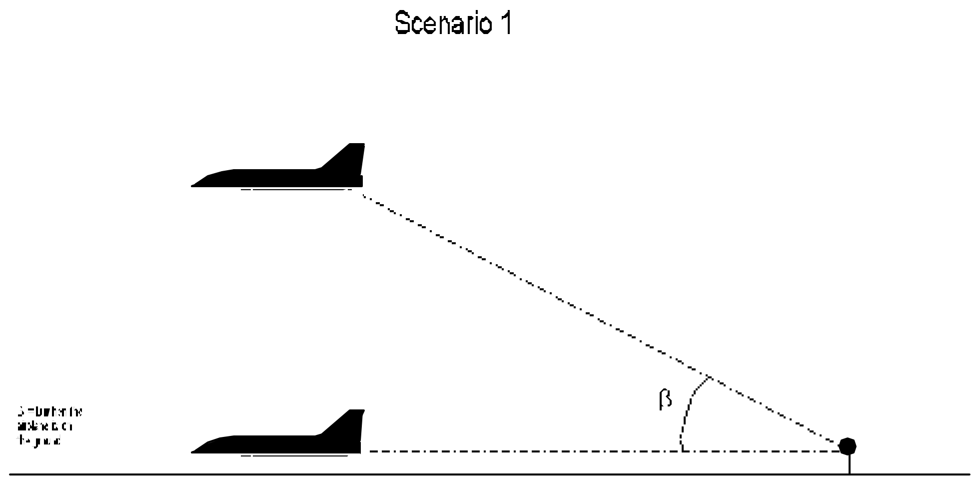
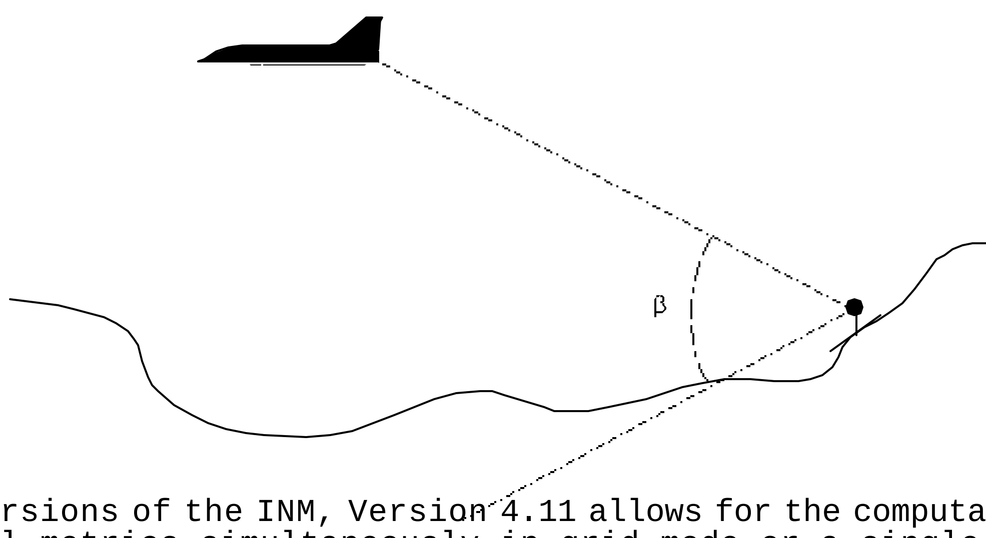



FIGURE 2-1: BETA ANGLE FOR INM VERSION 3.10 AND BEFORE

Scenario 2




versions of the INM, Version 4.11 allows for the computation of all metrics simultaneously in grid mode or a single user-defined metric in contour mode for a given input case. A brief description of the CNEL, WECPNL, LEQDAY, and LEQNIGHT noise metrics follows:

FIGURE 2-2: BETA ANGLE FOR INM VERSION 4.11

(1) Community Noise Equivalent Level (CNEL): The CNEL noise metric, which is primarily used in California, is similar to the Day-Night Sound Level (LDN) metric in that it incorporates the energy-averaged A-weighted sound level integrated over a 24-hour period. However, unlike LDN, CNEL incorporates an additional penalty for operations occurring between the evening hours of 1900 and 2200 hours. For CNEL, a 3 dB penalty is applied to operations occurring between 1900 and 2200 hours, and a 10 dB penalty is applied to operations occurring between 2200 and 0700 hours. The equation for computing CNEL within the INM is as follows:

$$CNEL = SEL + 10\log_{10}(N_{day} + 3N_{eve} + 10N_{night}) - 49.4,$$

where SEL = Sound Exposure Level in dBA;

$N_{day}$ = number of operations between 0700 and 1900 hours local time;

$N_{eve}$ = number of operations between 1900 and 2200 hours local time;

$N_{night}$ = number of operations between 2200 and 0700 hours local time;

and 49.4 = constant which normalizes CNEL to a 24-hour period, (i.e., $10\log_{10}(1/86{,}400$ sec/day$) = -49.4$).

(2) Weighted Equivalent Continuous Perceived Noise Level (WECPNL): The WECPNL noise metric, which is primarily used by the European Community, is based upon the PNLT noise metric and is computed within the INM as follows:

$$WECPNL = EPNL + 10\log_{10}(N_{day} + 3N_{eve} + 10N_{night}) - 39.4,$$

where all definitions are the same as in CNEL, above, except:

EPNL = Effective Perceived Noise Level in dB; and

39.4 = (49.4 - 10); where 49.4 is the constant which normalizes WECPNL to a 24-hour period, (i.e., $10\log_{10}(1/86{,}400$ secs/day$) = -49.4$); and -10 is the duration normalizing factor in the definition of EPNL.[6]

(3) Equivalent Sound Level During Daytime Hours (LEQDAY): The

LEQDAY noise metric is an energy summation of the aggregate environment, as measured in A-weighted decibel units (dBA) normalized to the 15-hour time period from 0700 to 2200. The equation for computing LEQDAY within the INM is as follows:

$$LEQDAY = SEL + 10\log_{10}(N_{day} + N_{eve}) - 47.3,$$

where all definitions are the same as in CNEL, above, except:

| | | |
|---|---|---|
| 47.3 | = | constant which normalizes LEQDAY to the 15-hour period from 0700 to 2200, (i.e., $10\log_{10}(1/54{,}000 \text{ sec}) = -47.3$). |

(4) <u>Equivalent Sound Level During Nighttime Hours (LEQNIGHT)</u>: The LEQNIGHT noise metric is an energy summation of the aggregate environment, as measured in A-weighted decibel units (dBA) normalized to the 9-hour time period from 2200 to 0700. The equation for computing LEQNIGHT within the INM is as follows:

$$LEQNIGHT = SEL + 10\log_{10}(N_{night}) - 45.1,$$

where all definitions are the same as in CNEL, above, except:

| | | |
|---|---|---|
| 45.1 | = | constant which normalizes LEQNIGHT to the 9-hour period from 2200 to 0700, (i.e., $10\log_{10}(1/32{,}400 \text{ sec}) = -45.1$). |

### 2.4 Airplane Runup Operations

This enhancement allows INM Version 4.11 to compute noise levels due to airplane engine runup operations. The need for this particular enhancement is recognized primarily around airplane maintenance facilities. To invoke this capability the user must define an airplane runup in the TAKEOFF section of the input file as follows:

!

```
INT.NM.
TAKEOFFS BY FREQUENCY:

TRACK RU1 RWY 09L STRAIGHT 50
      OPERATION 747200 RUNUP 1 D=30
      OPERATION 747200 STAGE 4 D=80
                  <OR>
      OPERATION 747200 STAGE 4 D=80 RUNUP 1 D=30
```

In the above example, a 30 second (D=30) runup operation is defined for a B747-200 airplane operation at the thrust setting of Stage Weight 1. The runup, as specified, takes place on a runway designated as 09L and a track designated as RU1. STRAIGHT 50 defines the length of the track in nautical miles. In fact, the track length for runup operations is ignored in the computation of runup noise. For runup noise computations it is assumed that the airplane covers a track with an arbitrarily chosen fixed length of 20 ft. The specific location and heading of the runup operation in the above example must be defined in the RUNWAYS section of the input file as shown in the following:

```
!     RUNWAYS
            RW 09L-27R   0   0 TO 9487   -497
```

In the above example, the runup operation takes place at the start of an active runway, i.e., Runway 09L. If the user wants to define a runup operation at a location at the airport other than on an active runway, e.g., at a maintenance facility, then the maintenance facility must be defined as if it were a runway. Here it is suggested that a maintenance facility, or any other location specified for a runup operation, be defined as a runway which is 20 ft in length. The definition of a maintenance facility as a 20 ft runway is shown in the following example.

```
!     RUNWAYS
            RW 13-31   0  5000 TO 20  5000
```

The above runup definitions assume that the full-power takeoff thrust associated with the user-defined stage weight is maintained for the duration of the runup. However, runup operations can occur at other than full-power thrust. To model such instances, a user-defined runup should be included in the input file as follows:

```
!     AIRCRAFT:
        TYPES
          AC 747200 STAGE 1=RU

      PROFILES TAKEOFF
        PF RU SEGMENTS=3 WEIGHT=525000 ENGINES=4
          DISTANCES        0      10     20
          ALTITUDES        0      0      0
          SPEEDS           160    160    160
          THRUSTS          35022  35022

      INT.NM.
      TAKEOFFS BY FREQUENCY:

      TRACK RU1 RWY 09L STRAIGHT 50
            OPERATION 747200 RUNUP 1 D=30
```

In addition, the specific location, e.g., the start of a runway or at a maintenance facility, and heading of the runup operation in the above user-defined example must be specified in the RUNWAYS section of the input file as discussed earlier in this section. A technical discussion of the airplane engine runup capability is presented in Appendix C.

## 2.5 Approach Runway Thresholds

The capability to account for displaced runway thresholds for approach operations has been added to INM Version 4.11. In previous versions of the INM, the runway touch-down point was assumed to be a fixed 954 ft from the edge of the runway for airplanes with a three degree approach glide slope, and 572 ft for the four airplanes with a five degree approach glide slope (INM airplane numbers 74 to 77). With INM Version 4.11, a user-defined displaced threshold (DT), either positive or negative, is added to the fixed runway touch-down point. To insure realistic DT's are defined by the user, they are checked versus the runway coordinates. If discrepancies exist, the user is notified in the echo file, as appropriate. In the following example, a 1454 ft runway touch-down point has been defined in the SETUP section of the input file for Runway 09L (i.e., 500 ft for the user-defined DT plus 954 ft for the fixed touch-down point); and a runway touch-down point of 954 ft has been defined for Runway 27R:

!
```
SETUP:

TITLE <EXAMPLE IMPLEMENTATION OF APPROACH RUNWAY THRESHOLD>
AIRPORT <RUNWAY THRESHOLD EXAMPLE>

ALTITUDE 23
TEMPERATURE 12.66 C

RUNWAYS
       RW 09L-27R  0 0 DT 500 TO 9487 -497 DT 0
                         <OR>
       RW 09L-27R  0 0 DT 500 TO 9487 -497
```

The above runway definition is depicted graphically below:

```
                      Runway 09L-27R
644444444L444444L444444444444&    /44L444444447
5 09L     *       *                          *     27R 5
944444444N444444N44444444444&    /4444N444444448
          8       8                          8

        954 ft  1454 ft              954 ft
       (Fixed) (Defined)            (Fixed)
```

FIGURE 2-3: RUNWAY DEFINITION

The inclusion of the 500 ft user-defined DT results in a runway touchdown point 1454 ft from the start of Runway 09L (i.e., 500 ft for the user-defined DT plus 954 ft for the fixed touch-down point).

## 2.6 Noise Contour Computations

INM Version 4.11 provides, in the echo file, a warning to users when there are insufficient grid points to accurately compute a specific noise contour. In previous versions, the INM would automatically make the determination that there were insufficient grid points, and return a run-time error to the computer display without further explanation. The INM's noise computation window must be redefined to encompass additional grid points in the area of interest.

If the user-defined computational window is too coarse to allow computation of a requested contour or the requested contour is not encompassed by the window, INM Version 4.11 will include a message in the echo file which is similar to the following:

```
!    CONTOUR          CONTOUR AREA
      LEVEL           (SQ. MILES)
     -------          ------------

     CN 3 *WARNING:  LDN 30.0 CONTOUR DOES NOT EXIST
```

In the above example, the defined window was either too coarse to reliably compute the user-requested 30 dB LDN contour or the contour was not encompassed by the window.

## 2.7 Takeoff Profile Segments

INM Version 4.11 provides for user-defined takeoff profiles with up to 18 segments. Previous versions of the INM limited the number of segments to 14. This enhancement allows for more precise user-defined takeoff profiles. It will also more easily facilitate the incorporation of a flight-procedure generator planned for a future version of the INM, since certain procedures may require higher resolution profiles, and thus more segments.

## 2.8 Echo File

All output reports generated by INM Version 4.11 have been modified to account for the enhanced capabilities discussed in Section 2.0, above.

# 3. REFERENCES


[1] Flythe, M.C., Integrated Noise Model Version 3, User's Guide - Revision 1, Report No. DOT/FAA/EE-92/02, Arlington, VA: CACI, Inc. - Federal, June 1992.

[2] Bishop, D.E., Mills, J.F., Update of Aircraft Profile Data for the Integrated Noise Model Computer Program, Volume 1, Report No. FAA-EE-91-02, Canoga Park, CA: Acoustical Analysis Associates, Inc., March 1992.

[3] Bishop, D.E., Mills, J.F., Update of Aircraft Profile Data for the Integrated Noise Model Computer Program, Volume 2, Report No. FAA-EE-91-02, Canoga Park, CA: Acoustical Analysis Associates, Inc., March 1992.

[4] Bishop, D.E., Mills, J.F., Update of Aircraft Profile Data for the Integrated Noise Model Computer Program, Volume 3, Report No. FAA-EE-91-02, Canoga Park, CA: Acoustical Analysis Associates, Inc., March 1992.

[5] Procedure for the Calculation of Airplane Noise in the Vicinity of Airports, SAE/AIR 1845, Warrendale, PA: Society of Automotive Engineers Committee A-21, Aircraft Noise, 1986.

[6] Federal Aviation Regulations, Part 36, Noise Standards: Aircraft Type and Airworthiness Certification, Washington, D.C.: Federal Aviation Administration, December 1988.

# APPENDIX A

# REVISIONS TO INM ALGORITHMS

This Appendix discusses, in general terms, revisions to several algorithms and subroutines included in INM Version 4.11. It also discusses the rationale for these revisions and presents their effects on the noise contours, where applicable. The associated computer source code is not included. All revisions discussed below are transparent to the user in that they do not affect user-operation of the INM. However, these revisions will result in more accurate INM noise predictions and an increase in INM computational efficiency. They include: (1) revisions to the flight significance testing within the INM; (2) implementation of a directivity smoothing equation; (3) revisions to the dipole directivity pattern within the INM; and (4) revisions to the INM Data Base.

## A.1 Flight Significance Testing

The methodology employed for determining flight noise significance during grid computations has been streamlined in INM Version 4.11. Rather than looping through each of the first four refinement levels individually and constructing the noise grid on a level-by-level basis, INM Version 4.11 begins by constructing the 17-by-17 point regular grid previously associated with the fourth refinement level, and setting all parameters associated with the 289 total points, including the noise significance flags for each point.

In restructuring the flight significance methodology, it was discovered that INM Version 3.10 was performing unnecessary (i.e., insignificant) noise computations due to improper setting of the flight significance flags. This impropriety had no effect on the computed noise levels but it did increase run-time unnecessarily. Revising the methodology for grid development, including the proper setting of flight significance flags, improved computation time by an estimated 40 percent over INM Version 3.10, for comparable input cases.

## A.2 Directivity Smoothing Equation

The directivity algorithm of SAE/AIR 1845 implemented for receivers behind start-of-takeoff roll, which is based on field-measured data published in 1980, has been maintained within INM Version 4.11. However, a directivity smoothing equation, operating as a function of distance, has been implemented. In previous versions of the INM, the directivity algorithm is applied to noise levels behind start-of-takeoff-roll regardless of lateral distance. In the 1980 study, measurements were made at distances from start-of-takeoff-roll of only 970 to 1280 ft. Recent studies[6,7] have indicated that INM Version 3.10 tends to underpredict noise levels behind start-of-takeoff-roll at distances of 3000 to 5000 ft, well beyond those represented in the 1980 study. This underprediction was especially evident for measurements made directly behind the airplane where the reduction in noise level due to the directivity algorithm is most pronounced.

As a result, an equation has been incorporated into INM Version 4.11 which smooths out the directivity effect as a function of distance behind the airplane, beginning at a distance of 2500 ft. The smoothing algorithm reduces the directivity effect in decibels by a factor of 50 percent per doubling of distance behind the airplane, beginning at a distance of 2500 ft. For example, a noise level attenuation of 10 dB computed by the directivity algorithm at a distance of 2500 ft will be reduced to 5 dB at 5000 ft due to the smoothing equation.

The smoothing equation built into INM Version 4.11 was empirically and conservatively derived from the data of Reference 6, the more detailed study of the two cited above. However, it is strongly recommended that additional measurments behind start-of-takeoff-roll be performed at a variety of offset distances and azimuth angles at several sites across the country to fine-tune the smoothing equation.

**A.3 Dipole Directivity Pattern**

The 90° dipole directivity pattern was originally instituted within the INM as a means of approximating the directivity characteristics of an airplane in flight. Although the exact directivity characteristics are a function of parameters such as airplane type, power setting, speed, and distance, the dipole model has served as a reasonable approximation. In INM Version 4.11, the 90° dipole directivity pattern has been modified. Figures A-1 and A-2 depict the dipole directivity pattern of INM Version 3.10 and earlier versions, and the modified pattern of INM Version 4.11, respectively. For INM Version 4.11, the original dipole directivity directly in front of and behind the airplane has been suppressed. In addition, the directivity algorithm of SAE/AIR 1845, with the addition of the smoothing equation discussed in Section A.2 above, is applied behind the airplane for <u>all</u> modes of operation. See Appendix C for a discussion of the appropriateness of the modified directivity pattern for runup operations.

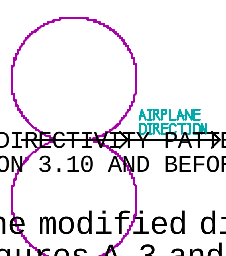


FIGURE A-1: DIPOLE DIRECTIVITY PATTERN, INM VERSION 3.10 AND BEFORE

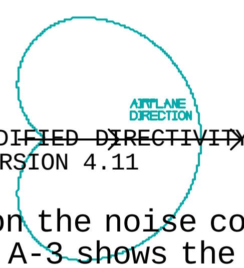


FIGURE A-2: MODIFIED DIRECTIVITY PATTERN, INM VERSION 4.11

The effect of the modified directivity pattern on the noise contours is depicted in Figures A-3 and A-4, below. Figure A-3 shows the effect on the SEL footprint for a single takeoff operation of the B737-200 airplane (INM number 47). Figure A-4 shows the effect on the LDN contour for the INM Input Testcase provided with INM Version 3.10.

```
-----  INM VERSION 3.10
       AND BEFORE
)))))  INM VERSION 4.11
```

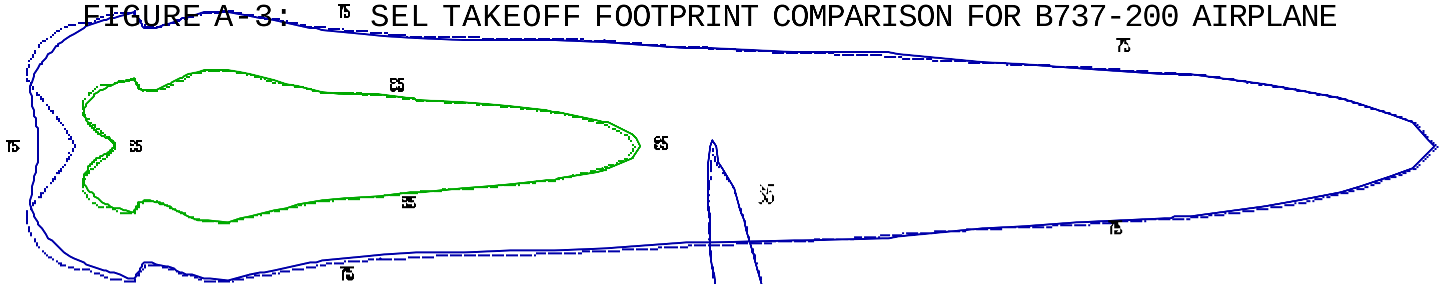
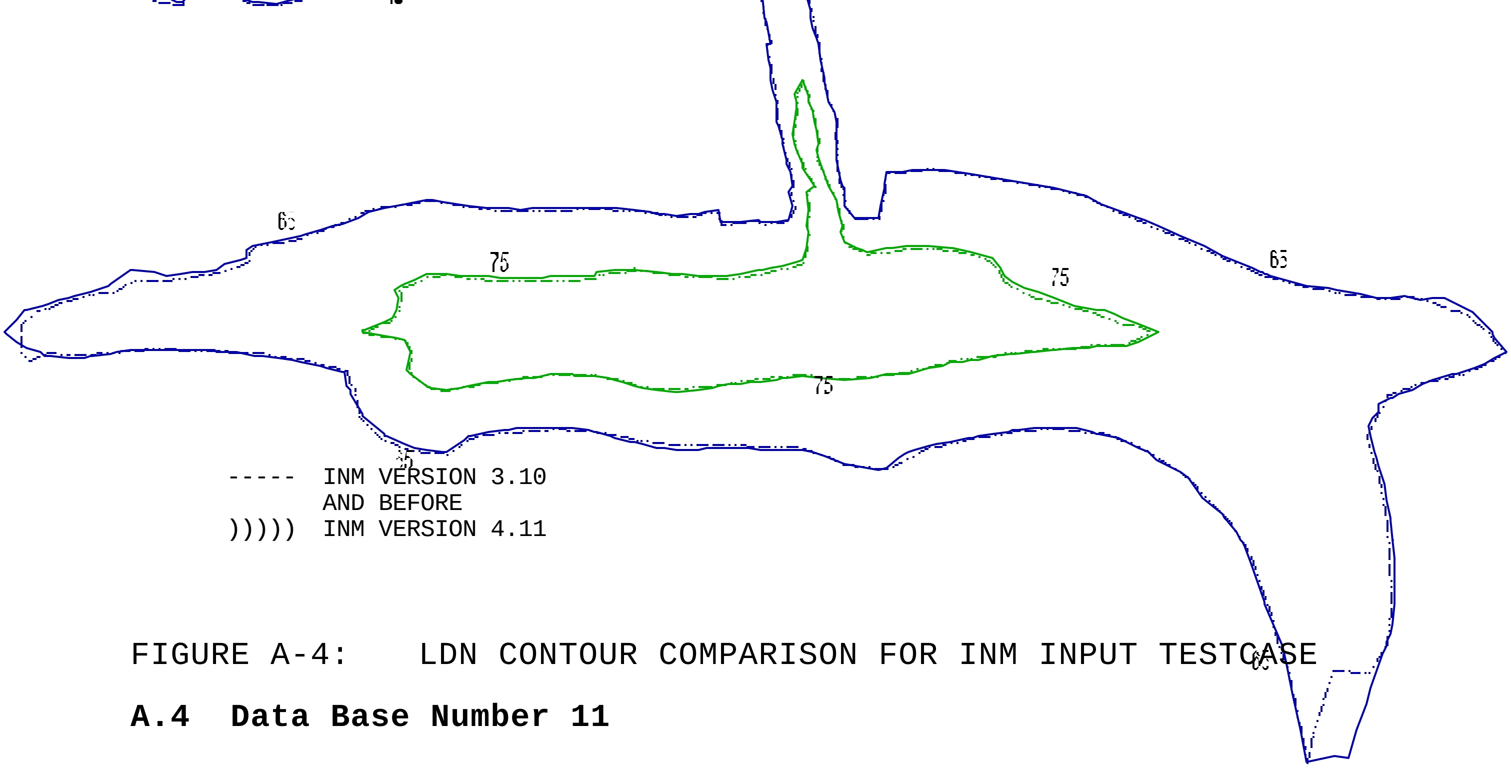



FIGURE A-3:    SEL TAKEOFF FOOTPRINT COMPARISON FOR B737-200 AIRPLANE




```
-----  INM VERSION 3.10
       AND BEFORE
)))))  INM VERSION 4.11
```

FIGURE A-4:    LDN CONTOUR COMPARISON FOR INM INPUT TESTCASE

## A.4 Data Base Number 11

Data Base Number 11 has been created through modifications, consisting primarily of the removal of artifacts from previous versions of the Data Base, and the addition of six new airplanes. As discussed in

Section 2.1, Data Base Number 11 was expanded to include airplane performance coefficients and standard flight procedures required for use with the takeoff profile generator. With the exception of INM airplane numbers 1, 6, 7, 8, 10, 24, 56, 100, 101, and four of the new airplanes discussed below, procedures and coefficients required for profile generation are included in the Data Base. For those airplanes without standard flight procedures and coefficients, the takeoff profile for standard conditions is utilized regardless of airport elevation and temperature.

In addition, six new airplanes have been added to Data Base Number 11 (See Table A-1). They include the MD11 with the CF6-80C2D1F and PW4460 engines (INM numbers 102 and 103, respectively), the F-16A with the F100-PW-200 engine (INM number 104), and the F-16C/D with the F110-GE-100, F100-PW-220, and F100-PW-229 engines (INM numbers 105, 106 and 107, respectively). The Noise-Power-Distance (NPD) data, standard-day profiles, performance coefficients and standard flight procedures included in the Data Base for the MD11 airplanes were obtained from the McDonnell Douglas Corporation.

The Volpe Center extracted the NPD data for the F-16 airplanes from the United States Air Force's (USAF) data base which is part of their NOISEMAP suite of computer programs. NOISEMAP, the military counterpart of the INM, is used for predicting noise exposure around airports dominated by military operations. The USAF data were normalized to an airspeed of 160 knots and adjusted for the effect of duration consistent with the procedures for developing the INM data base. The standard-day profiles, which are the same for the four F-16 airplanes, were also extracted from the USAF's data base. They are considered typical for transient F-16 airplanes. However, due to significantly varying takeoff procedures for F-16 airplanes throughout the world a user-defined takeoff profile may be more appropriate.

TABLE A-1: INM VERSION 4.11 DATA BASE AIRPLANE DEFINITIONS

| Airplane | | | Category | Noise | | Apprh | Takeoff Profiles by Trip Length (nm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Name | Description | Name | # | Name | # | 0-500 | 500-1000 | 1000-1500 | 1500-2500 | 2500-3500 | 3500-4500 | over 4500 |
| 102 | MD11GE | MD-11/CF6-80C2D1F | JCOM | 68 | 2CF68D | 102 | 374 | 375 | 376 | 377 | 378 | 379 | 380 |
| 103 | MD11PW | MD-11/PW 4460 | JCOM | 69 | PW4460 | 103 | 381 | 382 | 383 | 384 | 385 | 386 | 387 |
| 104 | F16A | F-16A/PW-200 | JMIL | 70 | PW200 | 104 | 388 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105 | F16GE | F-16C/D/GE-100 | JMIL | 71 | GE100 | 105 | 389 | 0 | 0 | 0 | 0 | 0 | 0 |
| 106 | F16PW0 | F-16C/D/PW-220 | JMIL | 72 | PW220 | 106 | 390 | 0 | 0 | 0 | 0 | 0 | 0 |
| 107 | F16PW9 | F-16C/D/PW-229 | JMIL | 73 | PW229 | 107 | 391 | 0 | 0 | 0 | 0 | 0 | 0 |

## A.5 References


[1] Horonjeff, R.D., Analysis of Aircraft Noise Levels in the Vicinity of Start-of-Takeoff Roll at Baltimore-Washington International Airport, Report No. FAA-EE-92-01, Lexington, MA: Harris Miller Miller & Hanson Inc., May 1992.

[2] Brown-Buntin Associates, "Letter Report, Noise Contour Adjustments - McCarran International Airport, Las Vegas -

Unpublished Data", August 1993.

# APPENDIX B

# TAKEOFF PROFILE GENERATOR

This Appendix presents a technical discussion of the takeoff profile generator within INM Version 4.11. The discussion, based on the algorithms of SAE/AIR 1845 and the aerodynamic coefficients and standard flight procedures in Data Base Number 11, is presented in two sections. The first section describes the computation of individual takeoff profile segments under standard conditions, i.e., airport temperature of 59°F and airport elevation of zero ft Above Mean Sea Level (MSL). The second section describes the computation of individual takeoff profile segments under non-standard conditions.

The horizontal distance and altitude increments computed for each acceleration segment at standard conditions are utilized for segment computations at non-standard conditions. In fact, the altitude Above Ground Level (AGL) at the end point of each segment is the same for the non-standard and standard profiles. However, for the non-standard case, the ground roll length of the takeoff segment and the flight angles of the airborne segments are modified in response to the user-defined airport conditions using the equations described below. The non-standard computations are achieved by: (1) an introduction of a specially developed routine for computation of atmospheric coefficients at a given altitude MSL as a function of the airport temperature and elevation; and (2) development of a routine for the automated adjustment of the rate-of-climb for acceleration segments due to atmospheric conditions. With the atmospheric coefficients and the rates-of-climb controlled by the user-defined airport elevation and temperature, the SAE equations remain intact.

The takeoff profile generator has been tested for non-standard temperatures from -10 to 100°F and airport elevations up to 6000 ft MSL. Accordingly, the third section of this Appendix presents a set of tables which summarize the runway requirements and operational boundaries of the takeoff profile generator for various combinations of airport elevation and temperature (Tables B-1 through B-9).

## B.1 Standard Conditions (15°C, Zero ft MSL)

This section describes the computation of a standard-condition takeoff profile on a segment-by-segment basis. The Subscripts 1 and 2 refer to the beginning and end of the segment, respectively. The following definitions, constants, and ratios apply to all computations described herein:

| | | | | | |
|---|---|---|---|---|---|
| Gravitational Constant: | $g$ | = | 32.17 | | |
| Thermal Gas Constant: | $R_c$ | = | 1716.2 | | |
| Temperature Lapse Rate: | $L$ | = | 0.003566 °F/ft or °R/ft | | |
| Standard Temperature,°F: | $T_{fap}$ | = | $T_{f0}$ | = | 59.0 |
| Standard Temperature,°C: | $T_{cap}$ | = | $T_{c0}$ | = | 15.0 |

| | | | | | |
|---|---|---|---|---|---|
| Standard Temperature,°R: | $T_{rap}$ | = | $T_{r0}$ | = | 518.67 |
| Temperature Ratio: | THETA | = | $1-[(L)(H_X)/T_{r0}]$, where $H_X$ is the altitude MSL for segment point X | | |
| Pressure Ratio: | DELTA | = | $THETA^{[g/((Rc)(L))]}$ | | |
| Density Ratio: | SIGMA | = | $THETA^{[(g/((Rc)(L)))-1]}$ | | |
| Airport Elevation MSL: | $H_{ap}$ | = | 0.0 ft | | |
| Brake Release Gross Weight | | = | W | | |
| Number of Engines supplying Thrust | | = | N | | |

## GROUND ROLL SEGMENT

For the ground roll segment the following apply:

| | | | | | |
|---|---|---|---|---|---|
| Airport Temperature: | $T_{c1}$ | = | $T_{c2}$ | = | $T_{cap}$ |
| Pressure Altitude MSL: | $H_1$ | = | $H_2$ | = | $H_{ap}$ |
| Initial Calibrated Airspeed: | $V_{c1}$ | = | 16.0 kts | | |

Given the above, the remaining parameters for the ground roll segment are computed as follows:

| | | | |
|---|---|---|---|
| Initial Thrust: | $Th_1$ | = | $E + F(V_{c1}) + G_1(H_1) + G_2(H_1)^2 + H(T_{c1})$ |
| Final Calibrated Airspeed: | $V_{c2}$ | = | $(C)(W)^{½}$ |
| Final Airplane True Speed: | $V_{t2}$ | = | $V_{c2}/(SIGMA)^{½}$ |
| Final Thrust: | $Th_2$ | = | $E + F(V_{c2}) + G_1(H_2) + G_2(H_2)^2 + H(T_{c2})$ |
| Segment Horizontal Length: | $S_g$ | = | $[(B)(THETA)(W/DELTA)^2]/[(N)Th_2]$ |

where E, F, $G_1$, $G_2$, and H are engine-dependent coefficients from Data Base Number 11 for maximum takeoff thrust mode;

C is a coefficient from Data Base Number 11 which is appropriate to the takeoff flap/slat setting;

B is a coefficient from Data Base Number 11 which is appropriate to a specific airplane/flap-deflection combination, and varies only with the takeoff flap/slat setting; and

SIGMA, THETA, and DELTA, defined above, are constants equal to 1 at sea level.

## CLIMB SEGMENT

For climb segments the following apply:

| | | | |
|---|---|---|---|
| Initial Calibrated Airspeed: | $V_{c1}$ | = | $V_{c2}$ of the previous segment |
| Final Calibrated Airspeed: | $V_{c2}$ | = | $V_{c1}$ |
| Initial Thrust: | $Th_1$ | = | $Th_2$ of the previous segment |
| Initial Temperature: | $T_{c1}$ | = | $T_{c2}$ of the previous segment |
| Initial Pressure Altitude MSL: | $H_1$ | = | $H_2$ of the previous segment |
| Final Segment Altitude AGL: | $Alt_{end}$ | = | As specified in the standard flight procedure |

Given the above, the remaining parameters for the climb segment are computed as follows:

| | | | |
|---|---|---|---|
| Final Segment Altitude MSL: | $H_2$ | = | $Alt_{end} + H_{ap}$ |
| Average Segment Altitude: | $H_{avg}$ | = | $0.5(H_1 + H_2)$ |
| Final Segment Temperature: | $T_{c2}$ | = | $[(T_{fap} - L(H_2)) - 32](5/9)$ |
| Average Segment Temperature: | $T_{cavg}$ | = | $[(T_{fap} - L(H_{avg})) - 32](5/9)$ |
| Average Calibrated Airspeed: | $V_{cavg}$ | = | $V_{c1} = V_{c2}$ |
| Average Segment Thrust: | $Th_{avg}$ | = | $E + F(V_{cavg}) + G_1(H_{avg}) + G_2(H_{avg})^2 + H(T_{cavg})$ |
| Average Airplane Weight: | $W_{avg}$ | = | $W/\{[THETA]^{[g/((Rc)(L))]}\}$ |
| Sine of the Flight Angle: | $SIN_{ang}$ | = | $k\{[(N)(Th_{avg}/W_{avg})] - R\}$ |

where k = 1.01 for $V_{cavg}$ # 200; and
= 0.95 for $V_{cavg} > 200$

| | | | |
|---|---|---|---|
| Cosine of the Flight Angle: | $COS_{ang}$ | = | $(1 - SIN_{ang}^2)^{1/2}$ |
| Horizontal Segment Distance: | $S_g$ | = | $(H_2 - H_1)/(SIN_{ang}/COS_{ang})$ |
| Final Segment Thrust: | $Th_2$ | = | $E + F(V_{c2}) + G_1(H_2) + G_2(H_2)^2 + H(T_{c2})$ |
| Final True Speed: | $V_{t2}$ | = | $V_{c2}/(SIGMA)^{1/2}$ |

where E, F, $G_1$, $G_2$, and H are engine-dependent coefficients from Data Base Number 11 for the thrust mode defined in the standard takeoff procedure; and

R is a coefficient from Data Base Number 11 which is the non-dimensional ratio of the airplane's drag coefficient to lift coefficient for a given flap setting and airplane configuration. The landing gear is assumed to be retracted.

## ACCELERATION SEGMENT

For acceleration segments the following apply:

| | | | |
|---|---|---|---|
| Initial Calibrated Airspeed: | $V_{c1}$ | = | $V_{c2}$ of the previous segment |
| Initial Airplane True Speed: | $V_{t1}$ | = | $V_{t2}$ of the previous segment |
| Initial Thrust: | $Th_1$ | = | $Th_2$ of the previous segment |
| Initial Temperature: | $T_{c1}$ | = | $T_{c2}$ of the previous segment |
| Initial Pressure Altitude MSL: | $H_1$ | = | $H_2$ of the previous segment |
| Final Calibrated Airspeed: | $V_{c2}$ | = | As specified in the standard flight procedure |
| Rate-of-Climb: | $V_{tz}$ | = | As specified in the standard flight procedure |

Given the above, computation of the remaining parameters is performed using an iterative procedure to arrive at the altitude increment, DelH. If the difference between DelH and $DelH_c$ (the computed altitude increment for the current iteration) is greater than one ft, DelH is set equal to $DelH_c$, and the iterative process is repeated until a difference of one ft or less is achieved.

| | | | |
|---|---|---|---|
| Initial Assumed Altitude Increment: | DelH | = | 250 ft |

Start of Iterative Loop:

| | | | |
|---|---|---|---|
| Final Segment Altitude MSL: | $H_2$ | = | $H_1$ + DelH |
| Final Segment Temperature: | $T_{c2}$ | = | $\{[T_{fap} - L(H_2)] - 32\}(5/9)$ |
| Final True Speed: | $V_{t2}$ | = | $V_{c2}/(SIGMA)^{½}$ |
| Final Segment Thrust: | $Th_2$ | = | $E + F(V_{c2}) + G_1(H_2) + G_2(H_2)^2 + H(T_{c2})$ |
| Average Segment Thrust: | $Th_{avg}$ | = | $0.5(Th_1 + Th_2)$ |
| Average True Speed: | $V_{tavg}$ | = | $0.5(V_{t1} + V_{t2})$ |
| Average Segment Altitude: | $H_{avg}$ | = | $H_1 + 0.5DelH$ |
| Average Airplane Weight: | $W_{avg}$ | = | $W/\{[THETA]^{[g/((Rc)(L))]}\}$ |

Sine of the Flight Angle: $SIN_{ang} = V_{tz}/(101.2686V_{tavg})$

Flight Angle: $GAMMA = \arcsin(SIN_{ang})$

Horizontal Segment Distance:

$$S_g = \frac{0.042062(V_{t2}^2 - V_{t1}^2)}{[(N)(Th_{avg})/W_{avg}] - R_{avg} - SIN_{ang}}$$

Computed Altitude Increment: $DelH_c = S_g[\tan(GAMMA)](1/0.95)$

Deviation of the Computed Altitude Increment from the Altitude Increment Assumed at the Start of the Current Iteration Cycle: $DEV = abs[DelH_c - DelH]$

At this point the status of the iterative process is checked. If DEV is less than 1 ft, then the iterative process is complete. Otherwise,

Altitude Increment: $DelH = DelH_c$

and the iterative process is repeated as above.

where E, F, $G_1$, $G_2$, and H are engine-dependent coefficients from Data Base Number 11 for the thrust mode defined in the standard takeoff procedure; and

$R_{avg}$ is a coefficient from Data Base Number 11 which is the non-dimensional ratio of the airplane's drag coefficient to lift coefficient for a given flap setting and airplane configuration. The landing gear is assumed to be retracted.

## THRUST REDUCTION SEGMENT

A thrust reduction segment of 1000 ft (horizontal distance) is introduced to allow for a smooth transition of the thrust associated with the Federal Aviation Regulations, Part 36 thrust cutback point. This segment replaces the first 1000 ft of horizontal distance of the next segment which may be either a climb or an acceleration segment. Computation of the parameters associated with the thrust reduction segment and the next segment is performed simultaneously. For the thrust reduction segment the following apply:

Initial Calibrated Airspeed: $V_{c1}$ = $V_{c2}$ of the previous segment

Initial Pressure Altitude MSL: $H_1$ = $H_2$ of the previous segment

Initial Temperature: $T_{c1}$ = $T_{c2}$ of the previous segment

Initial Thrust: $Th_{r1}$ = $Th_2$ of the previous segment

Initial Airplane True Speed: $V_{t1}$ = $V_{t2}$ of the previous segment

Horizontal Distance of the Thrust Reduction Segment: $S_r$ = 1000 ft

Given the above, the final thrust for the cutback segment is computed as follows:

Thrust: $Th_{r2} = E + F(V_{c1}) + G_1(H_1) + G_2(H_1)^2 + H(T_{c1})$

where E, F, G1, G2, and H are engine-dependent coefficients from Data Base Number 11 for the thrust mode defined in the standard takeoff procedure.

Thrust Reduction Followed by an Acceleration Segment:

When the thrust reduction segment is followed by an acceleration segment, the initial thrust of the acceleration segment is set equal to $Th_{r2}$ and computation of the remaining parameters associated with the acceleration segment is performed as described previously. The remaining parameters of the thrust reduction segment are computed as follows and the thrust reduction segment replaces the first 1000 ft of the acceleration segment:

True Speed at the end of the thrust reduction segment: $V_{tr2} = V_{t1} + (V_{t2} - V_{t1})(1000/S_g)$

Segment Altitude MSL at the end of the thrust reduction segment: $H_{r2} = H_1 + DelH(1000/S_g)$

where $V_{t2}$, $S_g$, and DelH are parameters computed above for an acceleration segment.

Thrust Reduction Followed by a Climb Segment:

When the thrust reduction segment is followed by a climb segment, the initial thrust of the climb segment is set equal to $Th_{r2}$ and computation of the remaining parameters associated with the climb segment is performed as described previously. The remaining parameters for the thrust reduction segment are computed as follows and the thrust reduction segment replaces the first 1000 ft of the climb segment:

True Speed at the end of the thrust reduction segment: $V_{tr} = V_{t1} = V_{t2}$

Segment Altitude MSL at the end of the thrust reduction segment: $H_r = H_1 + (H_2 - H_1)(1000/S_g)$

where $V_{t2}$, $H_2$ and $S_g$ are parameters computed above for a climb segment.

## EXCEPTIONS

The above computations assume the airplane is jet-powered and that the required thrust computations are performed in lbs-thrust. However, if the airplane is propeller-powered the following parameters are factored into the above computations: (1) propeller efficiency and installed net propulsive power for maximum takeoff thrust; and (2) propeller efficiency and installed net propulsive power for maximum climb thrust.

In addition, for a select few airplanes, the thrust for a particular segment is given in the standard flight procedure as fixed and as such is not computed by the takeoff profile generator. Finally, for airplanes in Data Base Number 11 for which thrust is expressed in percent-RPM, an intermediate computation is performed to convert to lbs-thrust.

## B.2 Non-Standard Conditions

This section describes the computation of a non-standard-condition takeoff profile on a segment-by-segment basis. Non-standard conditions exist when either the airport elevation is not zero ft MSL and/or the airport temperature is not standard at the airport elevation. The following definitions, constants, and ratios, based upon the concept of density altitude, supplement those described for standard conditions and apply to all computations described herein:

| | | | |
|---|---|---|---|
| Gravitational Constant: | $g$ | = | 32.17 |
| Thermal Gas Constant: | $R_c$ | = | 1716.2 |
| Temperature Lapse Rate: | $L$ | = | 0.003566 °F/ft or °R/ft |
| Airport Elevation MSL: | $H_{ap}$ | = | User-defined in ft |
| Non-Standard Temperature at Airport Elevation: | $T_{fap}$ | = | User-defined degrees F |
| Standard Temperature,°R: | $T_{r0}$ | = | 518.67 |
| Standard Temperature Lapsed to Airport Elevation, °R: | $T_{rap}$ | = | $T_{r0} - (L)(H_{ap})$ |
| Temperature at Altitude, °R: | $T_r$ | = | $T_{rap} - [(L)(H_x - H_{ap})]$; where $H_x$ is the altitude MSL for segment point X |
| Standard Air Pressure: | $P_0$ | = | 2116 |
| Standard Air Pressure at Altitude: | $P$ | = | $(P_0)(DELTA)$ |
| Standard Air Density: | $R_0$ | = | 0.002328 |
| Air Density at Altitude: | $R$ | = | $P/[(R_c)(T_r)]$ |
| Non-Standard Density Ratio: | $SIGMA_{ns}$ | = | $R/R_0$ |
| Non-Standard Temperature Ratio: | $THETA_{ns}$ | = | $SIGMA_{ns}^{(1/\{g/[(Rc)(L)-1]\})}$ |
| Non-Standard Pressure Ratio: | $DELTA_{ns}$ | = | $THETA_{ns}^{\{g/[(Rc)(L)]\}}$ |

**<u>GROUND ROLL SEGMENT</u>**

For the ground roll segment the following apply:

Airport Temperature: $T_{c1} = T_{c2} = (T_{fap} - 32)(5/9)$

Pressure Altitude MSL: $H_1 = H_2 = H_{ap}$

Initial Calibrated Airspeed: $V_{c1}$ = 16.0 kts

Given the above, the remaining parameters for the ground roll segment under non-standard conditions are computed as in Section B.1, Standard Conditions, using the non-standard THETA, SIGMA, and DELTA, as appropriate.

## CLIMB SEGMENT

The parameters for the climb segment under non-standard conditions are computed as in Section B.1, Standard Conditions, using the non-standard THETA, SIGMA, and DELTA, as appropriate.

## ACCELERATION SEGMENT

With the exception of the iterative process described below, the parameters for the acceleration segment under non-standard conditions are computed as in Section B.1, Standard Conditions, using the non-standard THETA, SIGMA, and DELTA, as appropriate.

Computation of the remaining parameters is performed using an iterative procedure to arrive at the horizontal distance of the segment, $S_{gns}$. If the difference between $S_{gns}$ and $S_{gc}$ (the computed horizontal distance for the current iteration) is greater than ten ft, $S_{gns}$ is set equal to the arithmetic average of $S_{gns}$ and $S_{gc}$, and the iterative process is repeated until a difference of ten ft or less is achieved.

Initial Assumed Horizontal Distance: $S_{gns}$ = $S_g$ computed for standard conditions

The equations for the acceleration segment under standard conditions are used to supplement the following non-standard computations:

<u>Start of Iterative Loop</u>:

Tangent of the Flight Angle: $TAN_{ang} = 0.95(DelH/S_{gns})$

Sine of the Flight Angle: $SIN_{ang} = \sin[\arctan(TAN_{ang})]$

Computed Horizontal Distance:

$$S_{gc} = \frac{(½g)(0.95)(V_{t2}^2 - V_{t1}^2)}{[N(Th_{avg})] - R_{avg} - SIN_{ang}}$$

Deviation of the Computed Horizontal Distance from the Horizontal Distance Assumed at the Start of the Current Iteration Cycle: $DEV = abs[S_{gc} - S_{gns}]$

At this point the status of the iterative process is checked. If DEV is less than ten ft, then the iterative process is complete. Otherwise,

Horizontal
Distance: $S_{gns} = 0.5[S_{gc} + S_{gns}]$

and the iterative process is repeated as above.

where E, F, $G_1$, $G_2$, and H are engine-dependent coefficients from Data Base Number 11 for the thrust mode defined in the standard takeoff procedure; and

$R_{avg}$ is a coefficient from Data Base Number 11 which is the non-dimensional ratio of the airplane's drag coefficient to lift coefficient for a given flap setting and airplane configuration. The landing gear is assumed to be retracted.

**THRUST REDUCTION SEGMENT**

The parameters for the thrust reduction segment under non-standard conditions are computed as in Section B.1, Standard Conditions, using the non-standard THETA, SIGMA, and DELTA, as appropriate.

**ERROR CHECKING**

The non-standard portion of the profile generator maintains several built-in error checks which guard against the computation of improper takeoff profiles. Computation of takeoff profiles is not performed if any of the following conditions are detected:

(1) the computed flight angle for a climb segment is zero or negative;

(2) the computed horizontal distance for an acceleration segment is zero or negative;

(3) the number of iterations required to compute the horizontal distance of an acceleration segment exceeds five hundred; and

(4) the length of the computed ground roll segment exceeds the length of the runway by more than ten percent; if the computed segment exceeds the runway length by less than ten percent, the user is warned of the discrepancy as discussed in Section 2.1.

**EXCEPTIONS**

The exceptions noted in Section 2.1, Standard Conditions, also apply for non-standard conditions.

## B.3 Runway Requirements/Operational Boundaries

Tables B-1 through B-9 present the length (ft) of the ground roll segment computed by the profile generator for all INM airplanes and stage weights. These tables are intended to give the user guidance on the operational boundaries and runway requirements of the profile generator for various airport temperatures, elevations, and runway lengths. These data are presented for nine combinations of airport elevation and temperature intended to cover the range of average yearly conditions at airports across the United States. Tables B-1 through B-3 present these data for 0 ft Above Mean Sea Level (MSL) elevation and three temperatures, 59°F, 40°F and 80°F, respectively. Tables B-4 through B-6 present these data for 3000 ft MSL elevation and three temperatures, 59°F, 40°F and 80°F, respectively. Tables B-7 through B-9 present these data for 6000 ft MSL elevation and three temperatures, 59°F, 40°F and 80°F, respectively. When the generator determines that a profile can not be computed, as discussed in Section B.2, Error Checking, a zero is inserted in the table, e.g., Table B-2, INM Airplane Number 71, Stage Weight 3.

TABLE B-1: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 0 FT MSL

| INM # | STAGE WEIGHT 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 4624 | 5004 | 5400 | 6352 | 7630 | 9173 | 10579 |
| 3 | 3719 | 4057 | 4501 | 5067 | 6644 | 6871 | --- |
| 4 | 2616 | 2926 | 3240 | 3752 | 4503 | 5309 | 6699 |
| 5 | 3846 | 4157 | 4481 | 5257 | 6297 | 7545 | 8679 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 3279 | 3739 | 4160 | 4913 | 5992 | 7186 | 8080 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 2684 | 3034 | 3405 | 4006 | 4436 | --- | --- |
| 12 | 3000 | 3338 | 3879 | 4666 | 5754 | 6709 | --- |
| 13 | 3705 | 4054 | 4607 | 5400 | 6483 | 7180 | 8167 |
| 14 | 3357 | 3684 | 4204 | 4956 | 5989 | 6660 | 7614 |
| 15 | 2693 | 3335 | 3959 | --- | --- | --- | --- |
| 16 | 3279 | 3739 | 4160 | 4913 | 5992 | 7186 | 8080 |
| 17 | 3705 | 4054 | 4607 | 5400 | 6483 | 7180 | 8167 |
| 18 | 6967 | 6967 | 8556 | 8556 | 9799 | 9799 | --- |
| 19 | 3997 | 4389 | 4943 | 5838 | 6813 | 7868 | --- |
| 20 | 3371 | 3656 | 3954 | 4609 | 5534 | 6575 | 7799 |
| 21 | 4669 | 5071 | 5463 | 6353 | 7614 | 9032 | 10657 |
| 22 | 5052 | 5383 | 5900 | 6443 | 7610 | 8883 | --- |
| 23 | 4611 | 4897 | 5343 | 5811 | 6741 | 7747 | 8869 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 26 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 27 | 5979 | 6964 | 8028 | 9074 | --- | --- | --- |
| 28 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 29 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 30 | 5263 | 6120 | 6965 | 7699 | --- | --- | --- |
| 31 | 3352 | 3846 | 4285 | 5206 | 6369 | --- | --- |
| 32 | 3414 | 3703 | 4015 | 4587 | 5362 | 6268 | 6811 |
| 33 | 3020 | 3274 | 3549 | 4062 | 4765 | 5576 | 5970 |
| 34 | 3067 | 3467 | 3924 | 4411 | 5328 | 6299 | --- |
| 35 | 3506 | 3981 | 4489 | 5506 | --- | --- | --- |
| 36 | 3187 | 3681 | 4135 | 5041 | --- | --- | --- |
| 37 | 4221 | 4827 | 5609 | --- | --- | --- | --- |
| 38 | 3292 | 4035 | --- | --- | --- | --- | --- |
| 39 | 3184 | 3746 | 4612 | --- | --- | --- | --- |
| 40 | 3634 | 4416 | 5227 | --- | --- | --- | --- |
| 41 | 2124 | 2638 | 3133 | --- | --- | --- | --- |
| 42 | 3075 | 3310 | 3893 | 4618 | --- | --- | --- |
| 43 | 3634 | 4416 | 5227 | --- | --- | --- | --- |
| 44 | 2124 | 2638 | 3133 | --- | --- | --- | --- |
| 45 | 3075 | 3310 | 3893 | 4618 | --- | --- | --- |
| 46 | 3653 | 4186 | 4839 | --- | --- | --- | --- |
| 47 | 3303 | 3688 | 4096 | 4526 | --- | --- | --- |
| 48 | 3897 | 4708 | 5601 | --- | --- | --- | --- |
| 49 | 3685 | 4155 | 4728 | 5991 | --- | --- | --- |
| 50 | 4002 | 4548 | 5131 | 6493 | --- | --- | --- |
| 51 | 2646 | 2846 | 3091 | 3573 | 4217 | --- | --- |
| 52 | 2747 | 2960 | 3219 | 3692 | 4376 | 5123 | --- |
| 53 | 2826 | --- | --- | --- | --- | --- | --- |
| 54 | 2569 | --- | --- | --- | --- | --- | --- |
| 55 | 3689 | --- | --- | --- | --- | --- | --- |

TABLE B-1: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 0 FT MSL (CONTINUED)

| | STAGE WEIGHT |
|---|---|

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 3130 | --- | --- | --- | --- | --- | --- |
| 58 | 3498 | --- | --- | --- | --- | --- | --- |
| 59 | 3725 | --- | --- | --- | --- | --- | --- |
| 60 | 2972 | --- | --- | --- | --- | --- | --- |
| 61 | 4945 | --- | --- | --- | --- | --- | --- |
| 62 | 3898 | --- | --- | --- | --- | --- | --- |
| 63 | 2697 | 3397 | 4586 | --- | --- | --- | --- |
| 64 | 1794 | --- | --- | --- | --- | --- | --- |
| 65 | 1211 | --- | --- | --- | --- | --- | --- |
| 66 | 3860 | 4921 | 5883 | --- | --- | --- | --- |
| 67 | 2638 | --- | --- | --- | --- | --- | --- |
| 68 | 2560 | --- | --- | --- | --- | --- | --- |
| 69 | 1239 | --- | --- | --- | --- | --- | --- |
| 70 | 3181 | 4201 | 5396 | --- | --- | --- | --- |
| 71 | 1520 | 1856 | 2234 | --- | --- | --- | --- |
| 72 | 1792 | 2332 | --- | --- | --- | --- | --- |
| 73 | 2082 | --- | --- | --- | --- | --- | --- |
| 74 | 632 | --- | --- | --- | --- | --- | --- |
| 75 | 738 | --- | --- | --- | --- | --- | --- |
| 76 | 1584 | --- | --- | --- | --- | --- | --- |
| 77 | 699 | --- | --- | --- | --- | --- | --- |
| 78 | 10532 | --- | --- | --- | --- | --- | --- |
| 79 | 4153 | 6477 | --- | --- | --- | --- | --- |
| 80 | 5158 | 7065 | --- | --- | --- | --- | --- |
| 81 | 4505 | 6732 | --- | --- | --- | --- | --- |
| 82 | 5120 | 7651 | --- | --- | --- | --- | --- |
| 83 | 3768 | 4193 | 4551 | 5313 | 6355 | 7861 | 9137 |
| 84 | 4084 | 4421 | 4756 | 5590 | 6711 | 8052 | 9291 |
| 85 | 3657 | 4252 | 4730 | 5769 | --- | --- | --- |
| 86 | 3569 | 4125 | 4636 | 5657 | --- | --- | --- |
| 87 | 2753 | 2985 | 3237 | 3708 | 4351 | 5096 | 5457 |
| 88 | 2942 | 3608 | 4350 | --- | --- | --- | --- |
| 89 | 3324 | 4085 | 4821 | --- | --- | --- | --- |
| 90 | 3187 | 3894 | 4678 | --- | --- | --- | --- |
| 91 | 11242 | --- | --- | --- | --- | --- | --- |
| 92 | 9308 | --- | --- | --- | --- | --- | --- |
| 93 | 3244 | 3596 | 4111 | 4820 | 5645 | --- | --- |
| 94 | 3004 | 3331 | 3676 | 4092 | --- | --- | --- |
| 95 | 3062 | --- | --- | --- | --- | --- | --- |
| 96 | 4190 | --- | --- | --- | --- | --- | --- |
| 97 | 3640 | 4331 | 5158 | 5984 | --- | --- | --- |
| 98 | 4136 | --- | --- | --- | --- | --- | --- |
| 99 | 2427 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 3968 | 4287 | 4619 | 5445 | 6343 | 7459 | 8831 |
| 103 | 4202 | 4543 | 4899 | 5784 | 6749 | 7950 | 9430 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-2: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 0 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 4254 | 4603 | 4968 | 5843 | 7020 | 8439 | 9733 |
| 3 | 3422 | 3732 | 4141 | 4662 | 6112 | 6322 | --- |
| 4 | 2406 | 2692 | 2981 | 3451 | 4142 | 4884 | 6163 |
| 5 | 3538 | 3824 | 4122 | 4837 | 5793 | 6942 | 7984 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 3017 | 3440 | 3827 | 4520 | 5512 | 6611 | 7434 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 2470 | 2791 | 3133 | 3686 | 4081 | --- | --- |
| 12 | 2760 | 3070 | 3569 | 4293 | 5294 | 6172 | --- |
| 13 | 3409 | 3729 | 4238 | 4968 | 5964 | 6606 | 7514 |
| 14 | 3088 | 3389 | 3868 | 4559 | 5510 | 6127 | 7005 |
| 15 | 2478 | 3068 | 3642 | --- | --- | --- | --- |
| 16 | 3017 | 3440 | 3827 | 4520 | 5512 | 6611 | 7434 |
| 17 | 3409 | 3729 | 4238 | 4968 | 5964 | 6606 | 7514 |
| 18 | 6410 | 6410 | 7872 | 7872 | 9015 | 9015 | --- |
| 19 | 3677 | 4038 | 4547 | 5371 | 6268 | 7239 | --- |
| 20 | 3101 | 3364 | 3638 | 4240 | 5091 | 6049 | 7175 |
| 21 | 4295 | 4666 | 5026 | 5844 | 7005 | 8309 | 9804 |
| 22 | 4648 | 4952 | 5428 | 5928 | 7001 | 8172 | --- |
| 23 | 4242 | 4505 | 4916 | 5346 | 6202 | 7127 | 8159 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 4152 | 4604 | 5080 | 5654 | --- | --- | --- |
| 26 | 5023 | 5566 | 6360 | 7450 | 8718 | --- | --- |
| 27 | 5500 | 6407 | 7386 | 8347 | --- | --- | --- |
| 28 | 4152 | 4604 | 5080 | 5654 | --- | --- | --- |
| 29 | 5023 | 5566 | 6360 | 7450 | 8718 | --- | --- |
| 30 | 4842 | 5630 | 6408 | 7083 | --- | --- | --- |
| 31 | 3084 | 3539 | 3942 | 4789 | 5860 | --- | --- |
| 32 | 3141 | 3407 | 3694 | 4220 | 4933 | 5767 | 6266 |
| 33 | 2778 | 3012 | 3265 | 3737 | 4384 | 5130 | 5492 |
| 34 | 2822 | 3189 | 3610 | 4058 | 4902 | 5795 | --- |
| 35 | 3226 | 3663 | 4130 | 5065 | --- | --- | --- |
| 36 | 2928 | 3382 | 3799 | 4631 | --- | --- | --- |
| 37 | 3883 | 4440 | 5160 | --- | --- | --- | --- |
| 38 | 3029 | 3712 | --- | --- | --- | --- | --- |
| 39 | 2930 | 3446 | 4243 | --- | --- | --- | --- |
| 40 | 3343 | 4062 | 4809 | --- | --- | --- | --- |
| 41 | 1954 | 2427 | 2883 | --- | --- | --- | --- |
| 42 | 2829 | 3045 | 3581 | 4249 | --- | --- | --- |
| 43 | 3343 | 4062 | 4809 | --- | --- | --- | --- |
| 44 | 1954 | 2427 | 2883 | --- | --- | --- | --- |
| 45 | 2829 | 3045 | 3581 | 4249 | --- | --- | --- |
| 46 | 3361 | 3851 | 4452 | --- | --- | --- | --- |
| 47 | 3038 | 3393 | 3768 | 4164 | --- | --- | --- |
| 48 | 3585 | 4332 | 5153 | --- | --- | --- | --- |
| 49 | 3390 | 3822 | 4349 | 5512 | --- | --- | --- |
| 50 | 3681 | 4184 | 4720 | 5974 | --- | --- | --- |
| 51 | 2434 | 2619 | 2843 | 3287 | 3879 | --- | --- |
| 52 | 2526 | 2722 | 2961 | 3395 | 4024 | 4712 | --- |
| 53 | 2600 | --- | --- | --- | --- | --- | --- |
| 54 | 2364 | --- | --- | --- | --- | --- | --- |
| 55 | 3394 | --- | --- | --- | --- | --- | --- |

TABLE B-2: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 0 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 2880 | --- | --- | --- | --- | --- | --- |
| 58 | 3218 | --- | --- | --- | --- | --- | --- |
| 59 | 3427 | --- | --- | --- | --- | --- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 60 | 2734 | --- | --- | --- | --- | --- | --- |
| 61 | 4550 | --- | --- | --- | --- | --- | --- |
| 62 | 3586 | --- | --- | --- | --- | --- | --- |
| 63 | 2435 | 3068 | 4141 | --- | --- | --- | --- |
| 64 | 1651 | --- | --- | --- | --- | --- | --- |
| 65 | 1093 | --- | --- | --- | --- | --- | --- |
| 66 | 3485 | 4443 | 5312 | --- | --- | --- | --- |
| 67 | 2382 | --- | --- | --- | --- | --- | --- |
| 68 | 2311 | --- | --- | --- | --- | --- | --- |
| 69 | 1119 | --- | --- | --- | --- | --- | --- |
| 70 | 2873 | 3794 | 4872 | --- | --- | --- | --- |
| 71 | 1372 | 1676 | 0 | --- | --- | --- | --- |
| 72 | 1618 | 2106 | --- | --- | --- | --- | --- |
| 73 | 1880 | --- | --- | --- | --- | --- | --- |
| 74 | 570 | --- | --- | --- | --- | --- | --- |
| 75 | 667 | --- | --- | --- | --- | --- | --- |
| 76 | 1431 | --- | --- | --- | --- | --- | --- |
| 77 | 632 | --- | --- | --- | --- | --- | --- |
| 78 | 9689 | --- | --- | --- | --- | --- | --- |
| 79 | 3820 | 5958 | --- | --- | --- | --- | --- |
| 80 | 4746 | 6500 | --- | --- | --- | --- | --- |
| 81 | 4068 | 6079 | --- | --- | --- | --- | --- |
| 82 | 4624 | 0 | --- | --- | --- | --- | --- |
| 83 | 3467 | 3858 | 4187 | 4888 | 5847 | 7232 | 8406 |
| 84 | 3757 | 4067 | 4376 | 5143 | 6174 | 7408 | 8547 |
| 85 | 3364 | 3912 | 4352 | 5307 | --- | --- | --- |
| 86 | 3284 | 3795 | 4265 | 5204 | --- | --- | --- |
| 87 | 2533 | 2746 | 2978 | 3411 | 4002 | 4688 | 5020 |
| 88 | 2707 | 3320 | 4002 | --- | --- | --- | --- |
| 89 | 3058 | 3758 | 4435 | --- | --- | --- | --- |
| 90 | 2932 | 3583 | 4304 | --- | --- | --- | --- |
| 91 | 10327 | --- | --- | --- | --- | --- | --- |
| 92 | 8563 | --- | --- | --- | --- | --- | --- |
| 93 | 2984 | 3308 | 3782 | 4434 | 5194 | --- | --- |
| 94 | 2764 | 3065 | 3382 | 3764 | --- | --- | --- |
| 95 | 2817 | --- | --- | --- | --- | --- | --- |
| 96 | 3855 | --- | --- | --- | --- | --- | --- |
| 97 | 3349 | 3985 | 4745 | 5505 | --- | --- | --- |
| 98 | 3805 | --- | --- | --- | --- | --- | --- |
| 99 | 2233 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 3369 | 3639 | 3920 | 4618 | 5378 | 6321 | 7479 |
| 103 | 3501 | 3784 | 4079 | 4812 | 5611 | 6605 | 7827 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-3: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 0 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 5053 | 5468 | 5901 | 6941 | 8338 | 10024 | 11561 |
| 3 | 4064 | 4433 | 4919 | 5537 | 7260 | 7509 | --- |
| 4 | 2858 | 3198 | 3541 | 4100 | 4920 | 5801 | 7321 |
| 5 | 4202 | 4542 | 4896 | 5745 | 6881 | 8245 | 9484 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 3583 | 4086 | 4545 | 5369 | 6548 | 7852 | 8830 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 2933 | 3315 | 3721 | 4378 | 4847 | --- | --- |
| 12 | 3278 | 3647 | 4239 | 5099 | 6288 | 7332 | --- |
| 13 | 4049 | 4430 | 5034 | 5901 | 7084 | 7846 | 8925 |
| 14 | 3668 | 4025 | 4594 | 5415 | 6544 | 7277 | 8320 |
| 15 | 2943 | 3644 | 4326 | --- | --- | --- | --- |
| 16 | 3583 | 4086 | 4545 | 5369 | 6548 | 7852 | 8830 |
| 17 | 4049 | 4430 | 5034 | 5901 | 7084 | 7846 | 8925 |
| 18 | 7614 | 7614 | 9350 | 9350 | 10708 | 10708 | --- |
| 19 | 4368 | 4797 | 5401 | 6380 | 7445 | 8598 | --- |
| 20 | 3683 | 3995 | 4321 | 5037 | 6047 | 7185 | 8523 |
| 21 | 5102 | 5542 | 5970 | 6942 | 8321 | 9870 | 11646 |
| 22 | 5521 | 5882 | 6447 | 7041 | 8315 | 9707 | --- |
| 23 | 5039 | 5351 | 5839 | 6350 | 7366 | 8465 | 9692 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 4932 | 5468 | 6034 | 6716 | --- | --- | --- |
| 26 | 5967 | 6612 | 7554 | 8849 | 10355 | --- | --- |
| 27 | 6533 | 7610 | 8773 | 9915 | --- | --- | --- |
| 28 | 4932 | 5468 | 6034 | 6716 | --- | --- | --- |
| 29 | 5967 | 6612 | 7554 | 8849 | 10355 | --- | --- |
| 30 | 5751 | 6688 | 7611 | 8413 | --- | --- | --- |
| 31 | 3663 | 4203 | 4683 | 5689 | 6960 | --- | --- |
| 32 | 3731 | 4047 | 4387 | 5012 | 5860 | 6850 | 7443 |
| 33 | 3300 | 3578 | 3878 | 4439 | 5207 | 6094 | 6524 |
| 34 | 3352 | 3788 | 4287 | 4820 | 5823 | 6883 | --- |
| 35 | 3832 | 4351 | 4905 | 6016 | --- | --- | --- |
| 36 | 3488 | 4029 | 4526 | 5518 | --- | --- | --- |
| 37 | 4613 | 5274 | 6129 | --- | --- | --- | --- |
| 38 | 3598 | 4409 | --- | --- | --- | --- | --- |
| 39 | 3480 | 4093 | 5040 | --- | --- | --- | --- |
| 40 | 3971 | 4825 | 5712 | --- | --- | --- | --- |
| 41 | 2321 | 2883 | 3424 | --- | --- | --- | --- |
| 42 | 3361 | 3617 | 4254 | 5047 | --- | --- | --- |
| 43 | 3971 | 4825 | 5712 | --- | --- | --- | --- |
| 44 | 2321 | 2883 | 3424 | --- | --- | --- | --- |
| 45 | 3361 | 3617 | 4254 | 5047 | --- | --- | --- |
| 46 | 3992 | 4574 | 5288 | --- | --- | --- | --- |
| 47 | 3609 | 4030 | 4476 | 4946 | --- | --- | --- |
| 48 | 4258 | 5145 | 6121 | --- | --- | --- | --- |
| 49 | 4027 | 4540 | 5166 | 6547 | --- | --- | --- |
| 50 | 4373 | 4970 | 5607 | 7095 | --- | --- | --- |
| 51 | 2891 | 3111 | 3377 | 3904 | 4608 | --- | --- |
| 52 | 3002 | 3236 | 3519 | 4036 | 4783 | 5600 | --- |
| 53 | 3088 | --- | --- | --- | --- | --- | --- |
| 54 | 2808 | --- | --- | --- | --- | --- | --- |
| 55 | 4031 | --- | --- | --- | --- | --- | --- |

TABLE B-3: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 0 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 3421 | --- | --- | --- | --- | --- | --- |
| 58 | 3823 | --- | --- | --- | --- | --- | --- |
| 59 | 4071 | --- | --- | --- | --- | --- | --- |
| 60 | 3248 | --- | --- | --- | --- | --- | --- |
| 61 | 5404 | --- | --- | --- | --- | --- | --- |
| 62 | 4260 | --- | --- | --- | --- | --- | --- |
| 63 | 3006 | 3787 | 5111 | --- | --- | --- | --- |
| 64 | 1961 | --- | --- | --- | --- | --- | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 65 | 1350 | --- | --- | --- | --- | --- | --- |
| 66 | 4302 | 5485 | 6558 | --- | --- | --- | --- |
| 67 | 2941 | --- | --- | --- | --- | --- | --- |
| 68 | 2853 | --- | --- | --- | --- | --- | --- |
| 69 | 1381 | --- | --- | --- | --- | --- | --- |
| 70 | 3546 | 4683 | 6014 | --- | --- | --- | --- |
| 71 | 1694 | 2069 | 0 | --- | --- | --- | --- |
| 72 | 1997 | 2599 | --- | --- | --- | --- | --- |
| 73 | 2321 | --- | --- | --- | --- | --- | --- |
| 74 | 704 | --- | --- | --- | --- | --- | --- |
| 75 | 823 | --- | --- | --- | --- | --- | --- |
| 76 | 1766 | --- | --- | --- | --- | --- | --- |
| 77 | 780 | --- | --- | --- | --- | --- | --- |
| 78 | 11509 | --- | --- | --- | --- | --- | --- |
| 79 | 4538 | 7077 | --- | --- | --- | --- | --- |
| 80 | 5637 | 7720 | --- | --- | --- | --- | --- |
| 81 | 5022 | 7504 | --- | --- | --- | --- | --- |
| 82 | 5707 | 8528 | --- | --- | --- | --- | --- |
| 83 | 4118 | 4582 | 4973 | 5806 | 6945 | 8590 | 9984 |
| 84 | 4463 | 4831 | 5197 | 6109 | 7334 | 8799 | 10152 |
| 85 | 3996 | 4646 | 5169 | 6304 | --- | --- | --- |
| 86 | 3901 | 4508 | 5066 | 6182 | --- | --- | --- |
| 87 | 3009 | 3262 | 3537 | 4052 | 4754 | 5569 | 5963 |
| 88 | 3215 | 3943 | 4754 | --- | --- | --- | --- |
| 89 | 3633 | 4464 | 5268 | --- | --- | --- | --- |
| 90 | 3483 | 4255 | 5112 | --- | --- | --- | --- |
| 91 | 12306 | --- | --- | --- | --- | --- | --- |
| 92 | 10171 | --- | --- | --- | --- | --- | --- |
| 93 | 3544 | 3929 | 4493 | 5267 | 6169 | --- | --- |
| 94 | 3283 | 3640 | 4017 | 4472 | --- | --- | --- |
| 95 | 3346 | --- | --- | --- | --- | --- | --- |
| 96 | 4579 | --- | --- | --- | --- | --- | --- |
| 97 | 3978 | 4733 | 5637 | 6539 | --- | --- | --- |
| 98 | 4520 | --- | --- | --- | --- | --- | --- |
| 99 | 2652 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 4777 | 5163 | 5564 | 6563 | 7651 | 9004 | 10667 |
| 103 | 5189 | 5613 | 6055 | 7156 | 8358 | 9858 | 11708 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-4: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 3000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 5750 | 6222 | 6714 | 7895 | 9482 | 11396 | 13139 |
| 3 | 4627 | 5046 | 5598 | 6301 | 8257 | 8540 | --- |
| 4 | 3255 | 3641 | 4031 | 4667 | 5600 | 6601 | 8327 |
| 5 | 4691 | 5069 | 5464 | 6409 | 7673 | 9191 | 10569 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 4028 | 4593 | 5109 | 6032 | 7355 | 8818 | 9913 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 3328 | 3761 | 4221 | 4965 | 5497 | --- | --- |
| 12 | 3848 | 4281 | 4976 | 5985 | 7382 | 8607 | --- |
| 13 | 4748 | 5195 | 5904 | 6921 | 8308 | 9202 | 10467 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | 4136 | 4537 | 5177 | 6101 | 7371 | 8195 | 9367 |
| 15 | 3403 | 4213 | 0 | --- | --- | --- | --- |
| 16 | 4028 | 4593 | 5109 | 6032 | 7355 | 8818 | 9913 |
| 17 | 4748 | 5195 | 5904 | 6921 | 8308 | 9202 | 10467 |
| 18 | 8684 | 8684 | 10661 | 10661 | 12208 | 12208 | --- |
| 19 | 5160 | 5666 | 6381 | 7537 | 8797 | 10160 | --- |
| 20 | 4130 | 4479 | 4844 | 5645 | 6775 | 8047 | 9543 |
| 21 | 6001 | 6519 | 7022 | 8166 | 9788 | 11611 | 13700 |
| 22 | 6265 | 6674 | 7315 | 7987 | 9429 | 11004 | --- |
| 23 | 5744 | 6100 | 6655 | 7236 | 8393 | 9643 | 11038 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 5823 | 6457 | 7125 | 7930 | --- | --- | --- |
| 26 | 6755 | 7485 | 8551 | 10015 | 11718 | --- | --- |
| 27 | 7666 | 8929 | 10294 | 11634 | --- | --- | --- |
| 28 | 5823 | 6457 | 7125 | 7930 | --- | --- | --- |
| 29 | 6755 | 7485 | 8551 | 10015 | 11718 | --- | --- |
| 30 | 6521 | 7582 | 8629 | 9537 | --- | --- | --- |
| 31 | 4324 | 4961 | 5528 | 6716 | 8218 | --- | --- |
| 32 | 4196 | 4550 | 4933 | 5634 | 6585 | 7695 | 8360 |
| 33 | 3606 | 3909 | 4236 | 4848 | 5684 | 6649 | 7117 |
| 34 | 3605 | 4072 | 4607 | 5177 | 6249 | 7383 | --- |
| 35 | 4159 | 4721 | 5320 | 6520 | --- | --- | --- |
| 36 | 3926 | 4534 | 5092 | 6206 | --- | --- | --- |
| 37 | 5428 | 6207 | 7212 | --- | --- | --- | --- |
| 38 | 4081 | 5000 | --- | --- | --- | --- | --- |
| 39 | 3965 | 4663 | 5741 | --- | --- | --- | --- |
| 40 | 4651 | 5651 | 6690 | --- | --- | --- | --- |
| 41 | 2712 | 3368 | 4001 | --- | --- | --- | --- |
| 42 | 3957 | 4259 | 5009 | 5943 | --- | --- | --- |
| 43 | 4651 | 5651 | 6690 | --- | --- | --- | --- |
| 44 | 2712 | 3368 | 4001 | --- | --- | --- | --- |
| 45 | 3957 | 4259 | 5009 | 5943 | --- | --- | --- |
| 46 | 4674 | 5355 | 6191 | --- | --- | --- | --- |
| 47 | 4094 | 4571 | 5076 | 5608 | --- | --- | --- |
| 48 | 4795 | 5792 | 6889 | --- | --- | --- | --- |
| 49 | 4548 | 5128 | 5834 | 7391 | --- | --- | --- |
| 50 | 5029 | 5715 | 6447 | 8157 | --- | --- | --- |
| 51 | 3259 | 3506 | 3806 | 4399 | 5191 | --- | --- |
| 52 | 3287 | 3541 | 3851 | 4414 | 5229 | 6119 | --- |
| 53 | 3377 | --- | --- | --- | --- | --- | --- |
| 54 | 3281 | --- | --- | --- | --- | --- | --- |
| 55 | 4770 | --- | --- | --- | --- | --- | --- |

TABLE B-4: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 3000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 3647 | --- | --- | --- | --- | --- | --- |
| 58 | 4240 | --- | --- | --- | --- | --- | --- |
| 59 | 4790 | --- | --- | --- | --- | --- | --- |
| 60 | 3458 | --- | --- | --- | --- | --- | --- |
| 61 | 5994 | --- | --- | --- | --- | --- | --- |
| 62 | 4798 | --- | --- | --- | --- | --- | --- |
| 63 | 3261 | 4108 | 5545 | --- | --- | --- | --- |
| 64 | 2156 | --- | --- | --- | --- | --- | --- |
| 65 | 1464 | --- | --- | --- | --- | --- | --- |
| 66 | 4667 | 5951 | 7115 | --- | --- | --- | --- |
| 67 | 3191 | --- | --- | --- | --- | --- | --- |
| 68 | 3095 | --- | --- | --- | --- | --- | --- |
| 69 | 1499 | --- | --- | --- | --- | --- | --- |
| 70 | 3847 | 5081 | 6525 | --- | --- | --- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 71 | 1838 | 2245 | 0 | --- | --- | --- | --- |
| 72 | 2167 | 2820 | --- | --- | --- | --- | --- |
| 73 | 2518 | --- | --- | --- | --- | --- | --- |
| 74 | 764 | --- | --- | --- | --- | --- | --- |
| 75 | 893 | --- | --- | --- | --- | --- | --- |
| 76 | 1916 | --- | --- | --- | --- | --- | --- |
| 77 | 846 | --- | --- | --- | --- | --- | --- |
| 78 | 13454 | --- | --- | --- | --- | --- | --- |
| 79 | 5094 | 7944 | --- | --- | --- | --- | --- |
| 80 | 6328 | 8665 | --- | --- | --- | --- | --- |
| 81 | 5448 | 8141 | --- | --- | --- | --- | --- |
| 82 | 6192 | 9252 | --- | --- | --- | --- | --- |
| 83 | 4637 | 5160 | 5599 | 6535 | 7815 | 9662 | 11228 |
| 84 | 5043 | 5459 | 5872 | 6900 | 8281 | 9932 | 11457 |
| 85 | 4503 | 5235 | 5823 | 7099 | --- | --- | --- |
| 86 | 4233 | 4890 | 5494 | 6698 | --- | --- | --- |
| 87 | 3464 | 3755 | 4071 | 4664 | 5471 | 6408 | 6861 |
| 88 | 3717 | 0 | 0 | --- | --- | --- | --- |
| 89 | 3949 | 4849 | 5718 | --- | --- | --- | --- |
| 90 | 4008 | 4896 | 5881 | --- | --- | --- | --- |
| 91 | 13820 | --- | --- | --- | --- | --- | --- |
| 92 | 11445 | --- | --- | --- | --- | --- | --- |
| 93 | 4029 | 4466 | 5106 | 5985 | 7008 | --- | --- |
| 94 | 3800 | 4214 | 4650 | 5176 | --- | --- | --- |
| 95 | 3660 | --- | --- | --- | --- | --- | --- |
| 96 | 5268 | --- | --- | --- | --- | --- | --- |
| 97 | 4698 | 5591 | 6659 | 7725 | --- | --- | --- |
| 98 | 5066 | --- | --- | --- | --- | --- | --- |
| 99 | 2913 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 4968 | 5367 | 5783 | 6816 | 7939 | 9335 | 11051 |
| 103 | 5183 | 5603 | 6041 | 7131 | 8318 | 9796 | 11616 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-5: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 3000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 5290 | 5724 | 6176 | 7263 | 8723 | 10484 | 12088 |
| 3 | 4256 | 4642 | 5150 | 5796 | 7597 | 7857 | --- |
| 4 | 2995 | 3350 | 3709 | 4293 | 5152 | 6073 | 7661 |
| 5 | 4315 | 4664 | 5027 | 5896 | 7059 | 8456 | 9723 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 3706 | 4226 | 4700 | 5550 | 6767 | 8112 | 9120 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 3062 | 3460 | 3884 | 4568 | 5057 | --- | --- |
| 12 | 3540 | 3939 | 4578 | 5506 | 6791 | 7918 | --- |
| 13 | 4368 | 4780 | 5432 | 6367 | 7643 | 8466 | 9630 |
| 14 | 3805 | 4174 | 4763 | 5613 | 6781 | 7539 | 8617 |
| 15 | 3130 | 3875 | 0 | --- | --- | --- | --- |
| 16 | 3706 | 4226 | 4700 | 5550 | 6767 | 8112 | 9120 |
| 17 | 4368 | 4780 | 5432 | 6367 | 7643 | 8466 | 9630 |
| 18 | 7989 | 7989 | 9808 | 9808 | 11231 | 11231 | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19 | 4747 | 5213 | 5870 | 6934 | 8093 | 9347 | --- |
| 20 | 3799 | 4121 | 4456 | 5193 | 6233 | 7403 | 8779 |
| 21 | 5521 | 5997 | 6460 | 7513 | 9005 | 10682 | 12604 |
| 22 | 5764 | 6140 | 6729 | 7348 | 8675 | 10124 | --- |
| 23 | 5284 | 5611 | 6122 | 6657 | 7721 | 8871 | 10154 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 5357 | 5940 | 6554 | 7295 | --- | --- | --- |
| 26 | 6215 | 6886 | 7867 | 9214 | 10780 | --- | --- |
| 27 | 7052 | 8215 | 9470 | 10703 | --- | --- | --- |
| 28 | 5357 | 5940 | 6554 | 7295 | --- | --- | --- |
| 29 | 6215 | 6886 | 7867 | 9214 | 10780 | --- | --- |
| 30 | 5999 | 6976 | 7938 | 8774 | --- | --- | --- |
| 31 | 3978 | 4564 | 5086 | 6179 | 7560 | --- | --- |
| 32 | 3860 | 4186 | 4538 | 5183 | 6058 | 7079 | 7691 |
| 33 | 3317 | 3596 | 3897 | 4460 | 5229 | 6117 | 6547 |
| 34 | 3316 | 3746 | 4238 | 4763 | 5749 | 6792 | --- |
| 35 | 3826 | 4343 | 4895 | 5998 | --- | --- | --- |
| 36 | 3607 | 4165 | 4678 | 5701 | --- | --- | --- |
| 37 | 4994 | 5710 | 6635 | --- | --- | --- | --- |
| 38 | 3754 | 4600 | --- | --- | --- | --- | --- |
| 39 | 3648 | 4290 | 5282 | --- | --- | --- | --- |
| 40 | 4279 | 5199 | 6155 | --- | --- | --- | --- |
| 41 | 2495 | 3099 | 3681 | --- | --- | --- | --- |
| 42 | 3640 | 3918 | 4608 | 5467 | --- | --- | --- |
| 43 | 4279 | 5199 | 6155 | --- | --- | --- | --- |
| 44 | 2495 | 3099 | 3681 | --- | --- | --- | --- |
| 45 | 3640 | 3918 | 4608 | 5467 | --- | --- | --- |
| 46 | 4300 | 4927 | 5696 | --- | --- | --- | --- |
| 47 | 3766 | 4206 | 4670 | 5160 | --- | --- | --- |
| 48 | 4411 | 5329 | 6337 | --- | --- | --- | --- |
| 49 | 4184 | 4717 | 5367 | 6799 | --- | --- | --- |
| 50 | 4626 | 5257 | 5931 | 7505 | --- | --- | --- |
| 51 | 2998 | 3225 | 3502 | 4047 | 4775 | --- | --- |
| 52 | 3023 | 3257 | 3542 | 4060 | 4809 | 5628 | --- |
| 53 | 3107 | --- | --- | --- | --- | --- | --- |
| 54 | 3019 | --- | --- | --- | --- | --- | --- |
| 55 | 4388 | --- | --- | --- | --- | --- | --- |

TABLE B-5: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 3000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 3355 | --- | --- | --- | --- | --- | --- |
| 58 | 3901 | --- | --- | --- | --- | --- | --- |
| 59 | 4407 | --- | --- | --- | --- | --- | --- |
| 60 | 3181 | --- | --- | --- | --- | --- | --- |
| 61 | 5514 | --- | --- | --- | --- | --- | --- |
| 62 | 4414 | --- | --- | --- | --- | --- | --- |
| 63 | 2945 | 3710 | 5007 | --- | --- | --- | --- |
| 64 | 1983 | --- | --- | --- | --- | --- | --- |
| 65 | 1322 | --- | --- | --- | --- | --- | --- |
| 66 | 4214 | 5373 | 6424 | --- | --- | --- | --- |
| 67 | 2881 | --- | --- | --- | --- | --- | --- |
| 68 | 2795 | --- | --- | --- | --- | --- | --- |
| 69 | 1353 | --- | --- | --- | --- | --- | --- |
| 70 | 3474 | 4588 | 5892 | --- | --- | --- | --- |
| 71 | 1660 | 2027 | 0 | --- | --- | --- | --- |
| 72 | 1957 | 2546 | --- | --- | --- | --- | --- |
| 73 | 2274 | --- | --- | --- | --- | --- | --- |
| 74 | 690 | --- | --- | --- | --- | --- | --- |
| 75 | 806 | --- | --- | --- | --- | --- | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 76 | 1730 | --- | --- | --- | --- | --- | --- |
| 77 | 764 | --- | --- | --- | --- | --- | --- |
| 78 | 12377 | --- | --- | --- | --- | --- | --- |
| 79 | 4686 | 7308 | --- | --- | --- | --- | --- |
| 80 | 5822 | 7972 | --- | --- | --- | --- | --- |
| 81 | 4920 | 7351 | --- | --- | --- | --- | --- |
| 82 | 5591 | 8354 | --- | --- | --- | --- | --- |
| 83 | 4266 | 4747 | 5151 | 6012 | 7189 | 8889 | 10329 |
| 84 | 4639 | 5022 | 5402 | 6348 | 7618 | 9137 | 10540 |
| 85 | 4143 | 4816 | 5357 | 6531 | --- | --- | --- |
| 86 | 3895 | 4499 | 5054 | 6162 | --- | --- | --- |
| 87 | 3186 | 3455 | 3745 | 4290 | 5033 | 5895 | 6312 |
| 88 | 3420 | 4193 | 0 | --- | --- | --- | --- |
| 89 | 3633 | 4461 | 5261 | --- | --- | --- | --- |
| 90 | 3687 | 4505 | 5411 | --- | --- | --- | --- |
| 91 | 12695 | --- | --- | --- | --- | --- | --- |
| 92 | 10529 | --- | --- | --- | --- | --- | --- |
| 93 | 3706 | 4108 | 4697 | 5506 | 6448 | --- | --- |
| 94 | 3496 | 3877 | 4278 | 4762 | --- | --- | --- |
| 95 | 3367 | --- | --- | --- | --- | --- | --- |
| 96 | 4846 | --- | --- | --- | --- | --- | --- |
| 97 | 4322 | 5143 | 6126 | 7107 | --- | --- | --- |
| 98 | 4661 | --- | --- | --- | --- | --- | --- |
| 99 | 2680 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 4224 | 4563 | 4915 | 5790 | 6742 | 7923 | 9374 |
| 103 | 4333 | 4683 | 5047 | 5953 | 6939 | 8166 | 9675 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-6: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 3000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 6283 | 6799 | 7336 | 8628 | 10362 | 12453 | 14358 |
| 3 | 5056 | 5514 | 6117 | 6885 | 9023 | 9332 | --- |
| 4 | 3557 | 3979 | 4405 | 5100 | 6120 | 7213 | 9099 |
| 5 | 5126 | 5540 | 5971 | 7003 | 8385 | 10044 | 11549 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 4402 | 5020 | 5583 | 6592 | 8037 | 9636 | 10833 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 3637 | 4110 | 4613 | 5426 | 6007 | --- | --- |
| 12 | 4205 | 4678 | 5438 | 6541 | 8066 | 9405 | --- |
| 13 | 5189 | 5677 | 6452 | 7563 | 9079 | 10056 | 11438 |
| 14 | 4519 | 4958 | 5658 | 6667 | 8055 | 8955 | 10236 |
| 15 | 3718 | 0 | 0 | --- | --- | --- | --- |
| 16 | 4402 | 5020 | 5583 | 6592 | 8037 | 9636 | 10833 |
| 17 | 5189 | 5677 | 6452 | 7563 | 9079 | 10056 | 11438 |
| 18 | 9489 | 9489 | 11650 | 11650 | 13340 | 13340 | --- |
| 19 | 5638 | 6192 | 6973 | 8237 | 9613 | 11102 | --- |
| 20 | 4513 | 4895 | 5293 | 6168 | 7403 | 8794 | 10428 |
| 21 | 6558 | 7123 | 7673 | 8924 | 10696 | 12688 | 14971 |
| 22 | 6846 | 7293 | 7993 | 8728 | 10304 | 12025 | --- |
| 23 | 6277 | 6665 | 7272 | 7908 | 9171 | 10537 | 12062 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 6363 | 7056 | 7785 | 8666 | --- | --- | --- |
| 26 | 7382 | 8179 | 9344 | 10944 | 12805 | --- | --- |
| 27 | 8377 | 9758 | 11249 | 12713 | --- | --- | --- |
| 28 | 6363 | 7056 | 7785 | 8666 | --- | --- | --- |
| 29 | 7382 | 8179 | 9344 | 10944 | 12805 | --- | --- |
| 30 | 7126 | 8286 | 9429 | 10422 | --- | --- | --- |
| 31 | 4725 | 5422 | 6041 | 7339 | 8980 | --- | --- |
| 32 | 4585 | 4973 | 5390 | 6157 | 7196 | 8409 | 9136 |
| 33 | 3940 | 4272 | 4629 | 5297 | 6211 | 7265 | 7777 |
| 34 | 3939 | 4450 | 5034 | 5657 | 6829 | 8068 | --- |
| 35 | 4545 | 5159 | 5814 | 7125 | --- | --- | --- |
| 36 | 4297 | 4962 | 5573 | 6792 | --- | --- | --- |
| 37 | 5931 | 6782 | 7881 | --- | --- | --- | --- |
| 38 | 4460 | 5464 | --- | --- | --- | --- | --- |
| 39 | 4333 | 5096 | 6274 | --- | --- | --- | --- |
| 40 | 5082 | 6176 | 7311 | --- | --- | --- | --- |
| 41 | 2964 | 3681 | 4372 | --- | --- | --- | --- |
| 42 | 4324 | 4654 | 5473 | 6494 | --- | --- | --- |
| 43 | 5082 | 6176 | 7311 | --- | --- | --- | --- |
| 44 | 2964 | 3681 | 4372 | --- | --- | --- | --- |
| 45 | 4324 | 4654 | 5473 | 6494 | --- | --- | --- |
| 46 | 5108 | 5852 | 6766 | --- | --- | --- | --- |
| 47 | 4473 | 4995 | 5547 | 6129 | --- | --- | --- |
| 48 | 5240 | 6330 | 7528 | --- | --- | --- | --- |
| 49 | 4970 | 5603 | 6375 | 8076 | --- | --- | --- |
| 50 | 5495 | 6245 | 7045 | 8914 | --- | --- | --- |
| 51 | 3561 | 3831 | 4159 | 4807 | 5672 | --- | --- |
| 52 | 3593 | 3871 | 4210 | 4825 | 5716 | 6689 | --- |
| 53 | 3690 | --- | --- | --- | --- | --- | --- |
| 54 | 3586 | --- | --- | --- | --- | --- | --- |
| 55 | 5212 | --- | --- | --- | --- | --- | --- |

TABLE B-6: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 3000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 3985 | --- | --- | --- | --- | --- | --- |
| 58 | 4633 | --- | --- | --- | --- | --- | --- |
| 59 | 5234 | --- | --- | --- | --- | --- | --- |
| 60 | 3779 | --- | --- | --- | --- | --- | --- |
| 61 | 6550 | --- | --- | --- | --- | --- | --- |
| 62 | 5243 | --- | --- | --- | --- | --- | --- |
| 63 | 3635 | 4580 | 6181 | --- | --- | --- | --- |
| 64 | 2356 | --- | --- | --- | --- | --- | --- |
| 65 | 1632 | --- | --- | --- | --- | --- | --- |
| 66 | 5203 | 6633 | 7930 | --- | --- | --- | --- |
| 67 | 3556 | --- | --- | --- | --- | --- | --- |
| 68 | 3450 | --- | --- | --- | --- | --- | --- |
| 69 | 1670 | --- | --- | --- | --- | --- | --- |
| 70 | 4289 | 5663 | 7273 | --- | --- | --- | --- |
| 71 | 2049 | 2502 | 0 | --- | --- | --- | --- |
| 72 | 2415 | 3143 | --- | --- | --- | --- | --- |
| 73 | 2807 | --- | --- | --- | --- | --- | --- |
| 74 | 851 | --- | --- | --- | --- | --- | --- |
| 75 | 995 | --- | --- | --- | --- | --- | --- |
| 76 | 2136 | --- | --- | --- | --- | --- | --- |
| 77 | 943 | --- | --- | --- | --- | --- | --- |
| 78 | 14702 | --- | --- | --- | --- | --- | --- |
| 79 | 5566 | 8681 | --- | --- | --- | --- | --- |
| 80 | 6915 | 9469 | --- | --- | --- | --- | --- |
| 81 | 6073 | 9074 | --- | --- | --- | --- | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 82 | 6902 | 10313 | --- | --- | --- | --- | --- |
| 83 | 5067 | 5638 | 6118 | 7142 | 8540 | 10559 | 12269 |
| 84 | 5511 | 5965 | 6417 | 7540 | 9049 | 10853 | 12519 |
| 85 | 4921 | 5721 | 6363 | 7758 | --- | --- | --- |
| 86 | 4626 | 5344 | 6003 | 7320 | --- | --- | --- |
| 87 | 3785 | 4103 | 4449 | 5096 | 5979 | 7002 | 7497 |
| 88 | 4062 | 0 | 0 | --- | --- | --- | --- |
| 89 | 4315 | 5299 | 6249 | --- | --- | --- | --- |
| 90 | 4380 | 5351 | 6427 | --- | --- | --- | --- |
| 91 | 15127 | --- | --- | --- | --- | --- | --- |
| 92 | 12506 | --- | --- | --- | --- | --- | --- |
| 93 | 4402 | 4880 | 5579 | 6540 | 7659 | --- | --- |
| 94 | 4153 | 4605 | 5081 | 5656 | --- | --- | --- |
| 95 | 3999 | --- | --- | --- | --- | --- | --- |
| 96 | 5756 | --- | --- | --- | --- | --- | --- |
| 97 | 5134 | 6109 | 7276 | 8442 | --- | --- | --- |
| 98 | 5536 | --- | --- | --- | --- | --- | --- |
| 99 | 3183 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 5970 | 6451 | 6952 | 8200 | 9557 | 11245 | 13320 |
| 103 | 6372 | 6892 | 7433 | 8782 | 10254 | 12089 | 14351 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-7: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 6000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 7231 | 7823 | 8441 | 9925 | 11917 | 14319 | 16507 |
| 3 | 5819 | 6346 | 7039 | 7922 | 10380 | 10735 | --- |
| 4 | 4096 | 4581 | 5072 | 5870 | 7043 | 8300 | 10467 |
| 5 | 5763 | 6227 | 6711 | 7870 | 9419 | 11279 | 12966 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 4949 | 5642 | 6274 | 7406 | 9027 | 10818 | 12160 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 4142 | 4680 | 5252 | 6176 | 6837 | --- | --- |
| 12 | 4961 | 5520 | 6416 | 7717 | 9518 | 11098 | --- |
| 13 | 6117 | 6692 | 7605 | 8915 | 10702 | 11854 | 13484 |
| 14 | 5128 | 5625 | 6418 | 7561 | 9132 | 10151 | 11600 |
| 15 | 0 | 0 | 0 | --- | --- | --- | --- |
| 16 | 4949 | 5642 | 6274 | 7406 | 9027 | 10818 | 12160 |
| 17 | 6117 | 6692 | 7605 | 8915 | 10702 | 11854 | 13484 |
| 18 | 10886 | 10886 | 13362 | 13362 | 15298 | 15298 | --- |
| 19 | 6694 | 7351 | 8279 | 9780 | 11415 | 13185 | --- |
| 20 | 5095 | 5525 | 5974 | 6961 | 8352 | 9918 | 11758 |
| 21 | 7753 | 8422 | 9072 | 10550 | 12646 | 15002 | 17702 |
| 22 | 7807 | 8316 | 9112 | 9948 | 11741 | 13698 | --- |
| 23 | 7189 | 7634 | 8328 | 9054 | 10499 | 12061 | 13803 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 7483 | 8298 | 9156 | 10191 | --- | --- | --- |
| 26 | 8729 | 9671 | 11049 | 12942 | 15142 | --- | --- |
| 27 | 9952 | 11592 | 13365 | 15105 | --- | --- | --- |
| 28 | 7483 | 8298 | 9156 | 10191 | --- | --- | --- |
| 29 | 8729 | 9671 | 11049 | 12942 | 15142 | --- | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 30 | 8423 | 9795 | 11146 | 12320 | --- | --- | --- |
| 31 | 5605 | 6432 | 7167 | 8708 | 10655 | --- | --- |
| 32 | 5191 | 5629 | 6101 | 6967 | 8140 | 9510 | 10331 |
| 33 | 4347 | 4712 | 5105 | 5840 | 6845 | 8004 | 8566 |
| 34 | 4329 | 4889 | 5529 | 6211 | 7493 | 8848 | --- |
| 35 | 4985 | 5656 | 6372 | 7804 | --- | --- | --- |
| 36 | 4868 | 5620 | 6311 | 7689 | --- | --- | --- |
| 37 | 7016 | 8023 | 9323 | --- | --- | --- | --- |
| 38 | 5089 | 6235 | --- | --- | --- | --- | --- |
| 39 | 4966 | 5840 | 7188 | --- | --- | --- | --- |
| 40 | 5983 | 7270 | 8607 | --- | --- | --- | --- |
| 41 | 3481 | 4323 | 5135 | --- | --- | --- | --- |
| 42 | 5121 | 5512 | 6483 | 7692 | --- | --- | --- |
| 43 | 5983 | 7270 | 8607 | --- | --- | --- | --- |
| 44 | 3481 | 4323 | 5135 | --- | --- | --- | --- |
| 45 | 5121 | 5512 | 6483 | 7692 | --- | --- | --- |
| 46 | 6011 | 6887 | 7962 | --- | --- | --- | --- |
| 47 | 5288 | 5905 | 6557 | 7245 | --- | --- | --- |
| 48 | 5939 | 7173 | 8529 | --- | --- | --- | --- |
| 49 | 5650 | 6368 | 7245 | 9176 | --- | --- | --- |
| 50 | 6354 | 7220 | 8145 | 10305 | --- | --- | --- |
| 51 | 4040 | 4346 | 4718 | 5451 | 6431 | --- | --- |
| 52 | 3970 | 4276 | 4649 | 5327 | 6308 | 7378 | --- |
| 53 | 4103 | --- | --- | --- | --- | --- | --- |
| 54 | 4172 | --- | --- | --- | --- | --- | --- |
| 55 | 6104 | --- | --- | --- | --- | --- | --- |

TABLE B-7: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 59°F , ELEVATION 6000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 4399 | --- | --- | --- | --- | --- | --- |
| 58 | 5180 | --- | --- | --- | --- | --- | --- |
| 59 | 6192 | --- | --- | --- | --- | --- | --- |
| 60 | 4168 | --- | --- | --- | --- | --- | --- |
| 61 | 7322 | --- | --- | --- | --- | --- | --- |
| 62 | 6054 | --- | --- | --- | --- | --- | --- |
| 63 | 3960 | 4989 | 6733 | --- | --- | --- | --- |
| 64 | 2613 | --- | --- | --- | --- | --- | --- |
| 65 | 1778 | --- | --- | --- | --- | --- | --- |
| 66 | 5667 | 7225 | 8639 | --- | --- | --- | --- |
| 67 | 3874 | --- | --- | --- | --- | --- | --- |
| 68 | 3758 | --- | --- | --- | --- | --- | --- |
| 69 | 1820 | --- | --- | --- | --- | --- | --- |
| 70 | 4672 | 6169 | 7923 | --- | --- | --- | --- |
| 71 | 2232 | 2726 | 0 | --- | --- | --- | --- |
| 72 | 2631 | 3424 | --- | --- | --- | --- | --- |
| 73 | 3057 | --- | --- | --- | --- | --- | --- |
| 74 | 928 | --- | --- | --- | --- | --- | --- |
| 75 | 1084 | --- | --- | --- | --- | --- | --- |
| 76 | 2327 | --- | --- | --- | --- | --- | --- |
| 77 | 1027 | --- | --- | --- | --- | --- | --- |
| 78 | 17276 | --- | --- | --- | --- | --- | --- |
| 79 | 6260 | 9762 | --- | --- | --- | --- | --- |
| 80 | 7779 | 10648 | --- | --- | --- | --- | --- |
| 81 | 6616 | 9885 | --- | --- | --- | --- | --- |
| 82 | 7519 | 11234 | --- | --- | --- | --- | --- |
| 83 | 5744 | 6391 | 6934 | 8092 | 9673 | 11956 | 13889 |
| 84 | 6267 | 6783 | 7296 | 8571 | 10283 | 12329 | 14218 |
| 85 | 5582 | 6488 | 7215 | 8794 | --- | --- | --- |
| 86 | 5073 | 5858 | 6578 | 8016 | --- | --- | --- |
| 87 | 4381 | 4749 | 5148 | 5897 | 6918 | 8101 | 8674 |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 88 | 0 | 0 | 0 | --- | --- | --- | --- |
| 89 | 4739 | 5815 | 6854 | --- | --- | --- | --- |
| 90 | 5068 | 6190 | 7434 | --- | --- | --- | --- |
| 91 | 17102 | --- | --- | --- | --- | --- | --- |
| 92 | 14072 | --- | --- | --- | --- | --- | --- |
| 93 | 5034 | 5580 | 6378 | 7475 | 8753 | --- | --- |
| 94 | 4833 | 5359 | 5913 | 6582 | --- | --- | --- |
| 95 | 4448 | --- | --- | --- | --- | --- | --- |
| 96 | 6659 | --- | --- | --- | --- | --- | --- |
| 97 | 6095 | 7253 | 8639 | 10023 | --- | --- | --- |
| 98 | 6323 | --- | --- | --- | --- | --- | --- |
| 99 | 3528 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 6256 | 6758 | 7281 | 8581 | 9994 | 11750 | 13906 |
| 103 | 6435 | 6955 | 7498 | 8848 | 10319 | 12149 | 14402 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-8: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 6000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 6652 | 7197 | 7766 | 9131 | 10964 | 13173 | 15186 |
| 3 | 5354 | 5838 | 6476 | 7288 | 9549 | 9876 | --- |
| 4 | 3768 | 4215 | 4666 | 5400 | 6479 | 7636 | 9630 |
| 5 | 5302 | 5729 | 6174 | 7240 | 8665 | 10376 | 11928 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 4553 | 5190 | 5772 | 6813 | 8304 | 9952 | 11187 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 3811 | 4305 | 4832 | 5682 | 6290 | --- | --- |
| 12 | 4564 | 5078 | 5902 | 7100 | 8756 | 10210 | --- |
| 13 | 5627 | 6157 | 6997 | 8202 | 9846 | 10906 | 12405 |
| 14 | 4718 | 5175 | 5904 | 6956 | 8401 | 9338 | 10671 |
| 15 | 0 | 0 | 0 | --- | --- | --- | --- |
| 16 | 4553 | 5190 | 5772 | 6813 | 8304 | 9952 | 11187 |
| 17 | 5627 | 6157 | 6997 | 8202 | 9846 | 10906 | 12405 |
| 18 | 10014 | 10014 | 12293 | 12293 | 14074 | 14074 | --- |
| 19 | 6158 | 6763 | 7616 | 8997 | 10501 | 12129 | --- |
| 20 | 4687 | 5083 | 5496 | 6404 | 7684 | 9124 | 10817 |
| 21 | 7132 | 7748 | 8346 | 9706 | 11634 | 13801 | 16285 |
| 22 | 7182 | 7650 | 8383 | 9152 | 10801 | 12602 | --- |
| 23 | 6614 | 7023 | 7661 | 8330 | 9659 | 11096 | 12698 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 6885 | 7634 | 8423 | 9376 | --- | --- | --- |
| 26 | 8030 | 8898 | 10165 | 11906 | 13930 | --- | --- |
| 27 | 9155 | 10665 | 12295 | 13896 | --- | --- | --- |
| 28 | 6885 | 7634 | 8423 | 9376 | --- | --- | --- |
| 29 | 8030 | 8898 | 10165 | 11906 | 13930 | --- | --- |
| 30 | 7749 | 9011 | 10254 | 11334 | --- | --- | --- |
| 31 | 5157 | 5917 | 6594 | 8011 | 9803 | --- | --- |
| 32 | 4775 | 5178 | 5613 | 6409 | 7489 | 8749 | 9504 |
| 33 | 3999 | 4335 | 4697 | 5373 | 6297 | 7364 | 7881 |
| 34 | 3982 | 4497 | 5086 | 5714 | 6894 | 8140 | --- |
| 35 | 4586 | 5203 | 5862 | 7179 | --- | --- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 36 | 4472 | 5163 | 5798 | 7064 | --- | --- | --- |
| 37 | 6455 | 7381 | 8577 | --- | --- | --- | --- |
| 38 | 4682 | 5736 | --- | --- | --- | --- | --- |
| 39 | 4569 | 5373 | 6613 | --- | --- | --- | --- |
| 40 | 5504 | 6689 | 7918 | --- | --- | --- | --- |
| 41 | 3202 | 3977 | 4724 | --- | --- | --- | --- |
| 42 | 4712 | 5071 | 5964 | 7077 | --- | --- | --- |
| 43 | 5504 | 6689 | 7918 | --- | --- | --- | --- |
| 44 | 3202 | 3977 | 4724 | --- | --- | --- | --- |
| 45 | 4712 | 5071 | 5964 | 7077 | --- | --- | --- |
| 46 | 5530 | 6336 | 7325 | --- | --- | --- | --- |
| 47 | 4864 | 5432 | 6032 | 6665 | --- | --- | --- |
| 48 | 5464 | 6599 | 7846 | --- | --- | --- | --- |
| 49 | 5198 | 5859 | 6665 | 8442 | --- | --- | --- |
| 50 | 5845 | 6643 | 7493 | 9480 | --- | --- | --- |
| 51 | 3717 | 3998 | 4340 | 5015 | 5917 | --- | --- |
| 52 | 3651 | 3933 | 4276 | 4900 | 5802 | 6786 | --- |
| 53 | 3775 | --- | --- | --- | --- | --- | --- |
| 54 | 3838 | --- | --- | --- | --- | --- | --- |
| 55 | 5616 | --- | --- | --- | --- | --- | --- |

TABLE B-8: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 40°F , ELEVATION 6000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 4047 | --- | --- | --- | --- | --- | --- |
| 58 | 4766 | --- | --- | --- | --- | --- | --- |
| 59 | 5697 | --- | --- | --- | --- | --- | --- |
| 60 | 3834 | --- | --- | --- | --- | --- | --- |
| 61 | 6736 | --- | --- | --- | --- | --- | --- |
| 62 | 5569 | --- | --- | --- | --- | --- | --- |
| 63 | 3576 | 4505 | 6080 | --- | --- | --- | --- |
| 64 | 2404 | --- | --- | --- | --- | --- | --- |
| 65 | 1606 | --- | --- | --- | --- | --- | --- |
| 66 | 5117 | 6524 | 7800 | --- | --- | --- | --- |
| 67 | 3498 | --- | --- | --- | --- | --- | --- |
| 68 | 3394 | --- | --- | --- | --- | --- | --- |
| 69 | 1643 | --- | --- | --- | --- | --- | --- |
| 70 | 4218 | 5571 | 7154 | --- | --- | --- | --- |
| 71 | 2015 | 2461 | 0 | --- | --- | --- | --- |
| 72 | 2376 | 3092 | --- | --- | --- | --- | --- |
| 73 | 2761 | --- | --- | --- | --- | --- | --- |
| 74 | 838 | --- | --- | --- | --- | --- | --- |
| 75 | 979 | --- | --- | --- | --- | --- | --- |
| 76 | 2101 | --- | --- | --- | --- | --- | --- |
| 77 | 927 | --- | --- | --- | --- | --- | --- |
| 78 | 15893 | --- | --- | --- | --- | --- | --- |
| 79 | 5759 | 8981 | --- | --- | --- | --- | --- |
| 80 | 7156 | 9796 | --- | --- | --- | --- | --- |
| 81 | 5974 | 8926 | --- | --- | --- | --- | --- |
| 82 | 6789 | 10144 | --- | --- | --- | --- | --- |
| 83 | 5285 | 5879 | 6379 | 7444 | 8899 | 10999 | 12777 |
| 84 | 5766 | 6240 | 6712 | 7885 | 9460 | 11342 | 13080 |
| 85 | 5135 | 5969 | 6638 | 8090 | --- | --- | --- |
| 86 | 4667 | 5389 | 6052 | 7374 | --- | --- | --- |
| 87 | 4030 | 4369 | 4736 | 5425 | 6364 | 7453 | 7980 |
| 88 | 0 | 0 | 0 | --- | --- | --- | --- |
| 89 | 4360 | 5349 | 6305 | --- | --- | --- | --- |
| 90 | 4662 | 5695 | 6840 | --- | --- | --- | --- |
| 91 | 15711 | --- | --- | --- | --- | --- | --- |
| 92 | 12946 | --- | --- | --- | --- | --- | --- |
| 93 | 4631 | 5133 | 5868 | 6877 | 8052 | --- | --- |

| INM # | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 94 | 4446 | 4930 | 5440 | 6055 | --- | --- | --- |
| 95 | 4092 | --- | --- | --- | --- | --- | --- |
| 96 | 6126 | --- | --- | --- | --- | --- | --- |
| 97 | 5607 | 6673 | 7948 | 9221 | --- | --- | --- |
| 98 | 5817 | --- | --- | --- | --- | --- | --- |
| 99 | 3245 | --- | --- | --- | --- | --- | --- |
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 5327 | 5754 | 6198 | 7301 | 8499 | 9988 | 11815 |
| 103 | 5395 | 5830 | 6283 | 7410 | 8636 | 10160 | 12035 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

TABLE B-9: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 6000 FT MSL

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 4358 | 4732 | 5223 | 5842 | 7545 | 7788 | --- |
| 2 | 7902 | 8549 | 9224 | 10846 | 13023 | 15647 | 18038 |
| 3 | 6359 | 6935 | 7692 | 8657 | 11342 | 11730 | --- |
| 4 | 4476 | 5006 | 5542 | 6415 | 7696 | 9070 | 11438 |
| 5 | 6297 | 6805 | 7334 | 8600 | 10293 | 12325 | 14168 |
| 6 | 4193 | 4671 | 5438 | 6551 | 8098 | 9433 | --- |
| 7 | 3963 | 4429 | 5176 | 6263 | 7767 | 8547 | --- |
| 8 | 2721 | 3109 | 3523 | 4193 | 4671 | --- | --- |
| 9 | 5408 | 6165 | 6856 | 8093 | 9864 | 11822 | 13288 |
| 10 | 2799 | 3128 | 3656 | 4424 | 5486 | 6037 | --- |
| 11 | 4526 | 5114 | 5739 | 6749 | 7471 | --- | --- |
| 12 | 5421 | 6032 | 7011 | 8433 | 10401 | 12127 | --- |
| 13 | 6684 | 7313 | 8311 | 9742 | 11695 | 12954 | 14735 |
| 14 | 5604 | 6147 | 7013 | 8262 | 9979 | 11092 | 12676 |
| 15 | 0 | 0 | 0 | --- | --- | --- | --- |
| 16 | 5408 | 6165 | 6856 | 8093 | 9864 | 11822 | 13288 |
| 17 | 6684 | 7313 | 8311 | 9742 | 11695 | 12954 | 14735 |
| 18 | 11895 | 11895 | 14601 | 14601 | 0 | 0 | --- |
| 19 | 7315 | 8033 | 9047 | 10687 | 12474 | 14408 | --- |
| 20 | 5567 | 6038 | 6529 | 7607 | 9127 | 10838 | 12849 |
| 21 | 8472 | 9203 | 9913 | 11529 | 13819 | 16393 | 19344 |
| 22 | 8531 | 9087 | 9957 | 10871 | 12830 | 14969 | --- |
| 23 | 7856 | 8342 | 9100 | 9894 | 11473 | 13179 | 15083 |
| 24 | 5968 | 6863 | 7821 | 8841 | --- | --- | --- |
| 25 | 8178 | 9068 | 10005 | 11137 | --- | --- | --- |
| 26 | 9539 | 10569 | 12074 | 14142 | 16547 | --- | --- |
| 27 | 10875 | 12668 | 14604 | 16506 | --- | --- | --- |
| 28 | 8178 | 9068 | 10005 | 11137 | --- | --- | --- |
| 29 | 9539 | 10569 | 12074 | 14142 | 16547 | --- | --- |
| 30 | 9204 | 10703 | 12180 | 13463 | --- | --- | --- |
| 31 | 6125 | 7029 | 7832 | 9516 | 11644 | --- | --- |
| 32 | 5672 | 6151 | 6667 | 7613 | 8895 | 10392 | 11289 |
| 33 | 4750 | 5149 | 5579 | 6382 | 7480 | 8747 | 9361 |
| 34 | 4730 | 5342 | 6042 | 6787 | 8188 | 9669 | --- |
| 35 | 5447 | 6180 | 6963 | 8528 | --- | --- | --- |
| 36 | 5327 | 6151 | 6907 | 8415 | --- | --- | --- |
| 37 | 7667 | 8767 | 10188 | --- | --- | --- | --- |
| 38 | 5562 | 6813 | --- | --- | --- | --- | --- |
| 39 | 5427 | 6382 | 7855 | --- | --- | --- | --- |
| 40 | 6538 | 7945 | 9405 | --- | --- | --- | --- |
| 41 | 3804 | 4724 | 5611 | --- | --- | --- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 42 | 5596 | 6024 | 7084 | 8406 | --- | --- | --- |
| 43 | 6538 | 7945 | 9405 | --- | --- | --- | --- |
| 44 | 3804 | 4724 | 5611 | --- | --- | --- | --- |
| 45 | 5596 | 6024 | 7084 | 8406 | --- | --- | --- |
| 46 | 6569 | 7526 | 8701 | --- | --- | --- | --- |
| 47 | 5778 | 6452 | 7165 | 7917 | --- | --- | --- |
| 48 | 6490 | 7838 | 9320 | --- | --- | --- | --- |
| 49 | 6174 | 6959 | 7917 | 10027 | --- | --- | --- |
| 50 | 6943 | 7890 | 8901 | 11261 | --- | --- | --- |
| 51 | 4415 | 4749 | 5156 | 5957 | 7028 | --- | --- |
| 52 | 4339 | 4674 | 5082 | 5823 | 6895 | 8065 | --- |
| 53 | 4484 | --- | --- | --- | --- | --- | --- |
| 54 | 4559 | --- | --- | --- | --- | --- | --- |
| 55 | 6670 | --- | --- | --- | --- | --- | --- |

TABLE B-9: RUNWAY REQUIREMENTS/OPERATIONAL BOUNDARIES OF THE PROFILE GENERATOR, TEMPERATURE 80°F , ELEVATION 6000 FT MSL (CONTINUED)

| INM # | STAGE WEIGHT | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 56 | 4136 | --- | --- | --- | --- | --- | --- |
| 57 | 4807 | --- | --- | --- | --- | --- | --- |
| 58 | 5661 | --- | --- | --- | --- | --- | --- |
| 59 | 6766 | --- | --- | --- | --- | --- | --- |
| 60 | 4555 | --- | --- | --- | --- | --- | --- |
| 61 | 8001 | --- | --- | --- | --- | --- | --- |
| 62 | 6615 | --- | --- | --- | --- | --- | --- |
| 63 | 4414 | 5561 | 7505 | --- | --- | --- | --- |
| 64 | 2855 | --- | --- | --- | --- | --- | --- |
| 65 | 1982 | --- | --- | --- | --- | --- | --- |
| 66 | 6317 | 8054 | 9629 | --- | --- | --- | --- |
| 67 | 4318 | --- | --- | --- | --- | --- | --- |
| 68 | 4189 | --- | --- | --- | --- | --- | --- |
| 69 | 2028 | --- | --- | --- | --- | --- | --- |
| 70 | 5207 | 6876 | 8831 | --- | --- | --- | --- |
| 71 | 2487 | 3038 | 0 | --- | --- | --- | --- |
| 72 | 2933 | 3817 | --- | --- | --- | --- | --- |
| 73 | 3408 | --- | --- | --- | --- | --- | --- |
| 74 | 1034 | --- | --- | --- | --- | --- | --- |
| 75 | 1208 | --- | --- | --- | --- | --- | --- |
| 76 | 2593 | --- | --- | --- | --- | --- | --- |
| 77 | 1145 | --- | --- | --- | --- | --- | --- |
| 78 | 18878 | --- | --- | --- | --- | --- | --- |
| 79 | 6840 | 10668 | --- | --- | --- | --- | --- |
| 80 | 8500 | 11636 | --- | --- | --- | --- | --- |
| 81 | 7374 | 11018 | --- | --- | --- | --- | --- |
| 82 | 8381 | 0 | --- | --- | --- | --- | --- |
| 83 | 6277 | 6983 | 7577 | 8842 | 10570 | 13065 | 15177 |
| 84 | 6848 | 7412 | 7973 | 9366 | 11237 | 13473 | 15537 |
| 85 | 6100 | 7090 | 7884 | 9609 | --- | --- | --- |
| 86 | 5544 | 6401 | 7188 | 8759 | --- | --- | --- |
| 87 | 4787 | 5190 | 5626 | 6444 | 7559 | 8853 | 9478 |
| 88 | 0 | 0 | 0 | --- | --- | --- | --- |
| 89 | 5178 | 6354 | 7489 | --- | --- | --- | --- |
| 90 | 5538 | 6764 | 8124 | --- | --- | --- | --- |
| 91 | 18717 | --- | --- | --- | --- | --- | --- |
| 92 | 15377 | --- | --- | --- | --- | --- | --- |
| 93 | 5501 | 6097 | 6970 | 8169 | 9565 | --- | --- |
| 94 | 5281 | 5856 | 6462 | 7193 | --- | --- | --- |
| 95 | 4860 | --- | --- | --- | --- | --- | --- |
| 96 | 7277 | --- | --- | --- | --- | --- | --- |
| 97 | 6660 | 7926 | 9440 | 10953 | --- | --- | --- |
| 98 | 6909 | --- | --- | --- | --- | --- | --- |
| 99 | 3855 | --- | --- | --- | --- | --- | --- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 100 | 4513 | 5004 | 5522 | 6146 | --- | --- | --- |
| 101 | 5460 | 6050 | 6913 | 8098 | 9476 | --- | --- |
| 102 | 7503 | 8107 | 8737 | 10302 | 12006 | 14124 | 16729 |
| 103 | 7878 | 8519 | 9187 | 10851 | 12665 | 14926 | 17713 |
| 104 | 3000 | --- | --- | --- | --- | --- | --- |
| 105 | 3000 | --- | --- | --- | --- | --- | --- |
| 106 | 3000 | --- | --- | --- | --- | --- | --- |
| 107 | 3000 | --- | --- | --- | --- | --- | --- |

# APPENDIX C

## AIRPLANE RUNUP OPERATIONS

This Appendix discusses the adaptation of an existing INM equation for use in computing runup noise within INM Version 4.11. This equation, also used in the Time-Above-Threshold (TA) equation, can be used to approximate the maximum A-weighted sound level ($L_{AMAX}$) and the maximum tone-corrected perceived noise level ($PNLT_{MAX}$) for a one-second time period as follows:

$$L_{AMAX} = SEL - 10\log_{10}[((500B)/(V))(.001R_0)^{(k)}] \text{ and} \quad (1)$$

$$PNLT_{MAX} = EPNL - 10\log_{10}[((500B)/(V))(.001R_0)^{(k)}] + 10, \quad (2)$$

where SEL = the Sound Exposure Level from the Noise-Power-Distance data base (dBA);

EPNL = the Effective Perceived Noise Level from the Noise-Power-Distance data base (dB);

V = the airplane velocity (ft/sec);

$R_0$ = the closest point of approach from airplane to receiver (ft);

k = a constant exponent with a fixed value of 0.6 in the INM; and for Equation (2),

10 = a duration correction as discussed in Section 2.3, Equation (2).

The above equations assume: (1) an approximate shape of an airplane's sound level time history; and (2) symmetry in the time history trace around the $L_{AMAX}$ or $PNLT_{MAX}$, as appropriate. The $L_{AMAX}/PNLT_{MAX}$ values computed with these equations were verified using measured $L_{AMAX}/PNLT_{MAX}$ data in the literature.[1]

Given the computed $L_{AMAX}/PNLT_{MAX}$ and the user-defined duration and location for a runup, the SEL/EPNL for the runup is computed by multiplying the acoustic energy associated with the $L_{AMAX}/PNLT_{MAX}$ by the user-defined duration, and converting the total runup energy to a decibel value as follows:

$$SEL_{RUNUP} = 10\log_{10}[(DUR)10\exp(L_{AMAX}/10)] \text{ and} \quad (3)$$

$$EPNL_{RUNUP} = 10\log_{10}[(DUR)10\exp(PNLT_{MAX}/10)], \quad (4)$$

where

$SEL_{RUNUP}$ = the Sound Exposure Level for the runup (dBA);

$EPNL_{RUNUP}$ = the Effective Perceived Noise Level for the runup (dB);

DUR = the user-defined duration of the runup (seconds);

$L_{AMAX}$ = the maximum A-weighted sound level computed, using Equation (1);

and $PNLT_{MAX}$ = the maximum tone-corrected perceived noise level computed, using Equation (2).

The $SEL_{RUNUP}$ value from Equation (3) is then used to compute the noise exposure due to runup operations for all INM noise metrics, except NEF and WECPNL. The noise exposure due to runup operations for NEF and WECPNL are computed using the $EPNL_{RUNUP}$ value from Equation (4).

## C.1 Verification

The runup enhancement within INM Version 4.11 was verified using measured runup noise level data for the A320 airplane with the newer CFM56-5-A1 engine, and the B747 airplane with the older JT9D-7A engine.[2,3] The measured data for the A320 agree extremely well with INM-predicted data, i.e., ± 3 dB with a mean difference of .6 dB and a standard deviation of 2.2 dB, for receivers located at angles of 0, 45, 90, 120, 135, and 180 degrees relative to the nose of the airplane. Note: At 180 degrees, the data used for comparison with the predicted levels were obtained by linear extrapolation of measured data. The agreement between measured and predicted data at the above six receiver locations was essentially independent of thrust for thrusts of 78, 86, and 90 percent N1. At the 150 degree location, the agreement was only modest. INM Version 4.11 overstated the noise by approximately 6 dB at thrust levels of 86 and 90 percent N1, and by almost 12 dB at 78 percent N1. Similar results were observed for the B747 airplane at all receiver locations.

The agreement between measured and predicted runup noise levels could be improved if the INM maintained a detailed data base of measured runup directivity patterns for all airplanes as a function of distance and thrust. In lieu of developing such a substantial and potentially costly data base, the simplified directivity pattern discussed in Appendix A is a reasonable approximation of runup directivity.

## C.2 References

[1] Bishop, D.E., Beckman, J.M., Bucka, M.P., Revision of Civil Aircraft Noise Data for the Integrated Noise Model (INM), Report No. 6039, Project No. 04453, Canoga Park, CA: BBN Laboratories Incorporated, September 1986.

[2] A320 Noise Definition Manual NDM, FRANCE: Airbus Industrie, 1990.

[3] An Excerpt from the Model B747 Flight Manual, A-Weighted Noise Level Contours, Seattle, WA: Boeing Commercial Airplane Company, 1986.

# APPENDIX D

## INM INPUT TESTCASE

This Appendix presents a copy of the INM Input Testcase, revised to reflect several INM Version 4.11 enhancements. The revised Testcase includes an airplane runup definition, and an approach runway threshold definition. The entry related to data base selection, contained in the PROCESS section of previous versions of the Input Testcase, has been deleted; the ACDB11.EXE computer program, included with the INM Version 4.11 release, should be used to access/print all elements of Data Base Number 11. The Input Testcase contained herein is included with the Version 4.11 release.

```
BEGIN.

SETUP:

  TITLE <ANNUAL AVERAGE EXPOSURE AT AN EXAMPLE OF A MEDIUM HUB AIRPORT>
  AIRPORT <EXAMPLE MHA>

  ALTITUDE 0
  TEMPERATURE 59 F

  RUNWAYS
    RW 09L-27R      0       0        TO  9487    -497   HEADING=93
    RW 27L-09R   4203   -1410        TO -6920   -1044   HEADING=272
    RW  35-17    7355    1366 DT 100 TO  6407    6742

AIRCRAFT:

  TYPES
    AC 747200
    AC DC1030
    AC DC870
    AC A300
    AC 757PW
    AC 727Q15
    AC DC930
    AC MD81
    AC 737300
    AC SABR80
    AC BEC58P
    AC S-76   CURVE=250C30 PARAM=HELI STAGE 1=HORFLT
              CATEGORY=PGA

NOISE CURVES

  NC 250C30          3 BY 8  3 BY 8
  EPNL
  THRUSTS     1          2         3
      200   90.2      91.2      97.2
      400   85.8      87.2      93.1
      600   83.1      84.5      90.6
     1000   79.4      80.7      87.4
     2000   73.7      75.1      82.6
     4000   67.6      68.2      77.2
     6000   63.1      63.8      73.7
    10000   56.8      57.4      68.7
  SEL
  THRUSTS     1          2         3
      200   88.6      90.0      95.6
      400   84.2      85.6      91.5
      600   81.5      82.9      89.0
     1000   77.8      79.1      85.8
     2000   72.1      73.5      81.0
     4000   66.0      66.6      75.6
     6000   61.5      62.2      72.1
    10000   55.2      55.8      67.1

APPROACH PARAMETERS

  AP HELI   WEIGHT=10000 ENGINE=2 STOP=1
            FINSP=160 TAXI=160
            LNDFFS=3

INT.NM.

PROFILES APPROACH

  PF ALT3D SEGMENTS=7
     DISTANCES    20.   10.      5.     3.     1. -.164 STOP
     ALTITUDES   6000  3236    1644   1007   370     0    0
     SPEEDS    TERMSP  INTSP  APPSP  FINSP LNDSP REVSP TAXI
     THRUSTS   INTFIS APPFAS LNDFFS LNDFLS   REV  IDLE

  PF COPTR SEGMENTS=7
     DISTANCES    3.9    3.1    2.4    1.6    0.8      0    0
     ALTITUDES   2500   2000   1500   1000    500      0    0
     SPEEDS     FINSP  FINSP  FINSP  FINSP  FINSP  FINSP TAXI
     THRUSTS   LNDFFS LNDFFS LNDFFS LNDFFS LNDFFS LNDFFS

ECHO.

FT.

  PROFILES TAKEOFF

    PF HORFLT SEGMENTS=8 WEIGHT=10000 ENGINES=2
      DISTANCES      0   1376   4126   6876   6877   9626  10000  15000
      ALTITUDES      0      0    500   1000   1000   1500   1500   1500
      SPEEDS        32    160    160    160    160    160    160    160
      THRUSTS        2      2      2      2      1      1      1
```

**Note: Standard conditions have been defined. To implement the takeoff profile generator see Section 2.1. In addition, the elevation enhancement has not been selected. To implement elevation see Section 2.2.**

**Note: A runway touch-down point of 1054 ft has been defined for approach operations on Runway 35 (i.e., 100 ft for the user-defined DT plus 954 ft for the fixed touch-down point).**

```
INT.NM.

TAKEOFFS BY FREQUENCY:
```

**<u>COMMENTS</u>**:

```
  TRACK TR1 RWY 09L STRAIGHT 4.1 LEFT 5 H 1.6 STRAIGHT 50
    OPER 747200 RUNUP 1 D=10 STAGE 1 D=1.1 STAGE 2 D=1.1 STAGE 3 D=1.1
    OPER DC1030 STAGE 1 D=1.5 STAGE 2 D=2.5 STAGE 4 D=2
    OPER 757PW  STAGE 2 D=1.5
    OPER 727Q15 STAGE 1 D=3 N=.5 STAGE 2 D=2.6 N=.6
                STAGE 3 D=1.2 N=.1
    OPER DC930  STAGE 1 D=26.5 N=.5 STAGE 2 D=8 N=.5
                STAGE 3 D=1.5
    OPER MD81   STAGE 2 D=1.0
    OPER 737300 STAGE 1 D=1.5 N=.5

  TRACK TR2 RWY 27R STRAIGHT 4.1 LEFT 88 D 1.6 STRAIGHT 50
    OPER DC1030 STAGE 1 D=1.5 STAGE 2 D=3 STAGE 3 D=1
                STAGE 4 D=1 STAGE 5 D=.5 STAGE 6 D=.5
    OPER DC870  STAGE 1 D=2 N=.5 STAGE 2 D=3.5 N=1
                STAGE 3 D=1 STAGE 4 D=2.5 STAGE 5 D=1
                STAGE 6 D=.5
    OPER A300   STAGE 2 D=2 STAGE 3 D=1
    OPER 727Q15 STAGE 1 D=6 N=1 STAGE 2 D=4.4 N=1.4 STAGE 3 D=1.8
                        N=.4

  TRACK TR3 RWY 09R STRAIGHT 1.3 LEFT 15 D 1.0 STRAIGHT 1.4
                    RIGHT 57 D 1.8 STRAIGHT .5 RIGHT 50 D 1.6
                    STRAIGHT 50
    OPER DC870  STAGE 1 D=2 N=.5 STAGE 2 D=3.5 N=1 STAGE 3 D=1
                STAGE 4 D=1.5 STAGE 5 D=.5
    OPER 757PW  STAGE 3 D=2.5
    OPER 727Q15 STAGE 1 D=21 N=2.5 STAGE 2 D=16.5 N=4
                STAGE 3 D=8 N=.5
    OPER DC930  STAGE 1 D=26.5 N=.5 STAGE 2 D=8 N=.5 STAGE 3 D=1.5
    OPER MD81   STAGE 1 D= 3 N=.5
    OPER 737300 STAGE 2 D=.5

  TRACK TR4 RWY 27R STRAIGHT 4.1 LEFT 230 H 2.2 STRAIGHT 50
    OPER SABR80 STAGE 1 D=3 N=.1

  TRACK TR5 RWY 35 STRAIGHT 50
    OPER SABR80 STAGE 1 D=30.5 N=2.5
    OPER BEC58P STAGE 1 D=13 N=1

  TRACK TR6 RWY 17 STRAIGHT 50
    OPER SABR80 STAGE 1 D=12.5 N=.5
    OPER BEC58P STAGE 1 D=30 N=3

  TRACK TR7 RWY 17 STRAIGHT 1.5 RIGHT 265 H .25 STRAIGHT 3
                   LEFT 245 H 1.0 STRAIGHT 50
    OPER S-76   STAGE 1 D=5

LANDINGS BY PERCENTAGE:

    OPER 747200 PROF=STD3D D=3 N=0
    OPER DC1030 PROF=STD3D D=22 N=2
    OPER DC870  PROF=ALT3D D=22 N=2
    OPER A300   PROF=STD3D D=2 N=1
    OPER 757PW  PROF=STD3D D=6 N=1
    OPER 727Q15 PROF=ALT3D D=70 N=10
    OPER DC930  PROF=ALT3D D=70 N=4
    OPER MD81   PROF=STD3D D=4 N=.5
    OPER 737300 PROF=STD3D D=1.5 N=.5
    OPER SABR80 PROF=STD3D D=25 N=2
    OPER BEC58P PROF=STD5D D=42 N=5
    OPER S-76   PROF=COPTR D=5

  TRACK TR8 RWY 27R STRAIGHT 50 RIGHT 82 D 1.5 STRAIGHT 4.2
                    PERCENT COM=72 GA=0

  TRACK TR9 RWY 09R HEADING 260 STRAIGHT 50 RIGHT 272 H 1.5
                    STRAIGHT 7 PERCENT COM=28 GA=0

  TRACK TR10 RWY 35 STRAIGHT 50 PERCENT COM=0 GA=30

  TRACK TR11 RWY 17 STRAIGHT 50 PERCENT COM=0 GA=70

TOUCHNGOS BY FREQUENCY:

  TRACK TR14 RWY 17 STRAIGHT 3 LEFT 180 D 2.0 STRAIGHT 6
                    LEFT 180 D 2.0 STRAIGHT 3
    OPER BEC58P STAGE 1 PROF STD5D D=23
```

**COMMENTS**:

**Note: A runup operation has been defined for the B747-200 airplane. The runup takes place at the start of Runway 09L and lasts for 10 seconds, (i.e., in terms of average yearly duration).**

```
PROCESSES:

FT.

NOWARN.
```

```
  GRID NEF LDN TA START=-3000 1500 STEP=1000 700 SIZE=2 BY 3

  GRID LEQ TA DBA=75 START=11000 3000 STEP=0 0 SIZE=1 BY 1 DETAIL

  CONTOUR LDN AT 65 75
          PLOT SIZE=11 8.5 SCALE=8000

END.
```

## APPENDIX E

## WINM USER'S MANUAL

This Appendix contains a copy of the User's Manual for the WINM computer software, an INM Version 4.11 plotting program for use with Microsoft Windows. The WINM software and its User's Manual, contained herein, were prepared by the SysTeam Corporation under contract to the FAA.