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DEFINITION OF TIRE PROPERTIES REQUIRED FOR LANDING SYSTEM ANALYSIS

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DEFINITION OF TIRE PROPERTIES REQUIRED FOR LANDING SYSTEM ANALYSIS

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I. INTRODUCTION

The measurement and interpretation of the mechanical properties of aircraft tires is a time-consuming, costly process due to the fact that such tires normally operate at quite high speeds, under heavy loads, and under transient conditions which are difficult to reproduce in the laboratory. At the present time the only facility capable of reproducing such conditions is the Landing Load Simulator Track at the National Aeronautics and Space Administration Langley Research Center, Hampton, Virginia. While this facility has been used to acquire a number of important measurements on the mechanical properties of aircraft tires, its capacity is limited and such data is being collected slowly.

Additional laboratories in this country which have less realistic facilities for the measurement of aircraft tire mechanical properties include the Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, and Bendix Corporation, Energy Controls Division, South Bend, Indiana. The equipment and test methods used at these locations consist of static test frames and either cylindrical road wheels or low speed flat plank machines. These diffe considerably from the methods available at Langley Research Center.

Over the past twenty years, these three laboratories have been active in the measurement of aircraft tire properties, mostly on the basis of individual project sponsorship. Only Langley Research Center has published their results in widely available form. The quantity of data accumulated has now reached a point where a need exists for it to be collected at one location, where it would be made available to the American aircraft industry as required. Further, the collection of data in one central location would allow comparison of results between different laboratories and would clearly point up those areas where measurements were lacking and where additional work would be useful.

In 1974 the University of Michigan began work on a central data bank which was to collect all available information in one location and make it readily available to airframe, wheel, and tire engineers needing such information. Very early in the development of this data bank it became apparent that, due to the quantity of data and its categorical forms, the most efficient storage method for both present and future needs would be in some form of computerized data retrieval system.

An initial consideration was whether a new computer program should be written specifically for the tire data bank or whether there was available an information management program capable of providing the service required. While many such programs are available, all have different strengths and weaknesses. Two such programs at the University of Michigan are SPIRES AND TAXIR.

SPIRES handles text-type information. By use of keywords, segments of the data base are selected and screened. This is suitable for title searches and for selection from abstracts, books, or papers.

TAXIR handles information that is produced in discrete units. The program retrieves taxonomic data, that is, data selected by category. Since tire data is logically stored as tabular information, the taxonomic system is most appropriate.

At the start of the project, there was no prior knowledge of the amount of data available, the format of such data, or the expected use of such data. Therefore, it was decided that there was no need to create an original or unique computer program for the initial collection of data. Instead, TAXIR was selected because: 1) it would handle the type of data known to be available, 2) it would allow for any amount of data, with additions and corrections during the course of the program, and 3) it would allow for various output formats, from short specific pieces of information to a book of data containing the entire contents of the data bank.

This eventually led to the construction of a computer program, modified from TAXIR, specifically designed to codify, store, and retrieve data on the mechanical properties of aircraft tires.

II. DATA ACQUISITION AND COMPILATION

The acquisition and compilation of the specific contents of the tire data bank was a cooperative venture involving input from aircraft tire manufacturers, airframe manufacturers, private laboratories, and government research agencies. For example, tire manufacturers provided such data as tire dimensions, ply ratings, commercial and military qualifications, tread type, tire load, speed, pressure rating, and weight. Landing gear manufacturers contributed such information as load-deflection curves, center of pressure shifts, and data needed in detailed analysis, such as relaxation lengths, footprint lengths, lateral damping, and pneumatic trail. Langley Research Center provided much data of this type, as well as data on high speed hydroplaning and braking taken from their Landing Load Simulator.

The actual data was obtained from unclassified publications and by permission from private sources. The major references were:

- Tire and Rim Association Yearbook
- B. F. Goodrich Aircraft Tire Engineering Data Manual
- Goodyear Aircraft Tire Manual and Data Book
- Firestone Aircraft Tire Engineering Data and Application Sheets
- Uniroyal Inc. (unpublished data)
- Bendix Aircraft Brake and Strut Division (unpublished data)
- Wright-Patterson Air Force Base (unpublished data)
- NASA Technical Reports and Notes

The nature of the data and some inherent restrictions in the computer program provided logical reasons for dividing the input data into two general categories. The first is labeled "On-Line Data" and refers to data which can be stored as discrete values. The second category is labeled "Tabular" and indicates data which are usually referenced as a unit in the form of tables, charts, and graphs. In the initial stages of data collection, tabular information was stored off-line.

It was decided that data should be collected for all of the quantities listed in Section 5 of the Appendix. This list contains the computer program code name and a brief description of each property.

After data had been collected and compiled for several months, discussions were held with engineering staffs from various companies in the aircraft industry. These included Boeing Airplane Company, Douglas Aircraft Company, North Americal Rockwell, Lockheed California, and Hydro-Aire

Incorporated. The purposes of these meetings were to describe the general content of the data bank to potential users and to solicit their comments and advice as to its optimum structure for industry use.

These discussions gave guidance in several areas. First, some important mechanical properties of aircraft tires had not been included in the initial data collection process. These properties have since been added and some information acquired on them. Second, certain characteristics of aircraft tires important for modern day design had neither been classified nor measured except on very specific project oriented instances. Among these were tire response to obstacles, tire characteristics under off-design conditions, data on retreaded tires, drag force at tire touchdown, and frequency response to cyclic yaw and braking. In addition, interest was found to exist in tire temperatures with particular reference to temperature rise during take-off.

Finally, as these meetings clearly brought out, industry engineers consider that aircraft tire mechanical properties are a vital part of landing gear and airframe design. As such, the lack of broad information severely affected the reliability of the design, and the consensus was that effort in this entire area should be emphasized in order to improve the quantity and type of information available. Specific recommendations from the meetings included:

a. NASA Technical Report R64, which still remains the standard reference work on aircraft tire mechanical properties throughout the industry, should be updated and expanded.

b. There is a need for standard testing techniques for the most widely used aircraft tire mechanical properties.

c. Much of the data on older types of aircraft tires are not of much value. More data on currently used aircraft tires are needed.

Finally, it was concluded from these discussions that industry users prefer a complete book of data in which they could find current information on any specific type of tire. Based on this response, a new version of the University of Michigan data bank was constructed and plans were made for it to be based at NASA Langley Research Center. A complete description of the data management system follows.

III. DATA MANAGEMENT COMPUTER PROGRAM

This section covers the basic processes used by the data management program, TAXIR. In addition, the specializations and improvements for the Langley version are described. The staff at Langley should be consulted for a more detailed explanation of the use of the TAXIR program or information about the programming itself.

The version of TAXIR which will reside at Langley Research Center is still in development. The version of TAXIR which is at the University of Michigan was documented in the Aircraft Tire Mechanical Properties Data Bank Users Manual (October 1975). The information and procedures for using the Langley version are included as an Appendix to this report. In the remainder of this report, "TAXIR" will refer to the general program at the University of Michigan, while "TAXIR(L)" will refer to the specialized program at Langley Research Center.

The data input and output routines of TAXIR(L) will only be used by the Langley staff. Data from users will be screened and entered by trained personnel. The output will be in book form directly usable by individuals in the industry. However, the internal workings of TAXIR should be of general interest so that all potential users will realize the capabilities of the system.

TAXIR is the acronym for TAXonomic Information Retrieval. Taxonomic data is information that appears in categories. The program takes advantage of the categorical nature of the data to store and retrieve the data efficiently. At the same time, the program has the capability of receiving data input or producing printed output that is easily read by the average user.

In the tire data system managed by TAXIR, an "item" is the complete description of a tire by category. A "descriptor" is a category of description for a tire, such as size, load rating, or number of plies. A descriptor "state" is a specific description in a category, such as "56x16", "76000 pounds", or "38 plies".

The TAXIR system requires two computer files, a vocabulary file and a data file. The vocabulary file contains a list of all the names of the "descriptors" with a code number for each, as well as a list of all the names of the "states" with a code number for each. The data file then contains all of the coded "items" in a very compact form.

When data is input to the program, the descriptors and states are compared to the vocabulary lists and a coded item is formed. When the program is requested to print output, the process is reversed and the coded lines are changed to legible output by the insertion of the descriptor names and state names from the vocabulary. Several routines in the program permit the use of words which are not in the vocabulary for input or output. The addition of such routines makes "conversations" with the computer possible, such as the following example:

(User:)	How many of the tires in the data bank have ODMAX, from 45 to 100?
(Computer:)	No. of items in query response: 106 No. of items in data bank: 769 Percentage of response/total data bank: 13.78%

A user can form a TAXIR question which is easy to understand, since it generally uses English words and syntax. The program interprets the question into the required codes. Then the data file is efficiently searched, item by item, for the requested information. The data is subsequently assembled in the required order and decoded for printing. The question can be very specific so that the data in the answer is limited to only a few (or no) tires. The question may be so general that the entire contents of the data bank is printed as a response.

The significance of the compact, coded form of data storage is not just in the reduced file space, but also in the reduced time required to search the file for specific items of information. The computer can locate, retrieve, and arrange data that appears as numeric codes much faster and more efficiently than data that appears as alpha-numeric words or phrases.

The above are some of the general properties of the TAXIR program. The specific capabilities of the system to reside at Langley Research Center are covered below.

The material supplied to Langley is sufficient to duplicate the TAXIR program. In addition, some special new indexing capabilities were also designed specifically for the tire data bank, and the documentation for these features was also supplied. Sections 2, 3, and 4 of the Appendix indicate the use of some of the potential features. A selection from the various potential features was made at Langley for TAXIR(L).

To improve the efficiency of TAXIR(L), some unnecessary capabilities of TAXIR were removed and others were improved. When implemented, therefore, TAXIR(L) will not be a general purpose program like the original TAXIR. Instead, it will have been tailored to the specific needs of the tire data bank.

The following basic modifications were made:

1) The conversational mode was removed, leaving a batch input-output capability.

2) The variable output format was removed, leaving only the book format that the users found to be most convenient.

3) The indexing capabilities were improved, allowing tables, charts, and graphs to be stored online if desired.

As a result of the first two changes, TAXIR(L) will produce a book of information which will be available to all users. With this book, a user can find the answer to a specific data question, thus relieving the Langley computer resources from the need to handle individualized data requests.

The third change removes a potential problem in handling tabular or graphic data. Many pieces of information are best stored, recalled, and presented as a table of numbers or as a figure rather than as individual data points. Such material has not been provided in a standard format for the current data bank. Transforming such information into computer records would necessarily require some approximations and, thus, the accuracy of the original authors, as well as their notes, would be lost to the computer data bank users.

This problem was avoided by assigning code numbers to identify each tire in the data bank and each type of useful chart or graph. Any charts or graphs available were then coded by type and tire number and stored in a separate file in the author's format and with his notes. The codes were stored in the data file. Thus, when tabular data is requested, the computer will print a coded file number if the data is available and "unknown" if the information is not in the file.

In the current plan for TAXIR(L), all tabular information will be stored in a computer file. Thus, when a table code is obtained from the data file, the table will be printed in the same way as the vocabulary words are printed when the descriptor codes are retrieved. However, continuous curves cannot be printed so these must be stored and inserted manually.

IV. RESULTS AND CONCLUSIONS

The data bank constructed under this grant provides two basic advantages for the user of aircraft tire information. First, computerization of the data bank allows mechanical property data to be stored, corrected, updated, and revised quickly and easily as more reliable tests and measurements are carried out. Secondly, the format of the book which can be printed from the computerized data bank can be easily adjusted to suit the needs of the users without the great expense normally associated with reprinting and editing books set by ordinary typography.

The presence of such a data bank in one central location now will make possible the widest dissemination of test results throughout the airframe and landing gear industry. Based on access to larger amounts of data, the properties of new tires not yet designed may be estimated much more closely than in the past. This should result in minimizing costs associated with the development of new aircraft and aircraft tires.

Interaction with engineers in industry clearly showed that NASA Technical Report R64 remains the primary source of aircraft tire mechanical property data in the United States airframe industry. Great interest is shown in keeping some form of this report in a continuously updated status for reference. It is hoped that in time the data bank will be able to produce a NASA Technical Report, containing the latest updated mechanical property information, for distribution to industry.

Construction of the data bank at the University of Michigan clearly illustrated that much more information is desired than is available. For example, very little information on center of pressure shift is available, particularly under dynamic conditions. A central information bank should facilitate the dissemination of available data and encourage the collection of other needed information.

One final conclusion reached through this work is that standardization of testing techniques for measurement of aircraft tire mechanical properties is needed. This work, while important, probably lies outside of the scope of governmental research activity and inside the general responsibility of some technical organization such as the Society of Automotive Engineers (SAE).

APPENDIX

INFORMATION AND PROCEDURES FOR TAXIR(L)

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CONTENTS

NOTE: This Appendix provides the most current documentation for the Aircraft Tire Mechanical Properties Data Bank and supercedes the manual for the data bank at the University of Michigan which was issued in October of 1975.

SECTION I: Introduction

The Department of Applied Mechanics at the University of Michigan assembled a data bank for the mechanical properties and pertinent operating characteristics of aircraft tires. This data bank was computerized so that rapid response could be made to individual inquiries. In addition, it was possible to add new information easily, so that periodically a complete and timely compendium of aircraft tire mechanical property data could be published and made available to users.

Excellent computer programs have been written for data storage and retrieval, and it was found that one of these (TAXIR) available at the University of Michigan was ideally suited for this purpose. However, the Langley Research Center computer system did not have the TAXIR program.

TAXIR, a program for efficiently storing and retrieving data, was designed for general purpose data banks. It permits the publication of reports from the data in any format, having all or part of the data appear in any order desired. TAXIR, a public program supported by the University of Michigan Computer Center, was written by R. C. Brill.

The new version, TAXIR(L), was designed by M. N. Lardas and J. R. Luchini. The programming for the NASA Langley Research Center CDC-6000 computer was written and implemented by M. N. Lardas, J. A. Tanner, and E. G. Smith.

The following conventions are used throughout the remainder of this Appendix:

b̸ represents a necessary blank space in a command.

Ø represents the letter O.

0 represents the number zero.

Lower case letters in a command indicate user-supplied information.

Commands may be entered in full according to the format presented. However, underlined parts of a command are abbreviations recognizable by the computer.

Commands may extend to two or more lines as necessary with TAXIR(L) responding "MORE" each time a line is entered which is not terminated by the appropriate control character.

SECTION II: TAXIR(L) Commands

After loading the program TAXIR will prompt the user with information indicating the program is in operation.

TAXIR will prompt the user with:

READY

The user may now interact with TAXIR using any of the following commands.

WHAT noise (descriptor list) noise: boolian expression?

This command indicates what tires in the data bank satisfy the condition specified in the Boolian expression. Additionally, for each of these tires the characteristics specified in the descriptor list are printed.

noise is any string of characters except for the control characters "(" or ")" or ":" or "?".

The boolian expression is any that can be specified as in Section III. This can extend over as many lines as necessary and is terminated with a question mark (?).

The descriptor list is the set of descriptors for which data is desired. It must be enclosed in parentheses. Descriptors should be separated by commas.

The WHAT command prints output in a fixed format. The output is formatted as one line for each descriptor in the list, with sequential descriptors for a single tire being indented. Duplicate listings are not printed.

SHOW noise (descriptor list) noise: boolean expression

noise and boolean expression are identical to the WHAT command definitions for these terms.

The SHOW command performs the same functions as the WHAT command, except that the SHOW command allows the user to set the output format. This is done by the use of formatting commands inserted in the descriptor list. A complete explanation of these commands is given in Section IV. Formatting commands will allow the user control of data on a single line, control of spacing of data, and addition of literal strings into lines.

VOCABULARY?

This command will provide the user with a list of all descriptors in the active data bank, their type, corresponding unit and range (if it is a from-to descriptor) or a state name (it if is a name variable).

MEMØ\noise?

This causes TAXIR(L) to ignore everything between MEMØ and "?". This input may extend over several lines, with TAXIR(L) responding "MØRE" to prompt each succeeding line until the "?" is entered.

FINISH

This command causes TAXIR(L) to print final use and time information, stops the running of the program, and unloads the program.

DISPLAY

This command allows the output of categorical and tabular data. However, at this time, the facility is being programmed at Langley Research Center and is not yet documented.

SECTION III: Boolean Expressions

To specify the subset of the data which is of interest in some application, the user must be able to use the algebra of sets or "Boolean Algebra". This is a formalized way of using five ordinary words:

```
FROM...TO
*AND*
*OR*
*NOT*
```

The Boolean expression is what determines which items are of interest. The simplest Boolean expressions might use none of the five words, such as:

```
SIZE,25X6.0
SIZE,25X6.75
TYPE,VII
TYPE,VIII
```

The descriptors in the above example (SIZE and TYPE) have unique noncontinuous states (for example, 25X6.75 or VII). These states are noncontinuous because there is no size "25X6.5" between "25X6.0" and "25X6.75", and there is no tire type between "VII" and "VIII".

There are two types of descriptors: named and continuous (of "FROM...TO"). Examples of named descriptors are "SIZE" and "TYPE". Examples of continuous descriptors are "SPEED", "PLYS", and "PRESSRL".

The Boolean expression for continuous descriptors uses the character string b̸FRØMb̸...b̸TØb̸, for example:

```
SPEED,b̸FRØMb̸99b̸TØb̸275
PLYS,b̸FRØMb̸10b̸TØb̸20
PRESSRL,b̸FRØMb̸50b̸TØb̸99
```

The complete list of descriptors, their types, and their states is included in Section V.

The Boolean expression permits a combination of descriptors and states to be specified using the control words:

```
*AND*
*OR*
*NOT*
```

in their usual grammatical senses. For example, to specify a tire with the following characteristics:

Type VII
Size 25 x 6.0 or 26 x 6.6
Speed rating from 210 mph to 275 mph
More than 16 plys (that is, not less than 17 plys)

the Boolean expression would be:

```
TYPE,VII *AND*SIZE,25x6.0*OR*SIZE,26x6.6
*AND*SPEED,ɃFRØMɃ210ɃTØɃ275
*AND**NØT*PLYS,ɃFRØMɃ0ɃTØɃ16
```

The Boolean expression may extend over as many lines as necessary (up to approximately 100) to specify the desired tires.

Obviously, confusion may result from complex Boolean expressions. Therefore, parentheses may be used to clarify the expression, both for the operator and for the computer. Operations implied by expressions enclosed in parentheses will be performed before an operation using the parenthetical expression. For example, consider:

```
TYPE,VII*AND*(SIZE,26x6.6*ØR*SPEED,ɃFRØMɃ210ɃTØɃ275)
*AND**NØT*PLYS,ɃFRØMɃ0ɃTØɃ16
```

The program will, in this example, locate tires which are either 26 x 6.6 or rated for speeds from 210 to 275, then sort these tires on type and number of plys.

SECTION IV: Formatting Commands

To arrange TAXIR(L) output in a manner either more compact or more understandable, the user must be familiar with the set of TAXIR(L) formatting commands. These commands fall into three categories: first, control of data on a single line; second, control of spacing of data; third, addition of literal strings into a line.

By enclosing portions of a descriptor list in hyphens, these portions will be printed on a single line of output. For example, a descriptor list containing the following:

```
(TYPE,SIZE,WIDTHMAX,ØDMAX)
```

would print out an answer in the following manner:

```
VII
     26x6.0
          6.25
               26.25
```

If that same list is modified in the following manner:

```
(TYPE,-SIZE,WIDTHMAX,-ØDMAX)
```

the output would appear as:

```
VII
     26x6.0 6.25
          26.25
```

If the user wished to have the output printed on two lines of two descriptors each, the following form could be used:

```
(-TYPE,SIZE,--WIDTHMAX,ØDMAX-)
```

which would appear as:

```
VII 26x6.0
     6.25 26.25
```

TAXIR(L), unless instructed otherwise, will indent each new line in a descriptor list. Normally, TAXIR(L) will not print duplicate listings. The user may alter these default values by the use of the following commands in the descriptor list:

<A> print all values

<Pnn> begin the answer on position nn

<Snn> allow a field of nn spaces for the answer

where nn represents an integer between 1 and 99. These commands are inserted immediately after the end of the descriptor name and before the comma that separates descriptors. These commands will only affect the descriptors to which they are attached. For example, a descriptor list contains:

(TYPE,ØDMAX,WIDTHMAX)

Normally, the answer would be printed in the following manner:

```
II
     23.75          tire 1
          8.35
     24.00          tire 2
          4.45
          6.50      tire 3
```

In the above example, data on three tires was given. For tire 1, TYPE, ØDMAX, and WIDTHMAX are given. For tire 2, only the ØDMAX and WIDTHMAX are given because the type is the same as in tire 1, and duplicate listings are not normally printed. For the same reason, tire 3 lists only WIDTHMAX, as that is the only respect in which it differs from tire 2.

Use of the <A> command will alter the output of the example descriptor list:

(TYPE<A>,ØDMAX,WIDTHMAX)

which would be printed as:

```
II
     23.75          tire 1
          8.35
II
     24.00          tire 2
          4.45
II                  tire 3
          6.50
```

Note that while the type is printed for all three tires, the ØDMAX for tire 3 is not printed because it is identical to the ØDMAX for tire 2, and there is no <A> declaration for ØDMAX.

Use of the <Pnn> specification will alter the positioning of the answer on the page. For example:

```
(TYPE,ØDMAX<P2>,WIDTHMAX<P4>)
```

This is the same descriptor list as in the previous example. However, the ØDMAX values will start on the second space of each line, and the WIDTHMAX values on the fourth:

```
II
 23.75  }  tire 1
   8.35
 24.00
   4.45 }  tire 2
   6.50 }  tire 3
```

This command can be very useful when combined with line markers. Using the same descriptor list as in the previous examples:

```
(-TYPE,ØDMAX,WIDTHMAX-)
```

but with a different set of answers, this can be illustrated:

```
BRITISH 14.7 4.25   }  tire 1
II 23.75 8.35       }  tire 2
VII 25.00 5.50      }  tire 3
```

A person just glancing at the output list may mistake the WIDTHMAX value for tire 2 as an ØDMAX value as it is directly below the ØDMAX for tire 1. Ambiguities of this sort can be solved by using the position command <Pnn> as in:

```
(-TYPE,ODMAX<P6>,WIDTHMAX<P12>-)
```

which will now appear as:

```
BRIT 14.7  4.25   } tire 1
II   23.75 8.25   } tire 2
VII  25.00 5.50   } tire 3
```

It should be noted that in cases where a state exceeds the length allotted to it, it is truncated so that there is a blank between it and the following state. All answers are left justified.

The field space specification, <Snn>, may be used in a similar manner. However, it will set the field size that the descriptor's state will go in. An example of the use of the field space specification is:

```
(-TYPE<S5>,ØDMAX<S6>,WIDTHMAX<S6>-)
```

which will have a response of:

```
BRIT 14.7  4.25   }   tire 1
II   23.75 8.25   }   tire 2
VII  25.00 5.50   }   tire 3
```

which happens to be the same output as the previous command using the position control.

Two specifications may be combined by enclosing both within a single set of brackets and dividing the two specifications by a comma as in:

```
(TYPE<S5,A>)
```

The above example would allow for all TYPE states to be printed out in a field of 5 spaces.

In order to all a label or literal string to the output, the expression should be enclosed in quotation marks and placed in the descriptor list. For example, to print a label with the outside diameters of the tires:

```
("MAXIMUM OUTSIDE DIAMETER",ØDMAX)
```

would print:

```
MAXIMUM OUTSIDE DIAMETER
     14.7                   }   tire 1
     23.75                  }   tire 2
     25.00                  }   tire 3
```

This facility can be combined with some of the above options to produce column headings to obtain a book format.

NOTE: A specific combination of the above options has been selected for TAXIR(L) to provide a book format. This format will be used for all output. Reprogramming would be required to change the default format.

SECTION V: Data Collection Categories

On-Line Data

NOTE: Units are either pounds, inches, pounds per square inch, or miles per hour.

TAXIR(L) Code	Description
SIZE	Size of tire. Name option (132).
PLYS	Ply rating of tire. From 1 to 99 by 1.
TYPE	Type of tire. Name option (8).
TUBE	Tube or tubeless tire. Name option (2).
MAINRL	Main gear rated load. From 0.005 to 900000.000 by 0.005. Note: For helicopter, multiply by: 1.67 for tires less than or equal to 26" OD. 1.50 for tires greater than 26" OD.
NOSE	Maximum nose gear load during braking. From 0.005 to 900000.000 by 0.005.
PRESSUNL	Rated pressure for unloaded tire. From 1 to 1000 by 1. Note: For helicopter, multiply by: 1.5. For maximum permissible pressure, multiply by: 1.8. With higher inflation pressures, tire OD and width will be greater than for conventional pressures.
SPEED	Maximum speed. From 1 to 1000 by 1.

On-Line Data, Con't

TAXIR(L) Code	Description
WEIGHT	Weight (approximate; will vary). From 0.01 to 1000.00 by 0.01.
MILQUAL	Qualifications - military. Name option (76).
CØMQUAL	Qualifications - commercial. Name option (2).
ØDMAX	Outside diameter - maximum. From 0.01 to 100 by 0.01.
ØDMIN	Outside diameter - minimum. From 0.01 to 100 by 0.01.
WIDTHMAX	Section width - maximum. From 0.01 to 100 by 0.01.
WIDTHMIN	Section width - minimum. From 0.01 to 100 by 0.01.
SHD	Shoulder diameter - maximum. From 0.01 to 100 by 0.01.
SHWD	Shoulder width - maximum. From 0.01 to 100 by 0.01.
J	Polar moment of inertia of a tire about the axle centerline*. From 0.01 to 100000 by 0.01.
I	Moment of inertia about an axis perpendicular to the wheel axis*. From 0.01 to 100000 by 0.01.
VØL	Contained volume. From 0.01 to 100000 by 0.01.
AR	Aspect ratio. From 0.001 to 10.000 by 0.001.
RD	Wheel rim diameter. From 0.01 to 100 by 0.01.

*In the absence of exact data, approximation formulas are available in Tire and Rim Association Handbook or NASA TR R-64.

On-Line Data, Con't

TAXIR(L) Code	Description
RW	Wheel rim width. From 0.01 to 100 by 0.01.
FD	Wheel flange diameter. From 0.01 to 100 by 0.01.
LW	Wheel ledge width. From 0.01 to 100 by 0.01.
BEADS	Number of beads. From 1 to 9 by 1.
RADRL	Radius at rated load. From 0.01 to 100.00 by 0.01.
PRESSRL	Pressure at rated load. From 1 to 1000 by 1.
RADFT	Radius of flat tire. From 0.01 to 100.00 by 0.01.
LD%DEFL	Loaded percent deflection. From 0.01 to 100.00 by 0.01.
LDEFL	Loaded deflection at rated load. From 0.01 to 100.00 by 0.01.
BØTLØAD	Bottoming load. From 0.005 to 900000 by 0.005.
BØTDEFL	Bottoming deflection. From 0.01 to 100 by 0.01.
TREADTYPE	Tread type of design. Name option (27).

Tabular Data

TAXIR(L) Code	Description
FPL	Footprint length*.
FPW	Footprint width*.
FPA	Gross footprint area*.
FPNA	Net footprint area*.
CENTG	Centrifugal growth.
PRESSR	Pressure rise.
GFP	Gross footprint pressure*.
ABP	Average bearing pressure.
SKZ	Vertical force - deflection characteristics, non-rotating.
DKZ	Vertical force - deflection characteristics, rotating.
SKY	Lateral force - deflection characteristics, non-rotating.
DKY	Lateral force - deflection characteristics, rotating.
SKX	Fore-and-aft force - deflection characteristics, non-rotating.
DKX	Fore-and-aft force - deflection characteristics, rotating.
STW	Twist moment - twist angle characteristics, non-rotating.
DTW	Twist moment - twist angle characteristics, rotating.
TMCR	Turning moment - curved path.
CAMC	Camber coefficient, non-rolling.

*Footprint characteristics will be different after retreading.

Tabular Data, Con't

TAXIR(L) Code	Description
CAMCR	Camber coefficient, rolling.
TM	Turning moment with camber.
PSL	Static center of pressure shift, lateral.
PSF	Static center of pressure shift, fore-aft.
PSCAM	Static center of pressure shift, tilted.
VSL	Static vertical sink, lateral.
VSF	Static vertical sink, fore-aft.
VST	Static vertical sink, twist.
CDF	Circumferential distortion.
SRL	Static relaxation length.
RRL	Unyawed rolling relaxation length.
YRL	Yawed rolling relaxation length.
RR	Rolling radius.
GFY	Normal force - yawed rolling.
CF	Cornering force - yawed rolling.
SAT	Self-aligning torque - yawed rolling.
PT	Pneumatic caster (trail).