SPECTRAL ANALYSIS

SPECT (REFERENCE MANUAL SECTION) COMMAND PROMPTS

SPECT-GENERAL INFORMATION - The Spectral Analysis, or SPECT, level is the level at which wavelength dependent data files may be manipulated. At this level, optical system transmission and other wavelength dependent analyses can be performed. SPECT level commands may be issued from the keyboard or as part of a macro.

SPECT FILE INITIALIZATION - The SPECT disk file system is initially created by entering the CMD level command:
ITF - To avoid accidental destruction of the existing SPECT disk file system, the "ITF" command performs no file initialization unless it is followed immediately by the command:
PROCEED - If the CMD level command "PROCEED" is not immediately entered following the "ITF" command, then the "ITF" command is ignored and canceled. THIS INITIALIZATION PROCEDURE SHOULD BE USED WITH CAUTION AS LARGE AMOUNTS OF DATA MAY BE LOST IF IT IS USED CARELESSLY. The "ITF" command is intended for a user who has no SPECT disk file system or for a user who intentionally desires to clean the slate and begin anew with an empty SPECT disk file system.

SPECT LEVEL
SPECT - The "SPECT" command causes the program to move into the SPECT level. All SPECT level commands and a limited sub-set of CMD level commands may be issued at this level.
EOS or **END** - The "EOS" or "END" command causes the program to leave the SPECT level and return to the CMD level.

SPECT DISK DATABASE - Just as there is a Lens Library at the CMD level which is used to store and recall lens system data, there is also a disk based data structure at the SPECT level which is used to store and recall tables of wavelength dependent data. This wavelength dependent data may represent optical transmittance or reflectance values or other wavelength dependent data which needs to be stored, recalled and manipulated.

SPECT MEMORY ORGANIZATION - There are two areas of computer memory available within the SPECT level. These areas are named the WORK memory areas and the CUMULATIVE memory area**.**

WORK MEMORY AREA - The WORK memory area is a memory area into which a SPECT disk data file may be read. This memory area is large enough to store up to 1001 pairs of wavelength dependent data.

CUMULATIVE MEMORY AREA - The CUMULATIVE memory area is a memory area into which linearly interpolated wavelength dependent data is multiplied. This memory area is large enough to store up to 1001 pairs of wavelength dependent data.

MEMORY AREA COMMANDS
START - The "START" command causes all the wavelength dependent data in the CUMULATIVE memory area to be set to 1.0. A "START" command is automatically executed each time the SPECT level is entered and whenever a "WAVLN" command is issued.
WAVLN , λlower , λupper , ntot - The "WAVLN" command defines the spectral region to be used in the CUMULATIVE memory area. The "λlower" wavelength must be greater than zero, the "λupper" must be greater than the "λlower" and the number of entries, and "ntot" must be an integer in the range 1 to 1001. There are no defaults for the "λlower" and "λupper" input values. The default value for "ntot" is 1001. Whenever a "WAVLN" command is issued, an automatic "START" command is also issued.
INT - The "INT" command causes Simpson's rule to be used to integrate the CUMULATIVE AREA over the spectral region specified by the preceding "WAVLN" command. The value of the integral is printed along with the lower and upper bounds of the current spectral region. The value of the integral is also placed into the macro accumulator.
WORK - The "WORK" command displays the current contents of the WORK memory area to the current output device.
CUME - The "CUME" command displays the current contents of the CUMULATIVE memory area to the current output device.
NAME - The "NAME" command displays the name of the current SPECT disk file loaded in the WORK memory area..

SPECT DATABASE COMMANDS
DIRECT or **DIR** or **DIRECT , i** or **DIR , i** - The "DIRECT" or "DIR" command issued alone displays a directory listing of the entire SPECT disk database. If "DIRECT" or "DIR" is issued with the numeric entry "i", then the directory listing of just the "i"th file is displayed. The SPECT disk database can store up to 999 database files.
DELETE (name) or **DELETE , i** - The "DELETE" command deletes the specified SPECT disk file. If "DELETE" is issued with the file name, the file with name = "name" will be deleted. If "DELETE" is issued with the numeric value "i", the "i"th SPECT disk file will be deleted.
FILE (name) - The "FILE" command causes the current wavelength dependent data in the WORK area to be stored on disk as a SPECT disk file with name = "name". Storage occurs only if there is data to store and if the file named "name" does not already exist.
LIST (name) or **LIST , i** or **LIST** - The "LIST name" command causes the SPECT disk file with name = "name" to be read into the WORK memory area and its contents displayed. "LIST , i" causes the "i"th SPECT disk file to be loaded into the WORK memory area and displayed. The "LIST" command simply displays the current WORK memory area.
PUNCH (name) or **PUNCH , i** or **PUNCH** - The "PUNCH" commands are identical to the "LIST" commands, except that the contents of the SPECT disk file are sent to the "CARDTEXT.DAT" file instead of to the display.
SPRINT (name) , a , b , c , d , e - The "SPRINT" command causes the SPECT disk file with name = "name" to be read into the WORK memory area. If the "name" is left blank, the CUMULATIVE memory area is moved into the WORK area. The data moved to the WORK area is modified by the transformations:

$$\lambda_{new} = (a \times \lambda_{old}) + b$$

and

$$f(\lambda)_{new} = \left[\left(c \times f(\lambda_{old})\right) + d\right]^{e}$$

If "a", "c" or "e" are blank, they are automatically set to 1.0. If "b" or "d" are left blank, they are set to zero. After the above transformations, the data in the WORK memory area is linearly interpolated to obtain n_{tot} equally spaced values between λ_{lower} and λ_{upper}. These n_{tot} functional values are displayed at the current output device. The CUMULATIVE memory area is not changed by this command. λ_{lower}, λ_{upper} and n_{tot} are specified by the last "WAVLN" command.

RENAME (old name) , (new name) - The "RENAME" command is used to rename a SPECT disk file named "old name" to "new name". "Old name" is entered as a qualifier word and "new name" is entered as a string.

DUP (old name) , (new name) - The "DUP" command is used to copy the SPECT disk file named "old name" to a new SPECT disk file named "new-name". "Old name" is entered as a qualifier word and "new name" is entered as a string.

GETFILE (name) , a , b , c , d , e - The "GETFILE" command causes the SPECT disk file with name = "name" to be read into the WORK memory area where it is modified by the transformations:

$$\lambda_{new} = \left(a \times \lambda_{old}\right) + b$$

and

$$f(\lambda)_{new} = \left[\left(c \times f(\lambda_{old})\right) + d\right]^{e}$$

If "a", "c" or "e" are blank, they are automatically set to 1.0. If "b" or "d" are left blank, they are set to zero. After the above transformations, the data in the WORK memory area is linearly interpolated to obtain n_{tot} equally spaced values between λ_{lower} and λ_{upper}. These n_{tot} functional values are then multiplied by the values currently in the CUMULATIVE memory area and the results are stored in the CUMULATIVE memory area. λ_{lower}, λ_{upper} and n_{tot} are specified by the last "WAVLN" command.

PUT (name) - The "PUT" command creates a SPECT disk file of name = "name". It will have n_{tot} points. The data in the current CUMULATIVE memory area is stored in this file. n_{tot} is specified by the last "WAVLN" command.

INTER (name) , λ - The "INTER" command is used to linearly interpolate a SPECT disk file with name = "name" to a value corresponding to the independent variable "λ". The interpolated value is displayed at the output device and placed into the accumulator.

BLACKBDY (qualifier word) , T - The "BLACKBDY" command without a "qualifier word" or with the qualifier "SRE" generates blackbody "spectral radiant emmittance" values at temperature "T". These values are calculated for each wavelength entry in the CUMULATIVE memory area and then multiplied into the CUMULATIVE memory area's stored functional values. "T" must be in degrees Kelvin. If "T" is not entered, 300.0 degrees Kelvin is assumed for the default. If the "qualifier word" "SRPE" is used, "spectral radiant photon emmittance" values are calculated and stored instead of "spectral radiant emmittance" values. The units of "spectral radiant emmittance" are: Watts-cm^{-2}-micron^{-1}. The units of "spectral radiant photon emmittance" are: Photons-sec^{-1}-cm^{-2}-micron^{-1}.

SPECT DATA INPUT

TABLE (filename) - The "TABLE" command is used to initiate the entry of data into an empty SPECT database disk file. "filename" is the name of that file. "TABLE" is followed by not more than 1001 input commands of the form:

DATA ,λ , f(λ) - where "λ " is the wavelength in microns and "f(λ)" is the functional value related to that wavelength. The entries must be in ascending order by wavelength.

ENDTABLE - The "ENDTABLE" command terminates file input and writes the data to the disk.

INSERT (name) ,λ , f(λ) - The "INSERT" command is used to insert an entry into the SPECT disk file with name = "name". The entry is positioned in the file by ascending value of "λ". This command may not be used to create a file or insert records into an "empty" file.

DROP name , i - This command causes the "i"th entry of the named SPECT disk file to be deleted or dropped from that file.

PHOTOPIC - This command causes the spect disk file named "PHOTOPIC" to be automatically created. It has 81 entries and represents the Photopic response function of the human eye from 0.380 micron to 0.780 micron. (Based on data taken from the American Institue of Physics Handbook.)

SCOTOPIC - This command causes the spect disk file named "SCOTOPIC" to be automatically created. It has 81 entries and represents the Scotopic response function of the human eye from 0.380 micron to 0.780 micron. (Based on data taken from the American Institue of Physics Handbook.)

SPECT FILE GRAPHICS - The following two The commands are used to graphically display the contents of a SPECT disk file. The plots are automatically displayed on the screen. They may then be re-displayed on the screen using the "DRAW" command or printed using the "GRAOUT" command. The two commands are identical in that they generate plots of the contents of SPECT disk files. They are different only in the fact that the "PLOTT" command labels the vertical axis as TRANSMISSION and the "PLOTR" command labels the vertical axis as REFLECTION. The horizontal scale will always be labeled "WAVELENGTH (MICRONS)".

PLOTT (file name) , λlower , λupper, F(λlower) , F(λupper) and

PLOTT , i , λlower , λupper, F(λlower) , F(λupper) and

PLOTR (file name) , λlower , λupper, F(λlower) , F(λupper) and

PLOTR , i , λlower , λupper, F(λlower) , F(λupper) - If the "file name" version of each command is used, the contents of the SPECT disk file with name = "file name" will be plotted. If the version with SPECT disk file number "i" is used, the "i"th SPECT disk file will be plotted. If not entered explicitly, the plot will be scaled in X and Y so as to include all data in the designated file. This automatic scaling can be overridden by explicitly entering the X-plot limits, λ_{lower} and λ_{upper}, and the Y-plot limits, $F(\lambda_{lower})$ and $F(\lambda_{upper})$.

SPECTRAL WEIGHTING FACTORS - Many times it is necessary to determine a set of wavelengths with associated spectral weighting factors which will be used during the design or analysis of an optical system. These values depend upon the spectral characteristics of the source illumination filtered by any filters and upon the spectral response of the detector. If SPECT data files are created and stored, using the SPECT commands described earlier in this section, which describe the filtered illumination and the detector response, then the "WFACTOR" command may

be used to determine an appropriate set of wavelengths and associated spectral weights.

WFACTOR , n - The "WFACTOR" command is entered with the number of wavelengths, "n", for which spectral weighting factors are desired. "WFACTOR" operates upon the current CUMULATIVE memory area. It first divides the CUMULATIVE area into "n" equal wavelength extent sub-sections. Each sub-section covers 1/"n" th of the spectral band included in the full CUMULATIVE area. The area of each of these equal wavelength sub-sections, normalized by the area under the complete CUMULATIVE area becomes the spectral weighting factor for that sub-section. Next, each sub-section is divided into two equal area pieces. The wavelength which lies at the boundary of these two equal area pieces of each sub-section becomes the wavelength for that sub-section. That wavelength is the wavelength which is to be related to that sub-sections spectral weighting factor.

WEIGHTING FACTOR EXAMPLE - Source illunination for the system under consideration is to be a black body at 5600 degrees Kelvin. The detector response is to be the Photopic response of the human eye. The number of wavelengths, "n", will be 6.

Step 1
Enter the SPECT program level
COMMAND(S):

SPECT

Step 2
Set up the Cumulative area with 1001 points from wavelength 0.38 to 0.78 microns.
COMMAND(S):

START
WAVLN 0.38 0.78

Step 3
Create a SPECT database file named PHOTOPIC which contains the Photopic response on the human eye from 0.38 to 0.78 microns. Then multiply this file into the Cumulative area.
COMMANDS:

PHOTOPIC
GETFILE PHOTOPIC

Step 4
Multiply into the Cumulative area the black body radiant emmittance at T = 5600 degrees Kelvin.
COMMANDS:

BLACKBDY 5600

Step 5
Issue the command "WFACTOR " with a numerical argument "6"
COMMANDS:

WFACTOR 6

Results are:

WAVELENGTH - (MICRONS)	SPECTRAL WEIGHT
0.4382	0.00416
0.4986	0.12037
0.5486	0.57045
0.6006	0.28706
0.6574	0.01777
0.7226	0.01777

Step 6
Exit the SPECT level
COMMAND:

EOS or **END**

Now use the WV and WV2 update lens commands to input the new wavelengths and the SPTWT and SPTWT2 commands to enter the new spectral weights.