TWA CALCULATOR

NOISE EXPOSURE DOSE TRAINER

USER GUIDE   Document revision 2.0

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Application Development: Michael Schaffer,
Nelson Acoustics

TWA Calculator MAIN SCREEN

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Introduction

TWA Calculator is a computational and visual tool for teaching noise exposure dose concepts in an occupational hearing conservation context. As the user creates daily noise exposure scenarios from a series of component exposure events that include duration and sound level, *TWA Calculator* computes and displays daily total noise exposure dose and 8-hour noise exposure metrics using both OSHA/MSHA and NIOSH values for criterion and exchange rate. *TWA Calculator* demonstrates the relationship between sound level, duration and partial dose for each component exposure as well as their effect on the total daily dose and 8-hour noise exposure quantities [OSHA/MSHA Time-Weighted Average (TWA) and NIOSH $L_{Aeq,8}$]. Real-time changes in input data and calculated parameters are displayed graphically and numerically.

Noise exposure scenarios may be created in a Microsoft Excel format import template and imported into *TWA Calculator*, and those created in the application may be exported, saved, edited and re-imported.

A built-in screen capture function facilitates the use of the application for preparing class notes, exams and other written materials.

Creating an Exposure Event

TWA Calculator defines an EXPOSURE EVENT as a single activity, in which an individual is exposed to a steady-state sound LEVEL for a specified DURATION. An EXPOSURE EVENT entry in *TWA Calculator* includes, in addition to LEVEL and DURATION, an EXPOSURE EVENT NAME, an EVENT NUMBER index and the PARTIAL DOSE, which is expressed as a calculated percentage of both the NIOSH recommended exposure level and OSHA/MSHA criterion level.

> **EXPOSURE EVENT NAME**
> When *TWA Calculator* is launched, there are no EXPOSURE EVENT entries, and all data entry fields are disabled. To begin, click the ADD EXPOSURE EVENT button at the top left of the MAIN SCREEN. The focus moves to the CURRENT EXPOSURE EVENT field, with the default text "New Exposure Event" highlighted. The other data entry fields also become enabled.
>
> Type a unique name for the first EXPOSURE EVENT entry and press either ENTER or TAB, or click outside the CURRENT EXPOSURE EVENT text box. The text in the EXPOSURE EVENT text box must be edited (to distinguish one event from another) before another EXPOSURE EVENT may be added. A unique name must be assigned to each EXPOSURE EVENT.
>
> **EVENT NUMBER**
> EVENT NUMBER is a unique index number that is assigned to each EXPOSURE EVENT entry. When only one EXPOSURE EVENT has been entered, the EVENT NUMBER is fixed at 1. When another EXPOSURE EVENT

is added, the EVENT NUMBER for the new event will be set to 2. Once at least two EXPOSURE EVENTS have been added, they can be renumbered from any point by changing the EVENT NUMBER of any EXPOSURE EVENT, which causes EXPOSURE EVENTS with equal or higher numbers to renumber from that point.   The maximum EVENT NUMBER will always be equal to the number of EXPOSURE EVENTS, and no two EXPOSURE EVENTS can have the same EVENT NUMBER.

EXPOSURE DURATION
EXPOSURE DURATION and LEVEL data can be entered once an EXPOSURE EVENT has been created. EXPOSURE DURATION is expressed in terms of HOURS, MINUTES and SECONDS, any of which can be edited by using the sliders or typing numerical data directly into the spinner boxes.

Note: *TWA Calculator* allows TOTAL EXPOSURE DURATION to exceed 24 hours in order to permit the back-calculation capability to function properly. *TWA Calculator'*s intended function is to serve as an educational tool, primarily in a classroom environment, for illustrating the mathematics behind the DOSE and 8-hour noise exposure calculations. In this context, the calculation of quantities that are occupationally meaningless is not a problem. When the aggregate DURATION of the EXPOSURE EVENTS exceeds 24 hours, the display is disabled since the total DOSE is no longer meaningful. Individual PARTIAL DOSES are still meaningful and continue to be displayed. The TOTAL DOSE display is re-enabled when the User edits the EXPOSURE DURATIONS so that the total is less than or equal to 24 hours.

LEVEL
The LEVEL control sets the LEVEL in A-Weighted decibels (dBA). When a value is entered into a spinner box, the corresponding slider automatically moves to the correct position. Likewise, adjusting the position of a slider changes the value of its spinner.

The LEVEL range was influenced by industrial dosimeters, a survey of which indicated a measurement range of 40 to 140 dBA. From a dose-response perspective, the low end can be anchored by the level that produces a 0.5% (minimum that rounds up to 1%) dose, which is 43.8 dBA using the OSHA/MSHA computations. The high end can be anchored by the unprotected exposure that leads to permanent mechanical hair cell damage: 138 dBA. For these reasons, the conventional 40 to 140 dBA range has been retained.

Display and Calculation Resolution

The resolution that has been assumed for TWA calculator quantities is:

Exposure Sound Level: 0.1 dBA on input and display of calculated quantities
Exposure Time: 1 sec on input and display of calculated quantities
Partial dose: 0.1% (output)
Total dose: 1% (output)
Total noise exposure: 1 dBA (output)

Output rounding for PARTIAL DOSE calculations uses standard rounding. Interim calculations are not rounded except to display PARTIAL EXPOSURE DOSES in the center graphical display of the MAIN SCREEN .

The resolution that can be achieved with the spinners for LEVEL, EXPOSURE DURATION and DOSE is finer than the resolution that can be achieved with the corresponding sliders for those variables, due to the fixed scale of the sliders.

Displaying Dose and 8-hour Noise Exposure Quantities
As the controls for EXPOSURE DURATION and LEVEL are adjusted, *TWA Calculator* computes the PARTIAL DOSE relative to both the NIOSH recommended exposure level and OSHA/MSHA criterion level. These values are automatically updated to the DOSE controls on the bottom left-hand portion of the screen, as well as to the PARTIAL EXPOSURES DISPLAY In the center of the MAIN SCREEN, which offers a visual representation of the PARTIAL DOSE values as horizontal bars.

The TOTAL DOSE/8-HOUR NOISE EXPOSURE DISPLAY on the right side of the MAIN SCREEN displays the total daily dose and 8-hour noise exposure, calculated using both NIOSH and OSHA/MSHA criterion levels and exchange rates. The left vertical bar displays NIOSH quantities, and the right vertical bar displays OSHA/MSHA quantities. The percentage values at the top of the vertical bars indicate the TOTAL DOSE, which is the sum of all the DOSES for the EXPOSURE EVENTS that have been entered. The dBA values below TOTAL DOSE are the OSHA/MSHA Time Weighted Average (TWA) exposure and NIOSH $L_{Aeq,8}$ for the total daily exposure time (which is displayed at the bottom center of the MAIN SCREEN).

The bars are divided into color segments representing various TOTAL DOSE regions. Each bar is blue between 0% and 50%. The OSHA/MSHA TOTAL DOSE bar turns gold at 50% to indicate that the dose has reached the "action level". Since there is no NIOSH "action level," the NIOSH TOTAL DOSE bar stays blue by default in this range and turns red at 100% to indicate that the NIOSH TOTAL DOSE is at the Recommended Exposure Level. The OSHA/MSHA TOTAL DOSE bar turns red above 100%, indicating that the

OSHA/MSHA TOTAL DOSE has exceeded 100%. The scale of the TOTAL DOSE bars changes to allow both NIOSH and OSHA/MSHA bars to remain visible.

Note: since NASA uses the same criterion level (85 dBA) and exchange rate (3 dB) as NIOSH but also maintains an Action Level of 50%, the NIOSH TOTAL DOSE bar can be set in the USER PREFERENCES menu to turn gold at 50% to signify the NASA Action Level.

"Standard" Rounding
All partial dose calculations are rounded to the nearest 0.1 dBA, using a rounding convention that differs slightly from the one most users will expect: if the least significant digit is 5 (for example, 85.25), the number to its left will be rounded to the nearest even value. This means that 85.15 and 85.25 will both be rounded to 85.2. In TWA Calculator this is called "Standard Rounding" because it is the default behavior of the LabVIEW™ platform on which the application was developed.

Building a Noise Exposure Scenario by Adding and Editing EXPOSURE EVENTS

A noise exposure scenario may be built by entering additional EXPOSURE EVENTS. To add an EXPOSURE EVENT, click the ADD EXPOSURE EVENT button and repeat the above process. (Note that the text in the EXPOSURE EVENT text box must be edited before another EXPOSURE EVENT may be added.)

A Scroll bar will appear on the PARTIAL EXPOSURES DISPLAY when the number of EXPOSURE EVENTS exceeds the display area to permit viewing of additional EXPOSURE EVENTS. There is no limit to the number of EXPOSURE EVENTS that may be added. Any of the EXPOSURE EVENTS may be edited by expanding the CURRENT EXPOSURE EVENT dropdown menu as shown and selecting the desired EXPOSURE EVENT. The EXPOSURE DURATION, LEVEL and DOSE controls will automatically populate with data previously entered for the selected EXPOSURE EVENT.
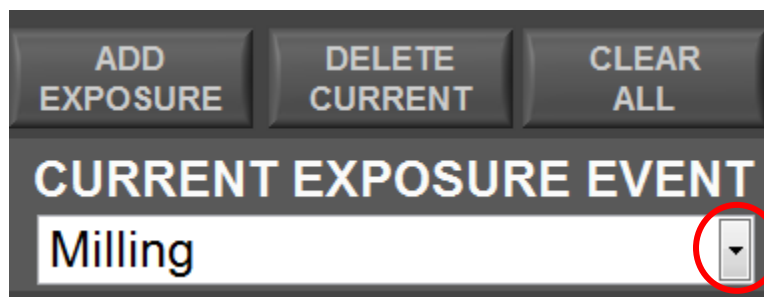
Locking Values and Back-Calculating

Given any two of the three EXPOSURE EVENT parameters (EXPOSURE DURATION, LEVEL or PARTIAL DOSE) *TWA Calculator* can compute the third. For example, for a given PARTIAL DOSE and LEVEL value, *TWA Calculator* will compute the EXPOSURE DURATION. In order to perform "back-calculations" such as this, one value must be "locked." Any of the three quantities can be locked by simply checking its corresponding LOCK checkbox.
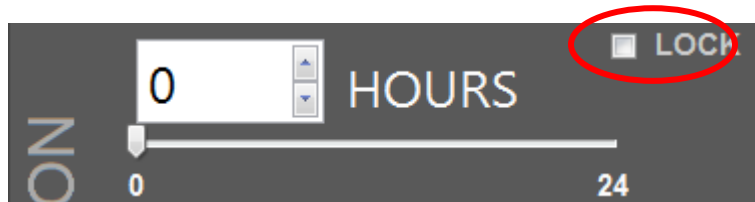
When a parameter is locked, the corresponding control becomes disabled and faded, and its value becomes fixed. At this point, the value of either of the other quantities may be changed, and the third will be calculated. To unlock the value, simply click the LOCK checkbox a second time.

Note: *TWA Calculator*'s back-calculation function permits the calculation of occupationally unrealistic LEVEL, DOSE, and DURATION values in order to enable the illustration of the mathematics behind the calculation of noise exposure quantities.

If no values are locked, the control for PARTIAL DOSE will be disabled (but not faded). Thus, by default, *TWA Calculator* forward calculates the PARTIAL DOSE based on the EXPOSURE DURATION and LEVEL values. To adjust the NIOSH PARTIAL DOSE or the OSHA/MSHA PARTIAL DOSE, either EXPOSURE DURATION or LEVEL must first be locked. When the PARTIAL DOSE CHECKBOX is checked, the LOCK OSHA/MSHA DOSE and LOCK NIOSH DOSE buttons will be revealed to allow the user to select which of the PARTIAL DOSE values to lock.
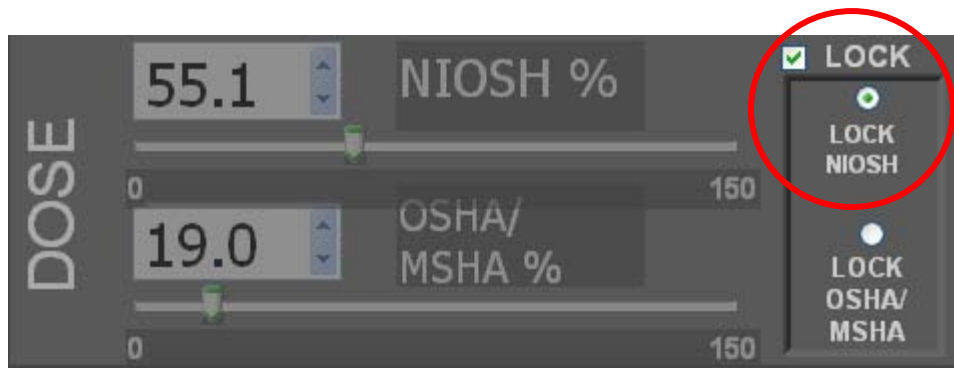
Note that if a SOUND LEVEL THRESHOLD (80 dBA or 90 dBA) has been selected in the USER PREFERENCES menu, the LOCK checkboxes are disabled, preventing back-calculating (since setting a SOUND LEVEL THRESHOLD creates a discontinuity in the equation used to calculate the DOSE, making back calculation impossible in

many cases). The LOCK EXPOSURE DURATION CHECKBOX is disabled when either the EXPOSURE DURATION or PARTIAL DOSE (either NIOSH or OSHA/MSHA) is equal to zero.

Deleting and Clearing EXPOSURE EVENTS

The currently selected EXPOSURE EVENT may be deleted at any time by simply clicking the DELETE CURRENT button at the top left of the screen. A dialog box will request confirmation of the request to delete the current EXPOSURE EVENT.   After an EXPOSURE is deleted, EXPOSURE EVENTS with EVENT NUMBERS greater than that of the deleted EXPOSURE EVENT are decreased by one to maintain proper chronology.

To delete all EXPOSURE EVENTS and start from scratch, click the CLEAR ALL button and select "Yes" at the dialog box.

Sorting and Reordering EXPOSURE EVENTS

As EXPOSURE EVENTS are added, the PARTIAL EXPOSURES DISPLAY will order them chronologically by default. However, this data display may be sorted by any of the following quantities: EVENT NUMBER, EXPOSURE DURATION, LEVEL, NIOSH DOSE or OSHA/MSHA DOSE. To do this, simply select an entry from the SORT BY dropdown menu in the bottom center portion of the screen.
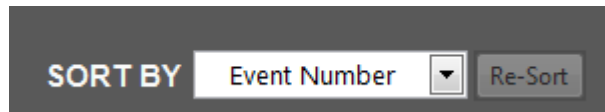
If a change is made to any of the EXPOSURE EVENTS that affects the sorting order, *TWA Calculator* will *not* automatically sort the data. Instead, it will display a "Sorting order has changed" message above the SORT BY dropdown, and the RE-SORT button will become enabled. Click the RE-SORT button to refresh the sorting in accordance with the parameter displayed in the SORT BY dropdown.
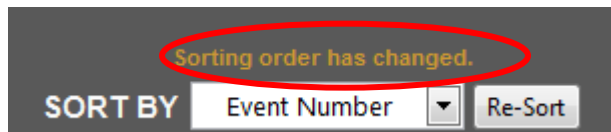
USER PREFERENCES Menu

To open the USER PREFERENCES menu, click the PREFERENCES button at the bottom of the screen. The default user preferences that are implemented on first launch are shown below.

Sound Level Threshold
The SOUND LEVEL THRESHOLD sets the minimum sound pressure level included in the dose calculation. For example, if the SOUND LEVEL THRESHOLD is set to 80 dBA, an EXPOSURE EVENT with a LEVEL value less than 80 dBA will have NIOSH DOSE and OSHA/MSHA DOSE values of 0%. Note that setting the SOUND LEVEL THRESHOLD to any value other than "None" will disable the LOCK checkboxes and back-calculating functionality (see the Locking and Back-Calculating section of this document).

When the SOUND LEVEL THRESHOLD setting is changed in the USER PREFERENCES MENU, all DOSE, TOTAL DOSE and 8-hour Noise Exposure values are automatically recalculated and updated after the preferences are saved.

NASA Action Level Display
The NASA ACTION LEVEL DISPLAY sets the color change behavior for the NIOSH TOTAL DOSE vertical bar to allow indication of the NASA Action Level. With "Do Not Display NASA Action Level" selected, the segment of NIOSH TOTAL DOSE bar between 50% and 100% will be blue. If "Change Color at NASA Action Level" is selected, the bar will turn gold at 50%.

Total Dose & Exposure Rounding Scheme
Total Dose and TWA/LeqA8 values are each calculated using the rounded partial dose values as inputs. The result of each calculation is rounded to the nearest integer using the currently selected "Total Dose/Noise Exposure Rounding" setting from the configuration file or USER PREFERENCES menu. If "Standard Rounding" is selected, the rounding will work as it does with partial doses, except that it will round to whole integers instead of to one decimal place (for example, 31.5% and 32.5% will be both rounded to 32%). If "Always Round Down" is selected, all values will be rounded down to the nearest whole integer (for example, 32.8 dBA will be rounded to 32 dBA). The "Always Round Down" setting is used to prevent values that would be below a limit if rounded more precisely (such 99.6%) from appearing to exceed the limit.

These rounding options are offered to permit the comparison and interpretation of TOTAL DOSE and 8-hour Noise Exposure values with respect to regulatory exposure limits and action levels.

No rounding is done on interim calculations until final calculated quantities are rounded for display.

Setting and Saving User Preferences

User preferences may be set and modified by the three processes that are described below.

Configuration File
The configuration file, C:\Program Files\TWA Calculator v2_0\Configuration File\TWA Calculator Configuration File.xls, sets the initial value of each of the four preferences found in the USER PREFERENCES menu. These settings may be changed outside the application by accessing the dropdown boxes in cells B4-B7 of this configuration file. After editing the settings, save and close the file. Do not rename or move this file.

Import and Export Template Files
Three of the four settings specified in the configuration file are also included in the import and export templates ("Show Splash Screen on Startup" is not included because it does not affect the calculation or display of noise exposure scenario quantities). Settings specified in a noise exposure file that is imported will change the USER PREFERENCE settings in TWA Calculator and will remain in effect until 1) they are changed in the USER PREFERENCES MENU, 2) another noise exposure scenario file is imported or 3) the session is terminated. The configuration file is not modified when the user preference settings are modified via file import.

Saving Preferences in the USER PREFERENCES Menu
When the SAVE button in the USER PREFERENCES menu is clicked, the selected preferences are applied, and the user is returned to the *TWA Calculator* MAIN SCREEN. *TWA Calculator* will update the configuration file so that these settings will be used the next time the application is launched and until they are changed, either by modifying the configuration file, importing a noise exposure scenario file or by changing the settings in the USER PREFERENCES menu.

Working With Noise Exposure Scenario Case Files

TWA Calculator allows the user to save a noise exposure scenario created in the application and then import that scenario at a later time. Saved scenario files may be edited before being imported. An imported scenario may also be modified within the application and resaved as a new scenario.

Saving Noise Exposure Scenarios
After creating a noise exposure scenario, click the SAVE button on the MAIN SCREEN. Browse for the desired folder and enter a filename.   In the in the COMMENTS field of the SAVE EXPOSURE SCENARIO dialog box that appears, enter up to two lines of optional notes.   Note: Additional scenario notes may be entered by adding a worksheet to the workbook and formatting as desired. Press the EXPORT button, and the scenario will be exported to a Microsoft Excel file. Exported files have a read-only attribute, which may be changed from the file properties menu of the exported file.

Saving a noise exposure scenario exports all data associated with the scenario, including the USER PREFERENCES settings. Settings in the configuration file are not affected by saving a noise exposure scenario.

If the TOTAL EXPOSURE DURATION exceeds 24 hours, the SAVE button is disabled.

Creating Noise Exposure Scenario Case Files
Noise exposure scenario files may be created outside of *TWA Calculator* using the Microsoft Excel file, C:\Program Files\TWA Calculator v2_0\Saved Scenarios\TWA Calculator Import Template.xls. A scenario consists of one or more EXPOSURE EVENTS that, together, comprise a total (e.g., workday) noise exposure. Each EXPOSURE EVENT consists of an EVENT NAME (descriptive text) DURATION (h/m/s) and LEVEL, which are entered into the spreadsheet. The allowable resolutions and ranges for numeric input quantities are as follows:

Hours	0 through 24	integer values
Minutes	1 through 59	integer values
Seconds	1 through 59	integer values
Level	40.00 through 140.0	

User preference settings are also specified in the import template, using the drop-down lists of preference options (which are set to default as follows: no sound level threshold/show NASA Action Level/standard rounding). There are also fields provided for optional file identification information, such as file name/path and scenario description.   These optional fields are not read by the application when the noise exposure scenario file is imported but are for information purposes only. The user may add notes to the file by creating another worksheet in the Excel workbook and formatting it as desired.
Input cells are shaded green. Other cells in the spreadsheet are locked to prevent accidental modification.

The import template is a read-only file. Scenarios created in the import template must be saved with a new filename. The new file will not have the read-only attribute; this should be added manually if desired.

If the import template becomes corrupted, replace it with a clean file downloaded from http://adl.amygelfand.com/twa-calculator-resources/.

Importing Noise Exposure Scenario Case Files
To import a noise exposure scenario file created using the import template, click the LOAD button on the MAIN SCREEN, and browse for the desired file. The scenario data and user preferences are imported, but the contents of the scenario description field are not.

An example noise exposure scenario, C:\Program Files\TWA Calculator v2_0\Saved Scenarios\ Groundskeeping example scenario.xls, is provided.

Imported noise exposure scenarios may be further modified inside the application. To re-save the modified scenario, follow the instructions for **Saving Noise Exposure Scenarios** and enter a new file name. Any scenario exposure notes that the user wishes to retain from the original scenario (scenario description field) must be re-entered into the COMMENTS field in the SAVE EXPOSURE SCENARIO dialog box.

Editing Exported Noise Exposure Scenario Case Files
Exported noise exposure scenario files may be edited outside *TWA Calculator* (in Excel) and then re-imported into the application. To edit an exported file, remove the read-only attribute or resave it with a different name. *Note that the dose and exposure quantities that are exported are static values and will not recalculate as data in the input fields are modified. It is recommended the contents of cells not shaded green be cleared before editing the file for re-importing.*

Capturing the Screen Image

An image of the MAIN SCREEN may be captured for printing or editing in an image processing application. To capture the image, click the CAPTURE button on the MAIN SCREEN. The image is opened in the default web browser, from which it may be copied, saved or printed.

Online Resources Available to Support *TWA Calculator*

To access the most current version of this *TWA Calculator User Guide*, click the HELP button on the MAIN SCREEN for a live hyperlink to http://adl.amygelfand.com/twa-calculator-resources/. Example noise exposure scenario files, a clean import template file and other online resources produced by the NASA Auditory Demonstration Laboratory are also downloadable from this page. Links to online databases of measured noise exposure and equipment noise emission data are provided as a source of input data for creating realistic noise exposure scenarios for a variety of occupations and tasks.

***TWA Calculator* RSS Feed**

Be sure to subscribe to the TWA Calculator RSS Feed to receive notices of product and documentation upgrades and error reports and the availability of new noise exposure scenario examples and other resources.

Share Your Noise Exposure Scenario Examples with Other *TWA Calculator* Users

Do you have cases you use to illustrate noise exposure and dose concepts in a teaching environment? Share them with other ***TWA Calculator*** users by contributing to a library of example noise exposure scenario files. Submit the pertinent data (and any key teaching points) for each case using our contact form. Examples could illustrate any of the following concepts, as well as the obvious relationships between DURATION, LEVEL and DOSE:

- Typical occupational noise exposure scenarios for various jobs
- Effects of measurement sound level threshold on calculations
- Workshifts longer than 8 hours
- OSHA vs. NIOSH comparisons
- Effect of rounding scheme on decision-making

Contributed examples will be used to create a downloadable file of example scenarios.

Questions, Help, and Error Reports

Please submit questions and error reports related to ***TWA Calculator*** and associated resources using the contact form at http://adl.grc.nasa.gov/about-earlab/contact-us/.