

DEVELOPMENT OF THE NIOSH "DETERMINATION OF SOUND EXPOSURES (DOSES)" MINING NOISE EXPOSURE MANAGEMENT SOFTWARE

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ABSTRACT

Overexposure to hazardous noise has been found in most mining sectors, with up to 100% of the surveyed workforce experiencing a noise dose over the Mine Safety and Health Administration (MSHA) permissible exposure level (PEL). As a result, miners show elevated rates of hearing impairment of 70-90% by retirement age. To help manage noise exposures, the National Institute for Occupational Safety and Health (NIOSH) developed the Determination of Sound Exposures (DOSES) software and implementation guide for use by mine management and safety personnel. The software relies on a time-motion study that profiles the worker's daily activities. Observations about the worker's location and tasks or other activities are recorded along with the start and end time, to determine the duration of the tasks, so they can later be matched up with the noise data. The software gives the user the option of assessing dose relative to the MSHA PEL, the Action Level or the NIOSH Recommended Exposure Limit. The software generates a variety of interactive on-screen displays showing where, when, and how the worker's noise dose accumulated. It also can generate customizable printed reports. These outputs can be used to highlight the tasks, locations, and times that are associated with the greatest amount of the worker's noise exposure. DOSES simplifies the record keeping and analysis associated with time-motion studies and worker noise exposures, so mine management can make engineering noise control or administrative control decisions to limit the noise over-exposure of their workers.

INTRODUCTION

The Determination of Sound Exposures (DOSES) software (1) was developed by the National Institute for Occupational Safety and Health (NIOSH) specifically for use by mine management and safety personnel. DOSES simplifies the recordkeeping and analysis associated with time-motion studies and worker noise exposures, making it easier to identify and solve noise problems. The software relies on a time-motion study that profiles the worker's daily activities. At the same time, noise measurements are collected with a dosimeter or sound level meter (SLM). Observations about the worker's location and tasks or other activities are recorded along with times and durations so they can later be matched up with the noise data. After the completion of a time-motion study of the worker's daily tasks and locations associated with possible noise sources and measurement of the worker's noise exposures during the recorded events, the information is entered into DOSES. The program then displays information about the worker's accumulated noise dose over time. The software gives the user the option of assessing dose relative to the NIOSH recommended exposure limit (REL), the Mine Safety and Health Administration (MSHA) permissible exposure level (PEL), or the MSHA action level (AL). To obtain the NIOSH REL dose the software uses a 3-dB exchange rate, an 80-dB threshold level, and an 85-dB criterion level (2). To obtain the MSHA PEL dose the software uses a 5-dB exchange rate, a 90-dB threshold level, and a 90-dB criterion level. To obtain the MSHA AL dose the software uses a 5-dB

exchange rate, an 80-dB threshold level, and a 90-dB criterion level [64 Fed. Reg.^a 49548 (1999)].

The software generates a variety of interactive on-screen displays showing where, when, and how the worker's noise dose accumulated. It also can generate customizable printed reports. These outputs can be used to highlight the tasks, locations, and times that are associated with the greatest amount of the worker's noise exposure. Mine safety personnel can then use these reports to make decisions about how to reduce or eliminate the factors that are creating an overexposure.

SYSTEM REQUIREMENTS

To run the DOSES program effectively, the user's computer should meet the following system requirements in Table 1:

Table 1. System Requirements.

Operating system: Windows 2000/XP/Vista		
Hardware	Minimum	Recommended
Processor	Pentium 200 Hz or equivalent	Pentium III or greater or Celeron 600 MHz or equivalent
Disk space	80 MB	80 MB
Memory	64 MB of RAM	256 MB of RAM
Screen resolution	800 x 600	1024 x 768

COLLECTING TIME-MOTION DATA

As with any computer program, the utility and outcome of DOSES depends greatly on the quality of information entered. Task observation, or time-motion study, is the basis for the program's input and must be complete and detailed. Gaps in observations and recorded durations will compromise the value of the results because they increase the likelihood of missing critical events related to overall noise exposure. These inaccurate results could lead to invalid comparisons and misguided or ineffective exposure reduction attempts. For effective time-motion studies, the following must be considered: Whether to perform task observations or location observations, what timeframe to record, and whether to conduct full- or partial-shift observations (4) (5).

Task Observations versus Location Observations

Depending on the classification of the worker being observed, it may be better to use one method of observation over another. Most of the time it is recommended and logical to use task observations. This is done by recording each task a worker performs and the task durations. Observing a machine operator, for instance, would logically involve task observations because these operators tend to remain with their machine, positioned at a relatively fixed location, and perform a uniform and repeated series of tasks throughout their shift. For example, a continuous miner operator, even operating remotely, would stay at a relatively fixed position with respect to the continuous miner and complete tasks such as moving (tramming), cutting, loading, cutting and loading, waiting on shuttle car, etc. Location observations

^a Federal Register. See Fed. Reg. in references.

best suit time studies of workers who move about frequently during the shift, perform many different tasks, and spend time at many locations. Examples include utility workers in underground coal mines or plant workers at coal preparation plants. These workers are on the move during the entire shift but return to specific locations often during the shift. They may repeat similar tasks, but tend to repeat them at the same locations throughout the shift. It is recommended that no matter which method of observation is used, detailed notes should be taken. When task observations are employed, the specific location of those tasks should be noted on the data sheets. Conversely, when location observations are used, the specific tasks being performed at each location must be noted. The end goal is to be able to get an accurate picture of each component of the employee's noise exposure so that crucial noise exposures can be managed and the difference in total dose (pre- and post-noise control) can be ascertained.

Timeframe Recorded

A second important part of the data collection process is determining the timeframe for recording each task/location. At a minimum, times should be recorded to the minute. Even better is to note the time intervals to the second, i.e., in the format hr:min:sec. As experience is gained conducting observations for various occupations, the precision and detail of both the observations and recording times will be easier to determine based on length of each task or time at each location. Long-duration tasks/locations likely require a less stringent time recording (hr:min), while rapidly occurring tasks or changing locations would require a "tighter" recording time (hr:min:sec).

Duration

The duration of the observations must be considered. Full-shift observations take just that—a full shift—to complete, plus the time needed to enter the observation data and dosimeter files into DOSES. This is a substantial time commitment for the observer. However, full-shift observations are recommended when the sources of a worker's noise exposure are not already well understood. The benefits of a full-shift observation include a complete description of what the worker has done during the shift and a full-shift dose measurement that can be used for compliance purposes. For certain workers, partial-shift observation can still be useful when time does not permit full-shift observation. If a worker is known to perform the same tasks, the same number of times, and for the same duration each time during a shift, it may be possible to ascertain that worker's exposures with a partial-shift observation. Observing several complete cycles of each of the tasks performed may be sufficient.

Data Sheets

The abbreviated data collection sheet shown in Table 2 (see Appendix) is an example of the type of information that should be recorded when completing a time-motion study for use in the DOSES program. The bold items are Field Titles while the nonbold items would be filled in by the observer. DOSES is designed for time-motion study data to be entered by start/stop time. The start and stop time of each work task and/or location and the related sound level (SL) measurement are critical to the final analysis report. It is important to keep the start and stop times sequential without any gaps. DOSES enforces sequential data collection to assure that no exposure events are overlooked. In cases where a gap in data collection is intended, the user can enter a filler task with a zero SL if no events that will contribute to overall dose are anticipated during the period. Another alternative is to end the study at the last observation before the gap and start a new study with the next observation. It is also important to attempt to list all possible tasks or locations on the data sheets before beginning the study and to leave some blank columns for unanticipated tasks or locations. The program also requires entries for the date of the study, the employee's MSHA occupation code, and the MSHA equipment operated code (6).

These data are needed to complete the DOSES analysis of the worker's work tasks and/or location contributions to the cumulative daily dose and for the mine's noise control database.

When using the time-motion study sheet, there is a need to be consistent, especially within a specific job classification. First, it is

important to always label the worker occupations with the same names using the MSHA occupation codes (6). Second, it is suggested that task and location descriptions also be consistent to allow for comparisons between time studies of the same employee and between employees with the same occupations.

Instrumentation

The instrumentation best suited for conducting exposure and SL analyses includes a person-wearable dosimeter for monitoring worker noise exposure and an SLM for measuring the SLs for each task or at each work location. DOSES can use data from a wide range of dosimeters that are used for occupational noise assessment. It allows for downloading of dosimetry data from all of the dosimeters commonly used at mining, including those that have received MSHA intrinsic safety approval for use in underground coal mines. Most dosimeters can also be used as long as they provide time-stamped SL data in plain ASCII text files. Therefore, companies can choose their own SLM or dosimeter for measuring SLs.

Dosimeter settings for the NIOSH REL, MSHA PEL, and MSHA AL are shown in Table 3. For most mining applications, the MSHA PEL and AL are the dosimeter settings likely to be used, although DOSES does not require any particular setting as long as a time and sound level are being saved to the dosimeter's internal memory. DOSES calculates the dose relative to three criteria—NIOSH REL, MSHA PEL, and AL—from the time and SLs downloaded from the dosimeter.

Table 3. Dosimeter Settings.

	NIOSH REL	MSHA PEL	MSHA AL
Weighting	A	A	A
Threshold level	80 dB	90 dB	80 dB
Exchange rate	3 dB	5 dB	5 dB
Criterion level	85 dB	90 dB	90 dB
Response	Slow	Slow	Slow
Upper limit	140 dB	140 dB	130 dB

USER INSTRUCTIONS

When the DOSES program is opened it displays the "Start DOSES" splash screen that shows three button choices: OPEN Time Study, NEW Time Study, and Continue (Figure 1). To open a saved file, select the "OPEN Time Study" button. A file browse dialog is displayed to allow selection of a previously saved study.

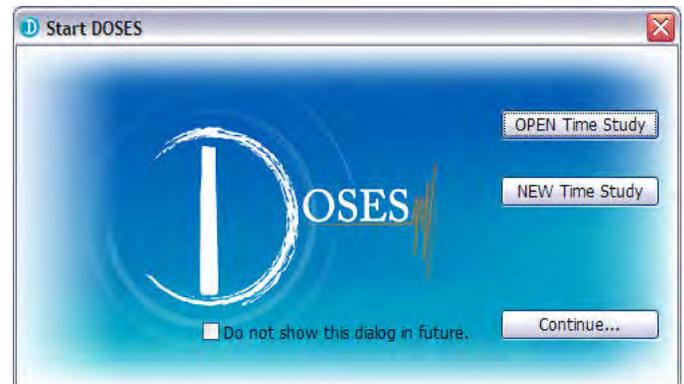


Figure 1. Start DOSES splash screen.

To enter a new study, select the "NEW Time Study" button. To close this screen, select the "Continue" button, the "Start DOSES" screen closes, and the "DOSES Time Study Editor" screen is displayed in a disabled mode. From here select "Open", "New" or "Exit" from the File menu, or the "Help" files can be viewed. The other menus will be disabled until an existing study is opened or a new study is created.

Time Study Properties—New Study Screen: Time Study

The next window is the default screen when "NEW Time Study" is selected from the "Start DOSES" screen (Figure 2). The other tabs: "Employee", "Mine", "Shift", and "Dosimeter" are selected and the information filled in after the Time Study screen is completed.

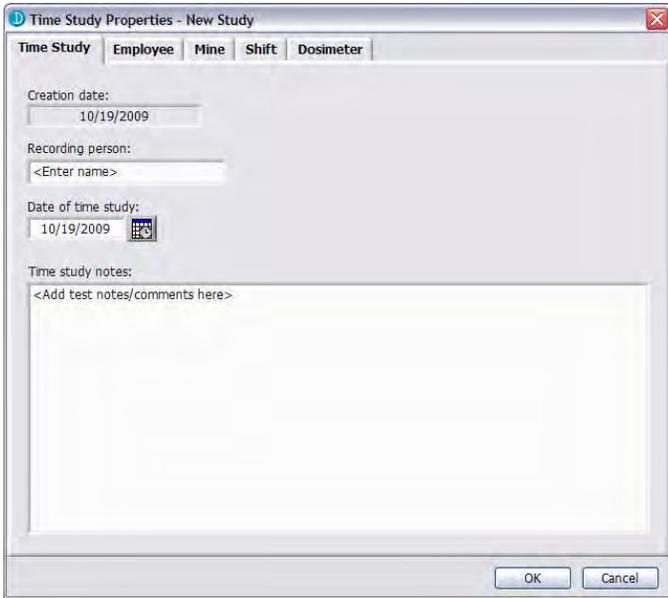


Figure 2. Time Study Properties - New Study Screen: Time Study.

Next Screen: Time Study Properties—New Study Screen: Employee

For the: “Employee” tab (Figure 3), the MSHA Occupation and Equipment Operated codes (6) are selected from the lists provided, other personnel information can be entered in the text boxes.

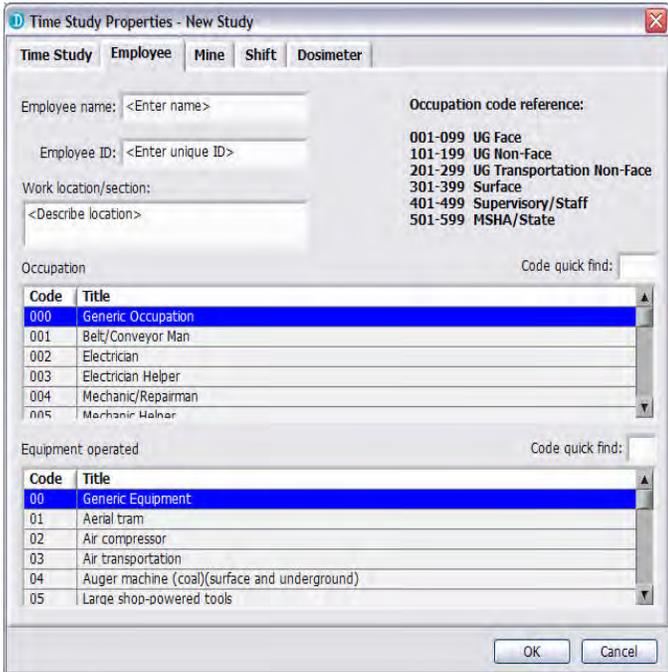


Figure 3. Time Study Properties - New Study Screen: Employee.

Time Study Properties—New Study Screen: Dosimeter

If a dosimeter was used to collect data, the information about the dosimeter and calibration can be entered by activating the “Dosimeter” tab (Figure 4). The dosimeter’s log file location (Drive and folder name) is entered in the window under “Log File”. This file has first to be exported from the dosimeter’s software into Excel or a similar spreadsheet program and formatted to the specifications of one of the ten formats in the “Format:” drop down list. Once a format is chosen from the list, an hour, minute, second and numeric format example appears in the “Example:” window. The chosen format example must be a duplicate of the dosimeter’s log file format for the file to download

into DOSES. After all the information is entered the “OK” button is clicked on to move to the “DOSES Time Study Editor” screen to enter the time-motion data.

NOTE: The dosimeter file is not needed to complete the analysis.

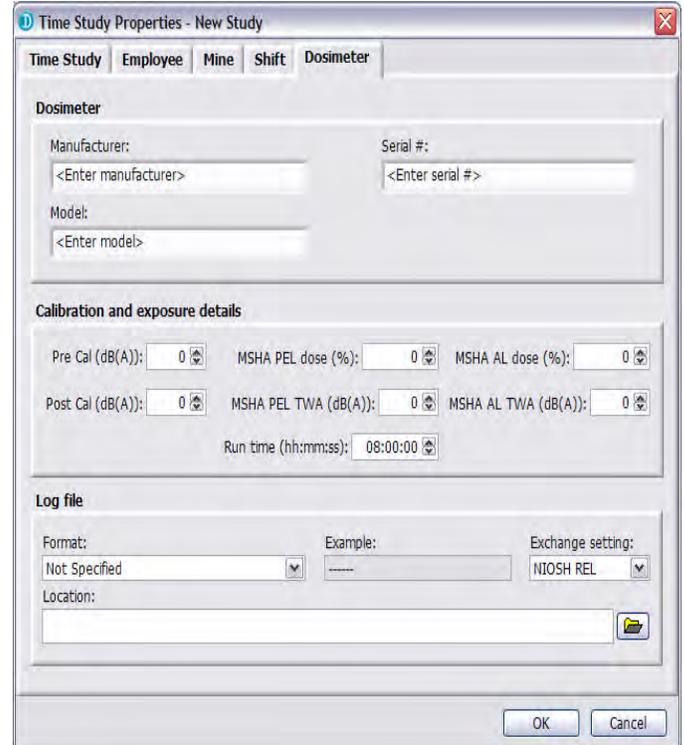


Figure 4. Time Study Properties - New Study Screen: Dosimeter.

DOSES Time Study Editor Screen

The “DOSES Time Study Editor” screen (Figure 5), is initially disabled when the program starts. However, this screen is enabled when an existing “Time Study” is opened or a “New Time Study” is successfully started. This screen contains these three areas: Observation Editor, Table View and Graph View. At the top of the screen four menu options are available: “File”, “Observation”, “Analysis” and “Help”.

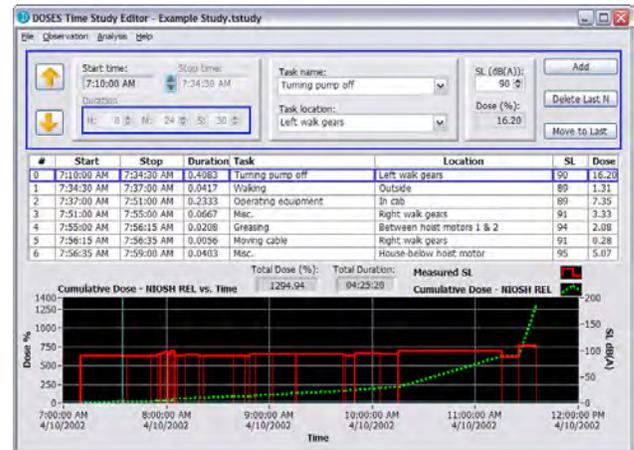


Figure 5. DOSES Time Study Editor Screen.

Observation Editor Area

This area is initially disabled when the program starts. The screen is enabled when an existing Time Study is opened or a new time study is successfully started. The “Observation Editor” (Figure 6), contains five main areas:

1. Previous/Next Observation (up/down yellow arrows)
2. Start time, Stop time, and Duration
3. Task name and Task location
4. SL (dB(A)) and Dose (%)
5. Editing Buttons

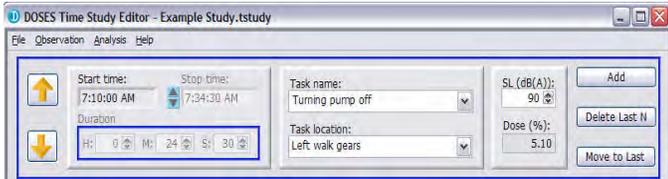


Figure 6. Example of Time Study Editor view.

Previous/Next Observation

Pressing the up or down yellow arrows allow for movement backward and forward in the list of observations.

Start/Stop Time and Duration Text Boxes

Each observation is defined in terms of a “Start time” and “Stop time”. The “Start time” is set once, when initializing the first observation with the “Set Study Start Time” dialog. From then on, the observation “Start time” is automatically set based on the “Stop time” of the previous observation. The “Stop time” is set as part of defining a new observation. It can be set by entering the exact stop time or by entering the “Duration” in hours (H), minutes (M), and seconds (S). Regardless of how the “Stop time” is set, the other stop time fields will update automatically.

NOTE: Only the “Stop time” of the last observation can be changed. If the “Stop time” of an observation within the study needs to be changed, all observations following must be deleted and reentered. This is to ensure time continuity in the observations.

Time Study Table View

The “Time Study Table” (Figure 7) is located in the center of the “DOSES Time Study Editor” screen. The “Time Study Table” provides a tabular view of the observations that were entered into the time study. Movement around the “Time Study Table” is possible by clicking on a row or scrolling down the table using the mouse or the keyboard. The table is updated automatically as observation data are entered. The current observation will have a blue border around it and new data cannot be entered by clicking on the last row of the table – only by using the “Observation Editor”.

#	Start	Stop	Duration	Task	Location	SL	Dose
0	7:10:00 AM	7:34:30 AM	0.4083	Turning pump off	Left walk gears	90	5.10
1	7:34:30 AM	7:37:00 AM	0.0417	Walking	Outside	89	0.00
2	7:37:00 AM	7:51:00 AM	0.2333	Operating equipment	In cab	89	0.00
3	7:51:00 AM	7:55:00 AM	0.0667	Misc.	Right walk gears	91	0.96
4	7:55:00 AM	7:56:15 AM	0.0208	Greasing	Between hoist motors 1 & 2	94	0.45
5	7:56:15 AM	7:56:35 AM	0.0056	Moving cable	Right walk gears	91	0.08
6	7:56:35 AM	7:59:00 AM	0.0403	Misc.	House-below hoist motor	95	1.01

Figure 7. Example of Time Study Table view.

Task Name and Task Location List Boxes

The task name and task location are entered for each observation. Entry is made by selecting the list box drop-down arrow and choosing from the list. A short explanation is displayed inside the list box for quick assistance. When starting a new time study with a previously unused occupation code, the “Add/Edit...” option is the only option available for both “Task name” and “Task location”. After selecting “Yes” to the “Do you want to Edit Task List?” dialog, an “Edit Item List” dialog appears, allowing for items to be added or removed from the list. Once the “Add/Edit” is completed, the new item(s) can be selected throughout the time study. The “Task name” and “Task location” list boxes are initially empty when creating a study using a new employee occupation code. They are populated as the

observations are entered and automatically saved for future use according to the employee occupation code.

NOTE: Removing an item from the list box does not remove it from the observations in the time study. Those entries will have to be manually reset to a valid list box value.

Sound Level and Dose

Each observation contains an SL number that is entered by either typing the number in the area provided or by using the numeric up/down control and moving to the desired number. The numeric up/down control increases or decreases the number by 1 dB(A). The dose is calculated by the program after the SL is typed in.

Time Study Analysis – Summary Tab

In the Summary section (Figure 8), the entered data are shown in two separate tables—one where the breakdown is by “Task,” the other where the breakdown is by “Location”. Included for reference beside the “Breakdown By Task” table is the “Overall Noise Exposure (%)” generated from the time study. The table can be sorted by clicking on any of the column headers. Clicking the same column header multiple times will toggle the sort between ascending and descending order. It is possible to visually chart the information contained in the table by clicking the “Draw Chart” button located below the table. The adjacent list box provides the option to chart the “# Obs.,” “Total Time,” “% Dose,” or “L_{AVG} dB(A) versus the Task Name”. To change the category, select from the list box by using the drop-down arrow.

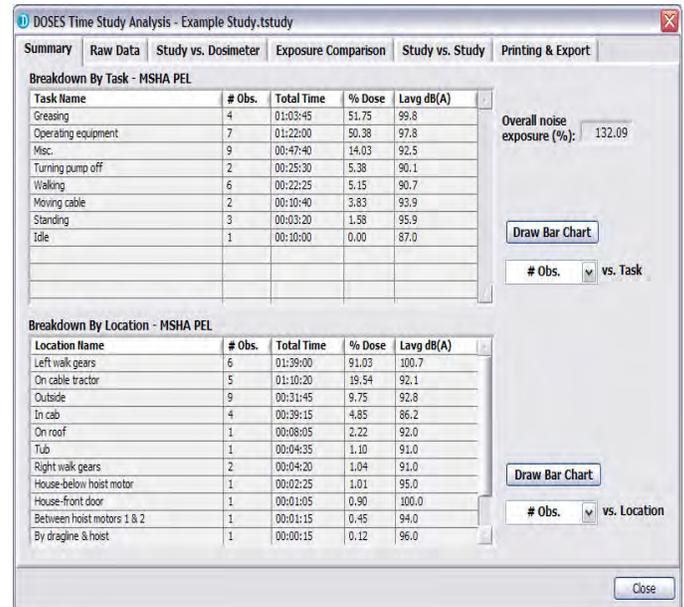


Figure 8. Example of Summary Section.

Time Study Analysis - Study vs. Dosimeter Screen

Using the “Study vs. Dosimeter” tab (Figure 9) displays a plot of the time study using one of the pre-selected calculations: NIOSH REL, MSHA PEL, or MSHA AL. The purpose is to provide a comparative view of the time study data and the dosimeter data.

Time Study Analysis Dialog – Printing & Export Screen

The “Printing & Export” tab (Figure 10) has the controls for printing reports and exporting the data. There are two report options for printing: “Study Report” and “Study vs. Study”. Specific options can be chosen for what parts to include in the study report by clicking the appropriate checkboxes. After the report option is chosen, left-click the “Print” button to access the print dialog. From this dialog, select whether to print to a file (HTML) or selected printer and the page orientation.

Export Button

The data are exported in an ASCII comma-delimited format with a default .csv extension which makes it readable by Microsoft Excel and other data analysis software (Figure 11). After selecting the export

option (Figure 10), left-click the “Export” button to access the export file dialog to select or choose to destination file.



Figure 9. Example of Study vs. Dosimeter graph.

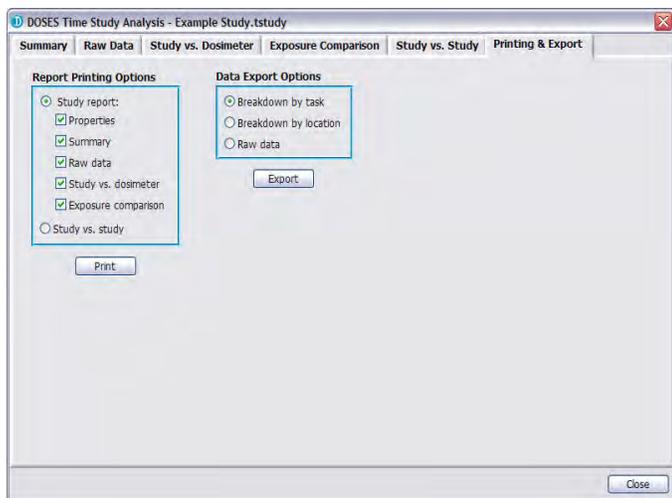


Figure 10. Time Study Analysis - Printing & Export Screen.

	A	B	C	D	E
1	Task Name	# Obs.	Total Time	% Dose	Lavg dB(A)
2	Greasing	4	01:03:45	51.75	99.8
3	Operating equipment	7	01:22:00	50.38	97.8
4	Misc.	9	00:47:40	14.03	92.5
5	Turning pump off	2	00:25:30	5.38	90.1
6	Walking	6	00:22:25	5.15	90.7
7	Moving cable	2	00:10:40	3.83	93.9
8	Standing	3	00:03:20	1.58	95.9
9	Idle	1	00:10:00	0	87

Figure 11. Microsoft Excel spreadsheet example.

INTERPRETATION OF RESULTS

The primary outcome of DOSES is an understanding of a worker’s noise exposure, what causes that exposure or locations where the exposure is occurring. The charts, graphs, and tables generated by DOSES are all designed to display this important information. Specifically, the outputs summarize a worker’s tasks/locations, time at each task/location, and dose accumulated at each task/location. This information is initially displayed as a

compilation by tasks/locations, listed from highest accumulated dose task/location to lowest accumulated dose task/location. This information can be sorted by task/location, duration, or accumulated dose. Mine safety personnel should be looking for the tasks or locations that result in the most accumulated dose. Once this determination has been made, then the appropriate intervention strategies can be selected. Interventions directed at the tasks or locations that result in the most dose have the best chance of significantly reducing a worker’s noise exposure.

INTERVENTIONS

DOSES is especially useful for evaluating the success of interventions intended to reduce noise exposure. There are two general types of exposure reduction interventions: engineering controls or administrative controls. Engineering noise controls attempt to reduce the SLs at the source or along the path from the source to receiver. The worker is exposed for the same length of time, but since the SL is reduced, less noise exposure occurs. Engineering controls might include quieter motors, reduced impact noise, sound barriers, sound-absorbing material, control rooms, and reduced metal-to-metal contact. Administrative controls attempt to remove the worker from the noisy area. In this case, the SLs remain the same, but since the worker does not spend as much time near the noise, the overall noise exposure is reduced. Administrative controls may include minimizing or eliminating tasks in high SL areas, remote monitoring, training to allow for faster task completion, and job rotation. In most cases, the most effective noise reduction is the use of an engineering control that reduces the SL. When all feasible engineering controls are implemented, administrative noise controls are the next best choice. One starting point for identifying specific engineering and administrative controls is MSHA Program Information Bulletin No. P08–12, “Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR Part 62)” (7).

Intervention Examples

Examples of interventions performed by NIOSH can illustrate some of the possibilities for noise reduction that could be evaluated with DOSES. To conduct these studies, NIOSH used several different time-consuming analysis techniques and software packages, a process that can be streamlined with DOSES.

One of the workers in underground coal mining likely to experience noise overexposures is the continuous mining machine operator. Exposure data collected by NIOSH showed that continuous mining machine operators had MSHA PEL doses as high as 347% (8). Some of the interventions that have been implemented include coated flight bars and coated tail rollers (engineering controls) and remote operator positioning and job rotation (administrative controls).

In another case, plant operators in coal preparation plants had MSHA PEL doses as high as 221% (8). The plant operators are the workers that routinely travel throughout the plant checking processes, cleaning, and performing minor maintenance. They are exposed to many different SLs emanating from any number of different pieces of processing equipment. Some of the interventions include: control booths, urethane screen decking, chute liners, and enclosing noise sources such as air compressors and pumps (engineering controls); remote monitoring, restricting travel to lowest SL areas, and job rotation with control room operators (administrative controls).

In a talc processing plant the baseline sound level measurements ranged from 93 dB(A) to 104 dB(A) (9). The initial engineering noise controls consisted of acoustic curtains installed around the fluid energy mill fans and a large crusher. Acoustic curtains were then used in front of the other crusher and the air classifying mills (ACMs), sound absorbing material was inserted under the hood of ACM 2, and maintenance and repairs on ACM 3 were completed. The sound levels measured after this work was completed (with the 60” roller mill – Off), ranged from 88 dB(A) to 94 dB(A), a significant reduction of 10 dB(A) from the highest baseline sound level. For the loudest ACM, the noise controls consisted of building a larger shroud, lining the inside of the shroud with a sound barrier material, and filling the interior of the shroud with sound absorbing material. The final control for this study

was wrapping the duct of a 60" roller mill with a sound barrier material. The sound level near the duct work of the 60" roller mill was reduced by about 4 dB(A). Using all these noise controls and fixing ACM 3, the mill floor's sound level was reduced to a range of 90 dB(A) to 94 dB(A).

Finally, in surface coal mining, dragline oilers had MSHA PEL measured doses as high as 193% (8). Interventions have included: sound barrier curtains around motor-generator sets, quieter motor blower fans, and wrapping of ductwork with insulation (engineering controls); restricting oiler time in the "house," remote greasing, and job rotation with dragline operator and dozer operator (administrative controls).

Intervention Success

Judging intervention success is accomplished by conducting time studies before a noise control has been implemented, then comparing the post-intervention time study with the pre-intervention time study. For instance, if an engineering control has been implemented, one would look for a dose reduction related to tasks using the modified equipments. If an administrative control has been employed as the exposure reduction method, one would simply check to see if the time spent at that location or task is less and, subsequently, if the result is less dose accumulation. DOSES allows these types of analyses to be completed rather easily by comparing pre- and post-intervention tables or dose graphs. Modeling of noise controls using the pre-intervention tables or dose graphs can determine the value of the noise controls before they are installed, thereby saving time and money. This is done by taking the attenuation of the selected noise control and applying it to the SL and using the total duration to determine the post-intervention dose.

SUMMARY

The NIOSH DOSES software can help streamline the process of conducting noise problem analysis and to evaluate noise control and administrative control solutions. The software requires very little additional equipment and works especially well with a series of task observations associated with sound level readings. NIOSH welcomes feedback from the DOSES user community via the contact information contained in the DOSES help system. For instance, suggestions from early users have been incorporated into a new test version that facilitates the use of high-resolution dosimeter data. In this dosimeter-optimized version, every data point collected by the dosimeter appears on the editing screen. The user can then use a cursor to select groups of data points that are associated with a task rather than entering task descriptions minute-by-minute. This and other user-suggested improvements will be incorporated into future iterations of DOSES that will be distributed through the NIOSH website.

REFERENCES

1. Cole GP, Spencer ER, Bauer ER (2009), "Determination of Sound Exposures (DOSES): Software Manual and Implementation

Guide.", U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Pittsburgh, PA: DHHS (NIOSH IC) Publication No. 2009-135.

2. NIOSH (1998). "Criteria for a Recommended Standard: Occupational Noise Exposure – Revised Criteria 1998", Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-126.

3. 64 Fed. Reg. 49548 (1999). Mine Safety and Health Administration: health standards for occupational noise exposure; final rule (30 CFR Parts 56, 57, 62, 70, and 71).

4. Hager LD, (2008), "Sound Exposure Profiling: A Noise Monitoring Alternative", AIHAJ, Vol. 59, 1998.

5. Virji MA, Woskie SR, Waters M, Brueck S, Stancescu D, Gore R, Estill C, Prince M. (2009), "Agreement Between Task-Based Estimates of the Full-Shift Noise Exposure and the Full-Shift Noise Dosimetry", Annals of Occ Hyg, 2009.

6. MSHA (2001), Information resource center. Part 50: diskette user's handbook. Available at: <http://www.cdc.gov/niosh/mining/data/pdfs/codes.pdf>

7. Stricklin KG, Quintana FA, Skiles ME (2008). "Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR part 62)", Arlington, VA: Mine Safety and Health Administration, Program Information Bulletin No. P08-12, June 18, 2008. Available at: <http://www.msha.gov/regs/complian/PIB/2008/pib08-12.pdf>

8. Bauer ER, Babich DR, Viperman JS (2006), "Equipment Noise and Worker Exposure in the Coal Mining Industry", Pittsburgh, PA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2007-105, IC 9492.

9. Spencer ER and Reeves ER. (2009), "Assessment of Engineering Noise Controls at a Talc Processing Plant", Mining Engineering, April 2009.

DISCLAIMER

The findings and conclusions in this report have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

APPENDIX

Table 2. Example of Time-Motion Study Sheet.

Data Sheet		Observations for: Continuous Miner Operator				
Date: 11/11/2007	Mine: XYZ	Section: North 11		Emp. First Name: Sam		
Unique ID: 1234	Manufacturer: Smith	Model: XYZ-1		Serial No.: 12345		
Normal Shift: [Y]	Shift Production: 2,000 tons			Dosimeter Tag: 12345		
Observer: Jane Doe			Other Info: Pittsburgh Coal Seam 3.4 m			
Time Start	Time Stop	Task – Location Observations				Sound Level Measurements
		Mantrip	Downtime	Con. Miner Operator at Face	Tramming in Crosscut	
06:00:00	06:25:20	X				95 dB(A)
06:25:20	07:00:45		X			73 dB(A)
07:00:45	11:00:00			X		97 dB(A)
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15:05:05	15:20:05				X	92 dB(A)
15:20:05	15:55:10		X			75 dB(A)
15:55:10	16:20:45	X				97 dB(A)