

CALCULATING STEL, TWA, MIN, MAX, AND AVERAGE VALUES FOR TOXIRAE PIDS

INTRODUCTION

This document gives an overview of the general meaning of TWAs and STELs and gives details on how these and other concentration data are determined and datalogged by the ToxiRAE PID, model PGM-30, through version 1.22 software. Depending on the datalogging options chosen, there may be differences between the instantaneously displayed values and the final datalogged values, as described below. The calculation methods also apply to nearly all other RAE instruments that datalog these values. All averages are calculated as arithmetic averages, rather than geometric.

DEFINITION OF TWA, STEL AND CEILING

Figure 1 gives a conceptual view of TWA, STEL and Ceiling values. Typically the TWA is the lowest value, STEL is somewhat higher and the Ceiling is the highest. Ceiling is the concentration that should never be exceeded, even for one instant. STEL is the Short Term Exposure Limit, which is a running 15-minute average concentration. The instantaneous concentrations may exceed the STEL value as long as they never exceed the Ceiling, and the 15-minute running average never exceeds the STEL limit. If the STEL alarm is reached, the worker must be removed from STEL level exposure for at least one hour. Workers can be exposed to a maximum of four STEL periods per 8 hour shift, with at least one hour between exposure periods.

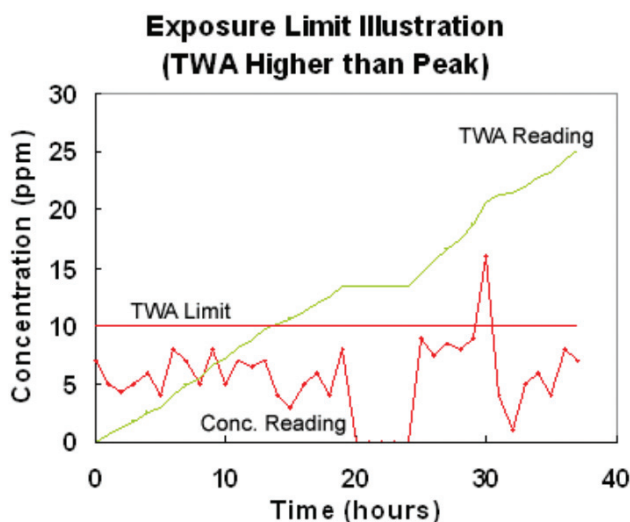


Figure 1. TWA can exceed the Peak value if readings are accumulated for more than 8 hours.

TWA is a dose that should not be exceeded over either an 8-hour period (OSHA PELs and ACGIH TLVs) or a 10-hour period (NIOSH RELs).

Displayed Values

- **Second Values:** Every second, the signal is sampled for several milliseconds and the data is averaged to give the instantaneous reading.
- **Minute Average:** The Second Values are added to a running sum and every minute this sum is divided by 60 to obtain a minute average. The Minute Average is not displayed, but is used to calculate the TWA and STEL. The Second Value, after the next instantaneous reading is made.
- **STEL:** The Minute Average values are then stored in a rolling buffer for fifteen minutes to calculate the STELs and then overwritten. The STEL is updated every minute as an average of the most recent fifteen Average Minutes.
- **TWA:** The Minute Average values are also used to update the TWA every minute, by adding to a running sum and dividing by the number of minutes in an eight-hour day (480). The TWA is the value accumulated from the time the instrument is turned on till the time of the last Minute Average, it assumes no further exposure from then on. The TWA continues to accumulate after eight hours until the instrument is turned off.
- **Peak Value:** The Peak Value is updated every second and is the highest measured Second Value since the unit was turned on.

Logged Values

The ProRAE-30 Program downloads minimum, average and/or maximum values within a defined datalogging period. The datalogging period is defined as a time interval within the total datalogging event. The user defines the datalogging period in one-second increments from one second up to one hour.

STEL and TWA values are not downloaded directly, but are recalculated from the downloaded minimums, averages or maximums.

- The **Minimum Value** is the lowest Second Value measured during each datalogging period.
- The **Average Value** is the arithmetic average of all Second Values measured during each datalogging period.

- The **Maximum Value** is the highest Second Value measured during each datalogging period.
- The **STEL** is calculated as the average of the maximum logged results of the previous fifteen-minute window:

$$\frac{\Sigma (\text{All max logged values in last 15 min})}{\# \text{ values in 15 min} = (15 * 60) / \text{period (sec)}}$$

- The **TWA** is calculated as:

$$\text{Previous TWA} + \frac{\text{max logged value} * \text{period (sec)}}{480 * 60}$$

Unlike a Running Average, the TWA is an accumulated exposure dose, and thus the value can never decrease.

As noted before, the logged values can be different from the displayed values if inappropriate datalogging parameters are chosen. The program always uses the highest values available to calculate the TWA and STEL. To ensure that the displayed and logged values are identical, the user should chose a datalogging period of fifteen minutes or less. It is also suggested that the user log average only or average and minimum values, but not peak values.

EXAMPLES

Following are two examples. One shows you how to properly set up your instrument obtain correct Time Weighted Averages (TWA) and Short Term Exposure Limits (STELs). The other is an example of an improper set-up that will lead to false and missing data. We hope that you will find both of them interesting and informational.

Example ONE: Proper Set-up to Obtain correct TWA and STEL Values

| S/N: 001403 | | User ID: 1 | | Site ID: 1 | | Cal: 9/20 16:56 | | 100.4 ppm |
|-------------|------|---------------|---------|--------------|-------|-----------------|------|-----------|
| Year: 1996 | | Period(s): 60 | | Data Pts: 40 | | Chk: 9/20 14:40 | | 100.5 ppm |
| Date | Time | Min | Avg ppm | Max | High | Low | STEL | TWA |
| | | | | | 100.0 | 50.0 | 25.0 | 10.0 |

| | | | | | | | | |
|-------|-------|---|------|---|--|--|-----|-----|
| 11/05 | 10:52 | - | 10.7 | - | | | 0.7 | 0.0 |
| | 10:53 | - | 9.7 | - | | | 1.4 | 0.0 |
| | 10:54 | - | 8.7 | - | | | 1.9 | 0.1 |
| | 10:55 | - | 8.0 | - | | | 2.5 | 0.1 |
| | 10:56 | - | 7.4 | - | | | 3.0 | 0.1 |
| | 10:57 | - | 7.0 | - | | | 3.4 | 0.1 |
| | 10:58 | - | 6.7 | - | | | 3.9 | 0.1 |
| | 10:59 | - | 6.4 | - | | | 4.3 | 0.1 |
| | 11:00 | - | 6.2 | - | | | 4.7 | 0.1 |
| | 11:01 | - | 6.0 | - | | | 5.1 | 0.2 |
| | 11:02 | - | 5.8 | - | | | 5.5 | 0.2 |
| | 11:03 | - | 5.7 | - | | | 5.9 | 0.2 |
| | 11:04 | - | 5.5 | - | | | 6.3 | 0.2 |
| | 11:05 | - | 5.4 | - | | | 6.6 | 0.2 |
| | 11:06 | - | 5.3 | - | | | 7.0 | 0.2 |
| | 11:07 | - | 5.2 | - | | | 6.6 | 0.2 |
| | 11:08 | - | 5.1 | - | | | 6.3 | 0.2 |
| | 11:09 | - | 5.0 | - | | | 6.0 | 0.2 |
| | 11:10 | - | 4.9 | - | | | 5.8 | 0.3 |
| | 11:11 | - | 4.8 | - | | | 5.7 | 0.3 |
| | 11:12 | - | 4.7 | - | | | 5.5 | 0.3 |

1. Logged Avg Values only; TWA & STEL agree with the readout.
2. The first Fourteen minutes of STEL values always increase because they assume zero concentration before the first time point.
3. After Fifteen minutes STEL is correct because Period < 7.5 minutes and divides evenly into Fifteen.

Example TWO: Improper Set-up to Obtain Correct TWA & STEL

S/N: 001403 User ID: 1 Site ID: 1 Cal: 6/20 45:29 106.6 ppm
 Year: 1996 Period(s): 600 Data Pts: 11 Chk: 4/3 15:41 100.3 ppm

| Date | Time | Min | Avg ppm | Max | High 100.0 | Low 50.0 | STEL 25.0 | TWA 10.0 |
|------|------|-----|------------|-----|---------------|-------------|--------------|-------------|
|------|------|-----|------------|-----|---------------|-------------|--------------|-------------|

| | | | | | | | | |
|------|-------|---|-----|-----|--|--|-----|-----|
| 5/10 | 11:24 | - | 2.7 | 3.6 | | | 3.6 | 0.1 |
| | 11:34 | - | 1.7 | 2.7 | | | 2.7 | 0.2 |
| | 11:44 | - | 1.6 | 2.7 | | | 2.7 | 0.2 |
| | 11:54 | - | 2.2 | 4.4 | | | 4.4 | 0.3 |
| | 12:04 | - | 3.9 | 4.6 | | | 4.6 | 0.4 |
| | 12:14 | - | 4.1 | 5.4 | | | 5.4 | 0.5 |
| | 12:24 | - | 2.9 | 3.8 | | | 3.8 | 0.6 |
| | 12:34 | - | 1.4 | 1.9 | | | 1.9 | 0.6 |
| | 12:44 | - | 2.2 | 4.0 | | | 4.0 | 0.7 |
| | 12:54 | - | 3.0 | 3.9 | | | 3.9 | 0.8 |
| | 13:04 | - | 1.8 | 3.8 | | | 3.8 | 0.9 |

1. Logged Avg & Max values; TWA & STEL differ from the readout because they are calculated from Max values.
2. Period > 7.5 minutes; STEL does not average the last Fifteen minutes correctly; it only tracks the Max value.