Noise Monitoring

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Iowa-Illinois Safety Council
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Objectives

At the end of the session, participants will understand:

- Noise exposure terminology and guidelines
- Essential equipment configurations
- How to interpret dosimeter output to make decisions
- Current trends of regulators and best practices

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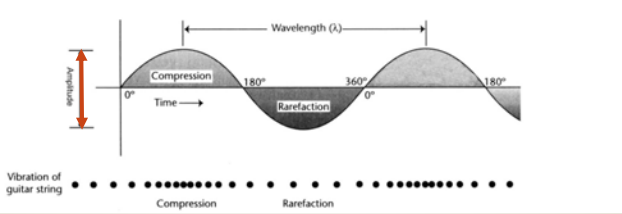
Sound/Noise Refresher

- Sound: small, quick variation in surrounding pressure, caused by compression and rarefaction of molecules
- Noise: Unwanted sound
- LOUDNESS = Pressure amplitude



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Sound/Noise Refresher

- LOUDNESS = Pressure amplitude
- Measure this sound pressure level (SPL) in units of dBA
  - Pressure ratio based on threshold of hearing

SPL in dB = 10 log $[p_1/p_0]^2$ = 20 log $[p_1/p_0]$

Reference level pressure = p_0
p_0 = 0.0002 dyne/cm^2 = 0.00002 N/m^2 = 20 μPa

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Sound/Noise Refresher

- Because dBA is in a log scale, we need to consider effects differently than arithmetic averages…
  - Pressures might add directly
  - Noise in dBA do not

$$Lp = 10\log_{10}\left[\sum_{i=1}^{n} 10^{\frac{Lp_i}{10}}\right]$$

  - Using this equation, we can see that ***two*** *noise sources of* ***same pressure*** *results in* ***3 dB increase*** in overall sound level

$$Lp = 10\log\left[10^{\frac{90}{10}} + 10^{\frac{90}{10}}\right] = 10\log\left[10^{9} + 10^{9}\right] = 10\log\left[2\times 10^{9}\right] = 10\times 9.3 = 93$$

  - Double INTENSITY → increase SPL by 3 dB

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Guidelines: Exposure Limits

- OSHA (1910.95; 1926.52)
  - Engineering: 90 dBA, 8 hr
  - Hearing Conservation: 85 dBA, 8 hr
- NIOSH
  - 85 dBA, 8 hr
- ACGIH
  - 85 dBA, 8 hr

We need to set up equipment specific to each limit.

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Guidelines: Exposure Limits

	Exchange/ Doubling Rate:
OSHA (1910.95; 1926.52)	
Engineering: 90 dBA, 8 hr	5 dB
Hearing Conservation: 85 dBA, 8 hr	5 dB
NIOSH	
85 dBA, 8 hr	3 dB
ACGIH	
85 dBA, 8 hr	3 dB

For every "doubling rate" dB increase, half the time allowed

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Guidelines: Exposure Limits

	Threshold:
OSHA (1910.95; 1926.52)	
Engineering: 90 dBA, 8 hr	90 dBA
Hearing Conservation: 85 dBA, 8 hr	80 dBA
NIOSH	
85 dBA, 8 hr	80 dBA
ACGIH	
85 dBA, 8 hr	80 dBA

Do not include sound levels that are ***BELOW*** these values in the computed time-weighted average exposure

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Guidelines: Exposure Limits

- **OSHA (1910.95; 1926.52)**
  - Engineering: **90** dBA, 8 hr
  - Hearing Conservation: **85** dBA, 8 hr
- Exposure limits based on TIME ALLOWED at a specific dBA

$$T_{(hrs)} = 8 / 2^{(L-90)/5}$$

L = measured A-weighted sound level

Sound Level (dBA)	Time Period (Hrs)
90	8
92	6.1
95	4
97	3
100	2
102	1.5
105	1
110	0.5
115	0.25

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Guidelines: Exposure Limits

- **NIOSH & ACGIH**
  - **85** dBA, 8 hr

$$T_{(hrs)} = 8 / 2^{(L-85)/3}$$

L = measured A-weighted sound level

Sound Level (dBA)	Time Period (Hrs)
85	8
88	4
91	2
94	1
97	0.5
100	0.25
103	7min 30sec
106	3min 45sec
109	1min 53sec

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Guidelines: Exposure Limits

- OSHA Engineering: 90 dBA TWA ← *"Criterion"*
  (**90 dBA threshold**, 5 dB doubling, slow, A-weight)
- OSHA HC setting: 85 dBA TWA
  (80 dBA threshold, 5 dB doubling, slow, A-weight)
- NIOSH/ACGIH setting: 85 dBA TWA ← *"Criterion"*
  (80 dBA threshold, **3 dB doubling**, slow, A-weight)

Why different?
- 3 dB doubling accounts for
  - Doubling of sound energy
  - Health outcomes
- 85 vs 90 dBA TWA:
  - *Neither* protects all workers.
  - NIOSH estimates 40-year lifetime risk (8 hr/day, 40 hr/week) of NIHL for workers:
    - 90 dBA: 1 in 4 workers (25%)
    - 85 dBA: 1 in 12 workers (8%)

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Monitor Configurations

- You must decide the standard(s) you want to use ***before*** you set up your monitors
  - ***ALL*:** Slow response, A-weighted
  - ***Doubling Rate:*** *OSHA (5)* or *Not-OSHA (3)*
  - ***Threshold:***
    - All ***hearing conservation*** sets this to 80 dBA
    - If you are assessing noise levels in quieter places (offices, restaurants, etc.), you can drop this even further… just note it on your records
- Modern dosimeters typically store and compute exposures for **2** settings

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Monitor Configurations

- Recommendation for two-setting units:
  - OSHA HC setting;
    80 dBA threshold, **5 dB** doubling, slow, A-weight
  - NIOSH/ACGIH setting
    80 dBA threshold, **3 dB** doubling, slow, A-weight
- This leaves out the 90 dBA engineering control limit
  - Using OSHA HC readings to make 90 dBA "feasible engineering control" decisions is ***conservative***
  - ***You may overestimate the "Engineering" TWA, but note to file how you sampled.***
  - You can also download data and manually zero data below the 90 dBA threshold and recalculate TWA

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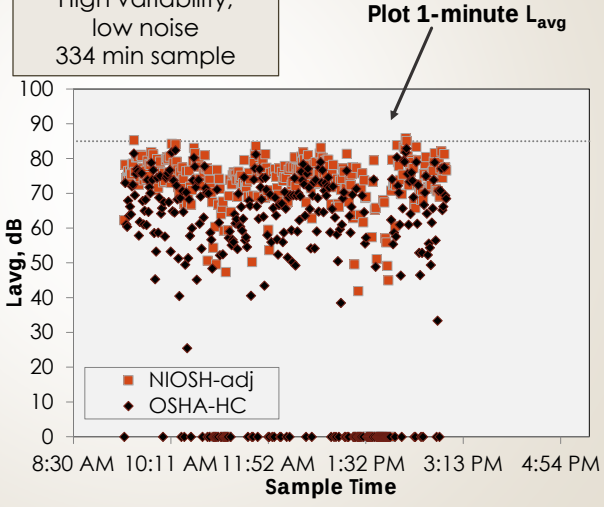
How Do Settings Affect Data?

NIOSH-adj
Threshold = 70 dB
- *lower than required*: concerned get no information

OSHA-HC
threshold of 80: lots of 1-minute data → 0 dB

Worker 1:
High variability, low noise
334 min sample



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How Do Settings Affect Data?

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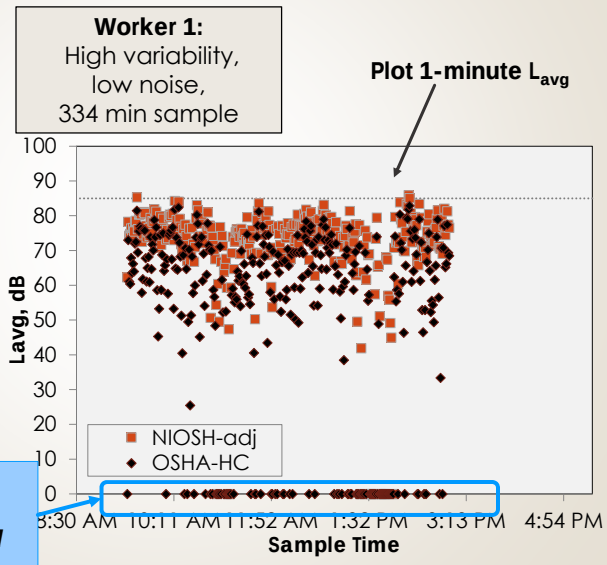
Threshold = 70 dB
- *lower than required*: concerned get no information

OSHA-HC
threshold of 80: lots of 1-minute data → 0 dB

All these were 1-min periods when no noise exceeded the threshold → 0 dBA

Worker 1:
High variability, low noise,
334 min sample



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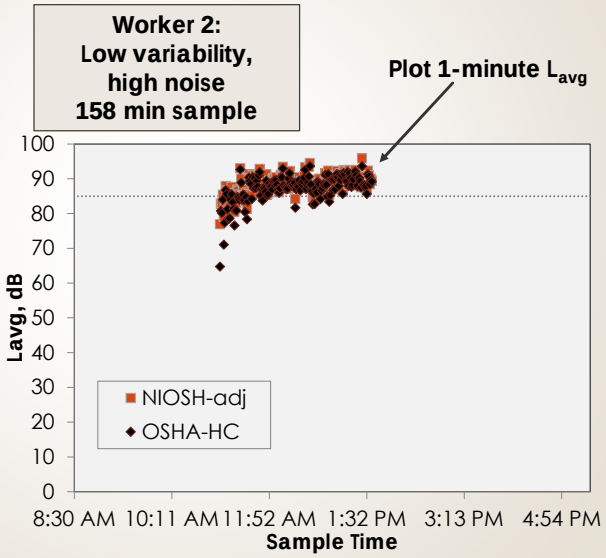
Low variability, high noise
158 min sample



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Sound Level Meter vs Dosimeter

- Sound Level Meter
  - Record *area readings* –
    - *Identify high / low noise areas*
    - *Do time-motion studies to compute TWAs*
  - Must identify **Time Spent** in sound level areas over a shift
  - Walk through: take readings at ear height, where workers stand
  - Compute Dose → TWA

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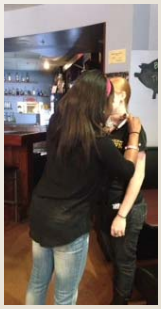
- Dosimeter
  - Obtain *personal exposures* measures sound and time spent at sound level
  - Microphone on shoulder (near ear)
  - Check throughout shift; beneficial to take sound level readings in work area
  - Electronic calculations



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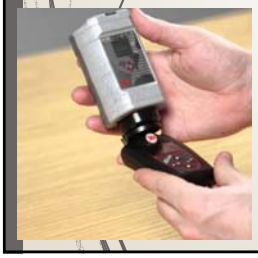
How to Select Meters

- Need at least Type 2 device
  - +/- 2 dB accuracy
- Slow response, A-weighting
- Wind screen

Type:
0: Lab
1: High precision field (OBA)
2: General purpose

ANSI S1.4 (Specifications for sound level meters)
Note: a 2002 version

- Need to calibrate
  - Before and after testing (2/day)
  - Fittings must mate to microphone
  - Units typically 114 dB at 1000 Hz
  - Annual checks of calibrator by MFR are needed



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Dosimeter Output

Output Display (Quest Q-300):

Serial No.	Pre-Cal	Peak	MAX	MIN	Dose	PDOSE	EXP
SEL	LAVG	TWA	RT	PT	UL	Post-Cal	

Output Display (Quest Q-400 and Q-500):

Serial No.	SPL	Peak	Max	Min	Dose	PrD.8	PrD.(Prt)	Exp.
SEL	Lav	TWA	TWA(prt)	RunTime	PKTime	MaxTime	MinTime	LogTime

Output Display (Metrosonic dB-3100):

Serial No.	Pre-Cal	LA	80A	90A	8A	8A1	
8A2	LH	LP	80d	80P	80d	90P	Post Cal

Quest Q-400 and Q-500 Terms Defined:

SPL: **Sound Pressure Level**– displayed each second as the maximum value for the previous 1 second period (dB)

Peak: **Absolute Unweighted Peak**–the highest instantaneous sound pressure that occurs during a given time period (dB)

Max: **Maximum Level** – the highest sound pressure level that occurs in a given time period (dB)

Min: **Minimum Level** – the lowest sound pressure level that occurs during a given time period (dB)

Dose: **Dose** – a percentage of the maximum allowable daily noise dose (%). This is a computation that is based on the following: criterion level, lower threshold, and exchange rate

PrD.8: **8-hour projected dose** – Computed by measuring dose from some period of time and extrapolating it to a different time period (50% dose / 4 hours = 75% projected dose / 6 hours)

PrD.(Prt): **Variable projected dose** –

EXP: **Exposure** – (Pascals² x hours)

SEL: **Sound Exposure Level**–the constant sound level which, if lasting for one second, would deliver the same amount of acoustical energy as that delivered over the entire measurement period. (dB)

LAV: **Average level (or LEQ)** - The average sound level for the measurement period based on a 3 dB exchange rate. If the exchange rate (ER) is 4, 5, or 6, then the LEQ becomes the LAVG.

TWA: **Time-Weighted Average** – the sound level that is accumulated for any time period but with its average level computed over an 8-hour time period. If the time period is less than 8 hours, the TWA will always be less than the LAVG. If the time period is more than 8 hours, TWA will always be more than the LAVG.

TWA (PRT): **Projected Time-Weighted Average** – Used to determine the TWA when the operator wishes to use a measurement time that is different from the worker's exposure time. For example, if measure for 5 minutes and the employee works 4 hours on a given day, program the Prt to 4 hours, take a 5 minute sample, then the average level is assumed to be constant over the projected time. Read out the Projected TWA.

Manual Data Recovery

1. Press "1" if the unit has been turned off
2. Press "1" and "3" together to call-up each function and value on the display. They appear in the order shown, below:

Dur: test duration
LA: L-average
80A: L-average with 80dB cutoff
90A: L-average with 90dB cutoff
8A: Time-weighted average
8A1: Time-weighted average with 80 dB threshold criterion
8A2: Time-weighted average with 90 dB threshold criterion
LH: L-max
LP: L-peak
80d: %Dose with 80 dB threshold criterion
80P: Projected dose with 80 dB threshold criterion
80d: %Dose with 90 dB threshold criterion
90P: Projected dose with 90 dB threshold criterion

Dosimeter Output

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Edge Dosimeter

Serial No.	L_{AS}	L_{ASMX}	L_{CPK}	L_{ASMIN}	L_{AVG}	L_{TWA}	L_{AE}
	(SPL)	Max SPL (<<115) **A**= A-wt **S**=slow	Peak Level (<140)	Lowest	Ave sound level (if 3 dB exchange: LEQ)	The TWA	SEL=sound exposure level (not used)
Dose	**PDose**	**UL**	**L_{C-AAVG}**	**Time Resp**	**RT**	**Weight**	
	Projected dose (to 8 hour)	Amt of time noise > preset level	dBC-dBA (For NRR calcs)	SLOW or FAST response time	Total run time	Filter weight selected	

Review the manufacturer's book AND sequence of output on screen to make a "form" to identify which output you want to record, by hand, at end of the day.

If renting equipment, make sure you get download software and export data (to excel)…

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Data Processing

- If Sound Level: Manual processing
- Download / grab off screen if dosimeter
- Objective:
  - Obtain exposure information:
    - TWA (or *projected* TWA if sample for << 8 hours)
    - Dose (and *projected* dose…)
    - Run time (to confirm projections)
    - Don't forget to document your setup!! (Doubling rate, Threshold, Criterion)
  - Compare the Exposures to your "Limits"
    - Determine who is included in HC Program
    - Include TWA (projected TWA) in audiometric files
    - Assess effectiveness of HPD (NRR)

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How to Calculate TWA?

$T_{(hrs)} = 8 / 2^{[L-85)/3}$

$T_{(hrs)} = 8 / 2^{[L-90)/5}$

Determine **Time Exposed** at a given SPL

Measure SPL

Compute **TIME ALLOWED** at that SPL

At SPL$_i$:
D_i = Time Exposed / Time Allowed

Compute Dose (over all day, all SPL)

$$D = \frac{\text{Exposed}_1}{\text{Allowed}_1} + \frac{\text{Exposed}_2}{\text{Allowed}_2} \ldots + \frac{\text{Exposed}_n}{\text{Allowed}_n}$$

Compute Projected DOSE

$$\text{Proj.D} = \text{Dose}_{\text{measured}} \times (\text{Hr}_{\text{Shift}} / \text{Hr}_{\text{Sampled}})$$

Compute TWA

$TWA_{OSHA} = [16.61 \log D] + 90$
$TWA_{NIOSH, ACGIH} = 10 \log D + 85$

D=dose, as fraction

Record TWA on audiogram

Is TWA < or > Exposure limit?

$$\text{Proj.D} = \text{Dose}_{\text{measured}} \times (\text{Hr}_{\text{Shift}} / \text{Hr}_{\text{Sampled}})$$

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Additional Considerations: #1

- **What if sample << full shift?**
  - MUST use ***projected data (unless zero exposure rest of shift)***
  - This DOES confuse people:
    - Noise doesn't merely *average* in the morning and afternoon, think of it *accumulating*
  - If we only sample <8 hours, our "TIME ALLOWED" presumes 8 hours

$$Proj.D = Dose_{measured} \times (Hr_{Shift} / Hr_{Sampled})$$

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Additional Considerations: #1

- **What if sample << full shift?**
  - MUST use ***projected data (unless zero exposure rest of shift)***
  - This DOES confuse people:
    - Noise doesn't merely average in the morning and afternoon, think of it accumulating
  - If we only sample <8 hours, our "TIME ALLOWED" presumes 8 hours
- Think about it this way:
  - If I sampled someone ***for only 4 hours***(… let's use NIOSH criteria): ***If*** at **88 dBA** over **4 hours → Time allowed** is **4 hours**:
    Dose = (Time at/Time allowed)
    = (4 hours at/ 4 hours allowed)
    = 1.0 (or 100%)
  - But **if *the rest of the day***, they ***continued*** *to receive* this noise exposure, they would have been **at "88 dBA" for 8 hours**:
    Dose = (8 hr exposed/4 hours allowed) = 2.0
    This is a 200% dose… *this requires control.*

Proj. Dose =
= 1.0 x (8-hr/4-hr sample) = 2.0

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Additional Considerations: #2

- What if work ***longer than 8-hours***?
- ***OSHA:*** Adjust the **HC limit** to account for longer shift (*Hr*) and less recovery time

$$Adjusted\ AL_{Hr} = 16.61 log_{10}\left(\frac{50}{12.5 \times Hr}\right) + 90$$

If work **9.5** hours, the "85 dBA hearing conservation" limit for 8-hours becomes:

16.61 x log(50/(12.5***9.5**)) + 90
= 16.61 x log(0.42) + 90
= 16.61*(-0.376) + 90
=(-6.24) + 90 = **83.7 dBA**

Interpretation:
Persons with exposures above **83.7** dBA result in inclusion in hearing conservation program ***when working a 9.5 hour shift***

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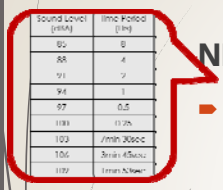
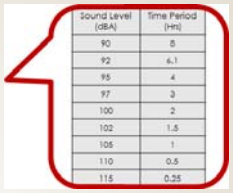
Interpreting Output





NIOSH & ACGIH

- TWA ≥ 85 (Dose > 1.0)
  - Reduce exposures to all workers at and above 85 (with 3dB doubling!)
- Implement HCP, protect everyone
- ***NIOSH indicates that 1 in 12 may still experience STS if we protect only to 85***

OSHA

- If TWA ≥85 dBA (Dose > 0.5):
  - Hearing Conservation (annual audiometric testing, training, etc.)
  - If anyone in this group has ***STS***, must reduce exposures to < 85 dBA
- If TWA ≥ **90** dBA (Dose>1.0):
  - Protect hearing to all workers (reduce exposure to ears to 90 dBA)
  - Implement "feasible" engineering or administrative controls

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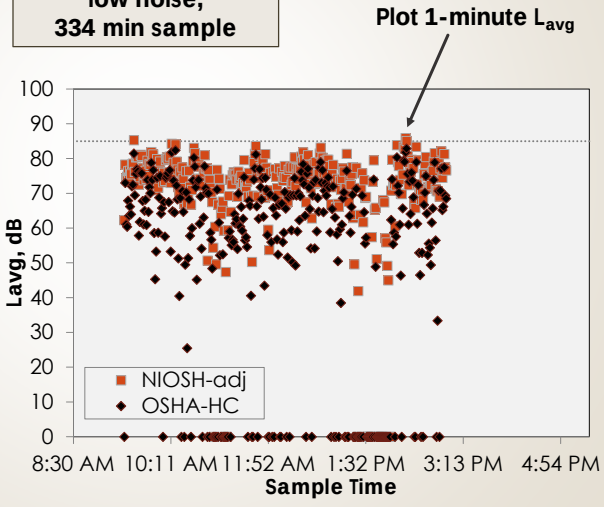
Worker 1 Example:

NIOSH-adj
Threshold = 70 dB
- *lower than required*: concerned get no information

OSHA-HC
threshold of 80: lots of 1-minute data → 0 dB

High variability, low noise, 334 min sample



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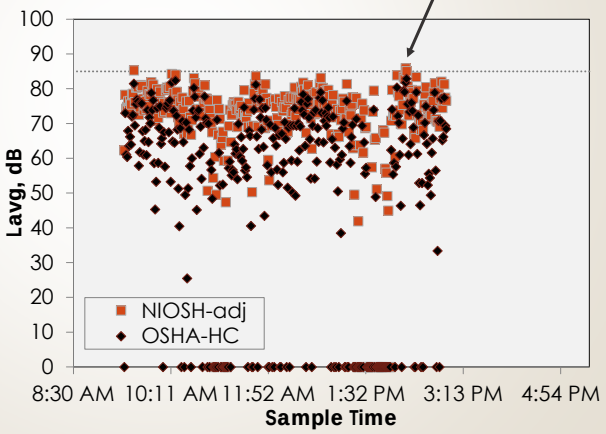
Worker 1 Example:

	OSHA HC	NIOSH-adj
Dose	0.03	0.10
TWA	65.7	75.0

High variability, low noise, 334 min sample

Plot 1-minute L_{avg}



$TWA_{NIOSH\text{-}adj} > TWA_{OSHA\text{-}HC}$

Are we concerned?

Are we done?

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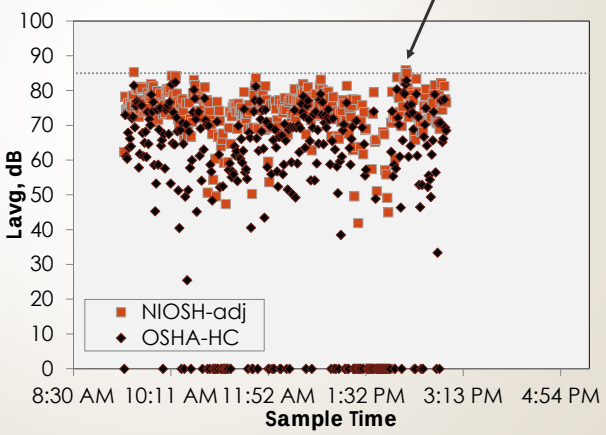
Worker 1 Example:

	OSHA HC	NIOSH-adj
Dose	0.03	0.10
TWA	65.7	75.0
pDose	0.05	0.14
pTWA	68.3	76.6

High variability, low noise, 334 min sample

Plot 1-minute L_{avg}



$TWA_{NIOSH\text{-}adj} > TWA_{OSHA\text{-}HC}$

Are we concerned?

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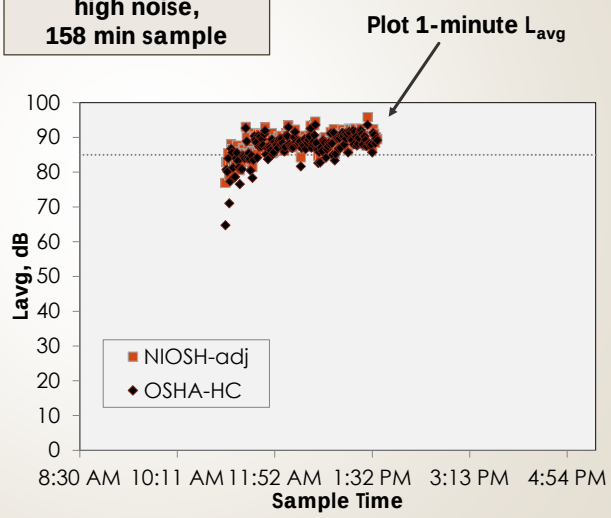
Worker 2 Example:

NIOSH-adj
Threshold = 70 dB
- *lower than required*: concerned get no information

OSHA-HC
threshold of 80:
No 1-minute data
→ 0 dB

Low variability, high noise, 158 min sample



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Worker 2 Example:

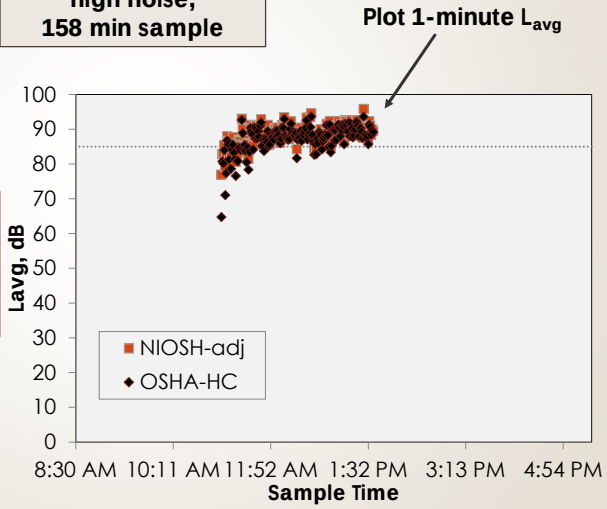
	OSHA HC	NIOSH-adj
Dose	0.25	0.90
TWA	**80.1**	**84.5**

$TWA_{NIOSH\text{-}adj} > TWA_{OSHA\text{-}HC}$

Are we concerned?

Are we done?

Low variability, high noise, 158 min sample



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Worker 2 Example

	OSHA HC	NIOSH-adj
Dose	0.25	0.90
TWA	**80.1**	**84.5**
pDose	0.77	2.72
pTWA	**88.1**	**89.4**

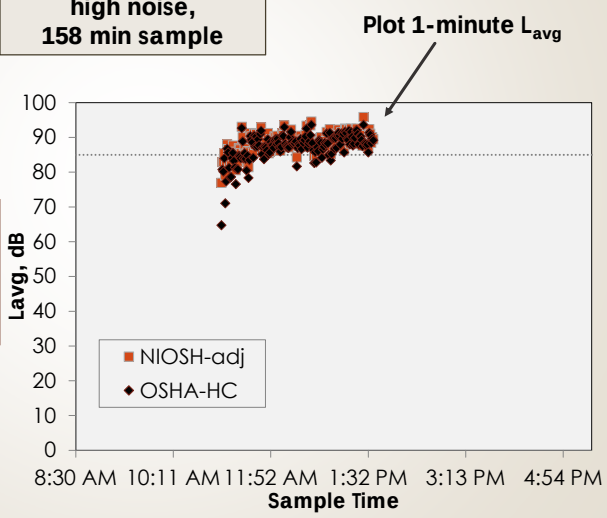
$TWA_{NIOSH\text{-}adj} > TWA_{OSHA\text{-}HC}$

Are We Concerned?

Are We Done?

Interpret:
- **OSHA**: worker in HCP (protection if STS)
- **NIOSH**: worker needs protection

Low variability, high noise, 158 min sample



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Questions on Measurements?

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Current Trends in Regulations

- OSHA:
  - 2010: Proposed interpretation of "Feasible" administrative/engineering controls
  - Docket number: OSHA-2010-0032
    - 2010 request for comments interpreting "feasible"…
    - 2011: News Release = review stage
    - Currently: no activity
  - OHSRC Decisions: "Cost-Benefit" interpretation of what is feasible (19
  - OSHA Enforcement: "Employers can rely on PPE if that method reduces noise exposures to acceptable levels and is less costly than administrative and engineering controls."

See: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=21773

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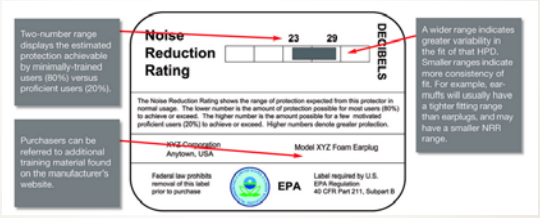
Current Trends in Regulations

- EPA NRR Activities
  - Proposal 8/5/09… 40 CFR 211 Subpart B
  - Still on docket, but no action ("Final Action: 06/2011")



Proposal: https://federalregister.gov/a/E9-18003
Rule Action: http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201104&RIN=2060-AO25

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Other Current Trends

- ANSI: A10.46: Hearing Loss Prevention in Construction and Demolition workers
- NIOSH: Prevention through design
  - Buy Quiet program
  - Power Tool database
- Engineering Controls:
  - Note that we have covered exposure assessment equipment today
  - If looking to control noise, need to look at frequency information (Octave Band Analyzers)

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Questions?

At the end of the session, participants will understand:

- Noise exposure terminology and guidelines
- Essential equipment configurations
- How to interpret dosimeter output to make decisions
- Current trends of regulators and best practices