

Noise surveys and Data Analyses

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Noise surveys

- Who to sample
 - Most exposed?
 - Representative?
- Statistical sampling
 - Random
 - Fixed times
- Dosimeters
- Documentation

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Why Conduct a Sound Survey?

- **Estimate noise hazard**
 - Reduce potential for noise-induced hearing loss
 - Essential to produce a database of noise exposures
- **Meet OSHA and other Regulatory Requirements**
 - Sound survey database provides info to satisfy monitoring requirements of OSHA
- **Input to Company's Hearing Conservation Program**
 - Id employees to include in program
 - Selection of hearing protectors
 - Targeting efforts for engineering of noise controls
- **ACGIH and Foreign Regulations**
 - ACGIH more stringent than OSHA
 - 85 dBA = 100% dose
 - 3-dB doubling
 - Some companies foreign-owned and follow home countries policies, if more restrictive than OSHA

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Why Conduct a Sound Survey?

- **Workers' Compensation Claims**
 - Record data for negative cases as well as over-exposed
 - Some state regulations different from OSHA
- **Safety Considerations**
 - Investigate whether hazards due to interference with communications
- **Special Requests**
 - Lunch room, meeting rooms, etc.
 - Even if not hearing conservation-related,
 - Educational
 - Good P.R.

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Classifying Noise Exposures- Ranking

TWA (dBA)	Classification
≤ 84	A (not HCP, but may require some use of hearing protectors)
85-89	B (in HCP)
90-94	C (engineering controls start being required)
95-99	D (some hearing protectors inadequate)
≥ 100	E (critical since most hearing protectors inadequate)

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Basic Versus Detailed Sound Survey

- **Basic Survey**
 - Purpose:
 - Identify work areas, stations, and/or jobs where more info needed
 - Identify areas or individuals with ≥ 85 dBA
 - Identify areas where TWAs are below action level
 - Establish sound level database to estimate exposures to similarly exposed workers. Basic survey: Should mark on floor plan where high and low areas were
 - If noise steady and either high or low, only sparse testing may be required
 - All areas should be checked, not just the loudest
- **Detailed Survey**
 - Complete the classification started in the basic survey.
 - At conclusion, should be able to define typical TWA ranges for all company employees.

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Classifying Exposure Groups: Strategy

- Can measure every individual repeatedly
 - Advantage: determine exposure for every individual
 - Disadvantage: time-consuming in the extreme if many workers
- Can measure some workers thought to be representative of others
 - If pick most exposed, give over-estimate of most workers' actual exposures
 - If pick "typical", may not sample workers who are atypically highly exposed
 - If pick at random, must sample many frequently to confidently predict group average. Determines only the group average, not individual workers unless can prove interchangeable.
- Can find noise associated with geography and assume represents workers in each area
 - Fails utterly if workers close to the source
 - Therefore works only in diffuse noise fields (i.e., reverberant)
 - Unless noise constant within an area, fails to determine actual exposures of individual workers

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Instrumentation Considerations

- Should use SLM and dosimeters
 - Results from the two may differ
 - Typically, dosimeter is slightly higher, probably due to reflections from body from directional sources
- May need octave band
- Expected accuracy
 - OSHA assumes 2 dBA error
 - Authors found that instrument error was <0.5 if calibration checked regularly

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Different Noise Exposure Criteria and Exchange Rates

- OSHA
 - 100% = 90 dBA TWA
 - 50% requires HCP
 - 5 dBA doubling
- ACGIH
 - 100% = 85 dBA TWA, requires HCP
 - 3 dBA doubling
- Difference in doubling rate occasionally can be large
 - Greatest effect when short, high exposures skew average
 - Normally: little effect. Typically, -1 to + 3 dBA
 - -1 occurs for workdays longer than 8 hours

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Evaluating the Data for OSHA Compliance

- Use slow-response, 5 dBA doubling
- Include 80-130 dBA to determine if employees should be in the hearing conservation program
- Include 90-130 dBA to determine if exceed 90 dBA.

- MSHA follows the same rules.

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OSHA Sampling Practices

- When the results of the walkaround survey indicate that noise levels may exceed those outlined in OSHA's noise standard [1910.95](#), additional monitoring is necessary.
- Establish a sampling protocol for your workplace. A [general protocol](#) (App III:B) is provided as an example.
- In addition to the general information collected during all health inspections, OSHA may collect certain information where it is pertinent to evaluate compliance with OSHA standards ([1910.95](#), [1926.52](#), or [1926.101](#)). [Additional information](#) (App III:C) on inspection data is also available.
- Sample the noise exposures of representative employees from each job classification that may be potentially overexposed.
- Use a dosimeter with a threshold of 80 dBA (A-weighted sound pressure level) and 90 dBA to measure noise exposures. Most modern dosimeters use simultaneous 80 and 90 dBA thresholds and may be used accordingly. [Additional information](#) (App III:A) on dosimeters is also available.
 - A dosimeter with a threshold of 80 dBA is used to measure the noise dose of those employees identified during the walkaround survey as having noise exposures that are in compliance with [Table G-16](#) of OSHA's noise standard [1910.95](#), but whose exposure may exceed the levels specified in [Table G-16a](#) [[1910.95 Appendix A: Noise Exposure Computation](#)]. In other words, the 80-dBA threshold is used to determine compliance with the 85 dBA time-weighted average (TWA) action level under OSHA's noise standard.
 - The dosimeter with a threshold of 90 dBA is used to measure the noise dose of those employees identified during the walkaround survey as having potential noise exposures that exceed the sound levels in [Table G-16](#) [[1910.95](#)] or [Table D-2](#) [[1926.52](#)]. In other words, the 90 dBA threshold is used to determine compliance with the permissible exposure limit (PEL).
- As a minimum, sampling should be conducted for a length of time necessary to establish whether exposures are above the limits permitted by [Table G-16](#), [Table G-16a](#), or [Table D-2](#) (for general industry or construction workplaces, respectively). Instrument accuracy must be taken into account.
- Consider the following with respect to the monitoring results:
 - TWA exposures at or above the action level of 85 dBA require a hearing conservation program [[1910.95 \(c-n\)](#)] (results obtained from the 80 dBA threshold).
 - TWA exposures exceeding the PEL ([Table G-16](#)) require feasible engineering or administrative controls to be implemented [[1910.95\(b\)](#)] (results obtained from the 90 dBA threshold). Refer to the [OSHA Field Inspection Reference Manual \(FIRM\)](#) for additional information.

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Pre-survey Considerations

- **Notify plant personnel before survey**
 - You need their help and information
 - Make sure day will be “normal”
- **Do a “walk-through”**
 - Walk through and observe before doing survey
- **Collect information on environment & equipment**
 - Past surveys
 - Info on process equipment and machines
 - Production records
 - Talk to operators and supervisors
- **Prepare check list and survey outline**
 - Should list every little thing you will need and check them off as you pack them (do the same before return!)
 - Write brief summary of objectives and a preliminary outline of procedures.

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Information to Record

- **Supporting information**
 - Production records
 - Work schedules
 - Floor plan drawings (get from management or draw, yourself)
 - Photos (show to management and delete ones they object to)
- **Calibration data**
 - Don't adjust unless deviation exceeds 0.25 dB.
 - If adjustment necessary, state how much then re-check calibration.
 - Describe model and serial number of instruments, including the calibration device.
 - Record date and sign it
 - Calibrate before and after survey. If shifted by ≥ 0.5 dB, do survey over again?

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Information to Record - continued

- Survey sound level data
 - Should allow estimation of TWA for all personnel
 - If SLM value swings more than 8 dBA
 - Close eyes, count to two and write down first value
 - Repeat 3 times and use the median value
 - Sign all forms

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Collecting the data for basic survey

- Area survey
 - Do L_{OSHA} initially
 - If noise varies by less than 8 dBA, 10 readings spaced randomly over the day should be sufficient if the average is not near a decision point.
 - Measure at height of 1.5 m where workers would be during exposures
 - Record A and C values
- Workstation/Job Description Survey
 - An area survey may underestimate personal exposures, so need to check specific workstations and tasks
 - If close to sources, be wary of directional sources₁₆

Detailed Sound Survey- Collecting the Data

- Using a noise dosimeter
 - Place microphone in center of shoulder on most exposed side. If unknown, alternate with different employees.
- Microphone holders usually not useful
 - Use safety pins, instead
 - Be sure can tear lose if cable is snagged and avoid dangling wires to snag
 - Dosimeter case should be attached firmly to employee's belt
 - Usually best on side rotated a bit towards the back
 - Ask employee which way they prefer and demonstrate each
 - Carry belts with you. Make sure you have some VERY long ones with you to avoid embarrassing obese workers.
 - If very cold, place case inside clothing

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Detailed Sound Survey- Collecting the Data, continued

- Start
 - Close to beginning of shift, if possible
 - Must be ready before shift begins
- Stop
 - Just before end of shift
 - Be ready in case they leave the floor early
- Unsampled period
 - Royster: assume same for short periods
 - Me: ask about work during unsampled times and use SLM, if possible. Otherwise, consider best and worst cases.

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Detailed Sound Survey- Collecting the Data, continued

- Carefully instruct employees
- Be re-assuring
- Tell what to do if go to bathroom, lunch, breaks
- At end of survey, ask if any problems or noteworthy events. WRITE THEM DOWN !
- Stay near the workers and look in on them frequently
- Take SLM data to support dosimeter findings

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Contamination of Data

- Shouting or thumping dosimeter with finger unlikely to produce substantial effects (<0.5 dBA for extreme test)
- Blowing more significant, but would have to do dozens of times to produce 1 dBA increase
- Would have to produce noise levels near 140 dBA to have effect in short duration effort
- In an example, Royster found that personal radios added 1.9 dBA. Those were NOT "Walkman" headphone or earplug speakers.

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Detailed Sound Survey- Collecting the Data: Using a SLM

- Place microphone at intersection of ear and shoulder or at where that would be if employee were present.
- Try both shoulders and use the highest
- Take whatever reading you have. Don't wait for it to return to "normal."

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Sound level and distance from body

- To estimate exposure, must sample what the ear gets
- Thus must be near ear, especially if in near field and highly directional noise
- However, reflections from body distort readings
- So measure above shoulder at height of ear
- Measure for each ear
- Use non-directional sensor

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Info to Record During Survey

- While monitoring, you need to note:
 - Location (distance and direction from machine)
 - dBA
 - Name, model of machine
 - Materials, feed speeds, die #, etc.
 - Date, Time
 - Worker comments
- Me: Do not write down anything you would not want anyone and everyone to know!

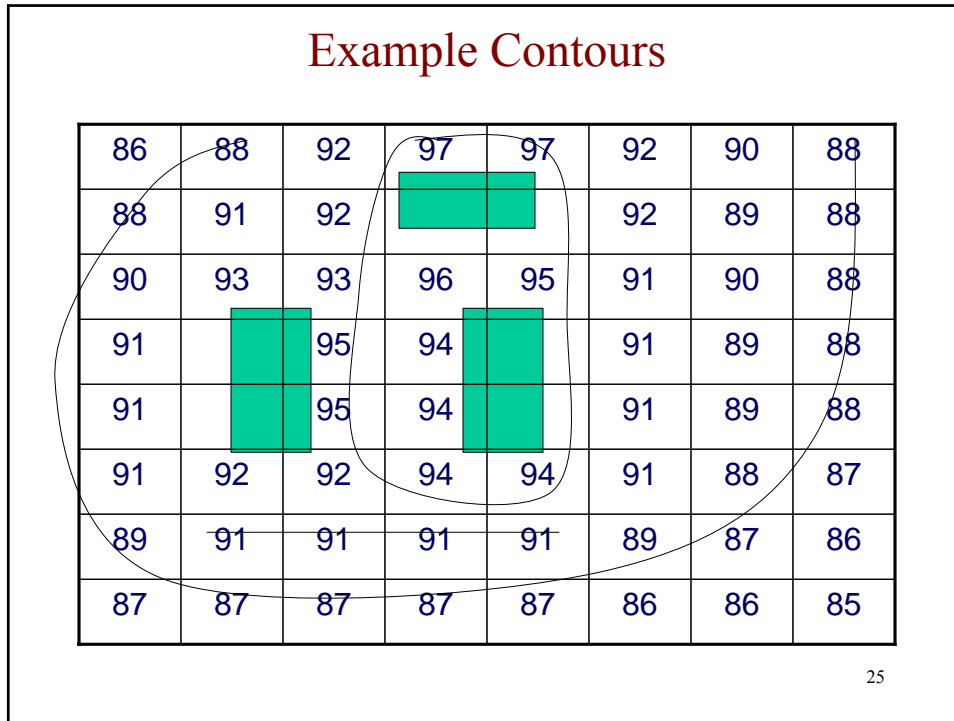
Akladios

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Individual Worker Classification

- Determine TWA for each worker
- Hope (but not true that)
 - will inoculate for workers' comp
 - more protective since more detailed information
- Surveys just aren't much better than 5 dBA ranges
- Worker mobility and changes to noise environment mean less precision in characterizing lifetime exposure

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- ### Sound Level Contours
- Used to
 - Illustrate noise to workers and management
 - Identify dominant sources
 - Identify high noise locations
 - Construction
 - Write noise levels down on corresponding location on floor plan
 - May need a grid
 - More frequent readings near sources
 - For educational purposes, use 5 dBA contours
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What is learned?

- Contours
 - Areas where exposure < 85 dBA
 - Areas > 90 dBA (100+)
- Source identification
 - Machine levels
 - If 2nd machine is added, machine is moved, etc., can estimate new noise levels
 - Effects of reducing noise from specific sources

Akladios

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Sound Exposure Profiling

- Determine both the mean and variability
- Should repeat surveys every 2 to 3 years
- Sound Exposure Profiling
 - Task-based noise sampling
 - Estimate time spent at each task and range of times might be spent at each task to get range of exposures

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Important Considerations in Noise Surveys

- Use wind screens but otherwise microphone unobstructed
- Calibrate before survey
- Measurement must correspond to noise at ear
- Minute-by-minute levels vary enormously, so sampling strategy important
 - Mean of sample levels should be same as true mean exposure
 - Random
 - Fixed times
 - Dosimeters (back up with sound level meter readings)

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Important Considerations in Noise Surveys

- Actual exposures greatly affected by work practices (e.g., lean close)
- Variability between individuals, jobs, plants, etc. can be great
- Day to day variability can be great
- Compute time-weighted average
- Document people, use of hearing protection, layout of work, sources, incidents, work rate

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Atypical Exposures and OSHA

- OSHA generally bases citations on the day of their sampling. If exposure < 1 day/ wk, will ignore.
- OSHA bases citations on full-shift sampling, only. Non-sampled periods = 0.

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Atypical work schedules: Non-OSHA

- Partial shift sampling
 - Must be careful in extrapolating results
 - May have periods of low-exposures (breaks, lunch)
 - If did linear extrapolation to unsampled time, could over or underestimate TWA
 - If dosimeter includes lunch, then extrapolating to afternoon would underestimate true TWA
 - If dosimeter stopped before lunch, but time extrapolated included lunch, would overestimate dose for the day
 - If will sample partial shift, recommend
 - Omit breaks, setup, cleanup, and lunch from dosimeter and from total time of exposure
 - Be sure those times are actually low exposures

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12-hour Shifts

- If extrapolating dose from partial shift to 12-hour shift, simple linear conversion for %dose
- If determining TWA from %dose taken >8hours:

$$\text{Eq 8-hr dose} = (T_{\text{actual}}/480 \text{ min}) \text{Dose}_{\text{meter}}$$

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Weekly, Monthly, or Yearly Eq Values

- Should use 3-dBA doubling
- If >8 hours/day, simply accumulate dose
- Same if > 40 hrs/wk
- If individual days frequently have average level of >
- 99 dBA, don't average with low dose days

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Homework: Find Dose and Equivalent Average Noise Level for each situation in web downloads:

- 1) Dose and dose equivalent averages
- 2) Unusual work schedules

For a random sample of measured values, each of the N values is assumed to represent 1/N times the period sampled

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Engineering Noise Control Survey- Purpose

- Determine sources (which machines)
- Determine component sources (what within the machine)
- Find frequencies to aid in control development (affects absorption, transmission)
- Determine reductions due to implementing controls

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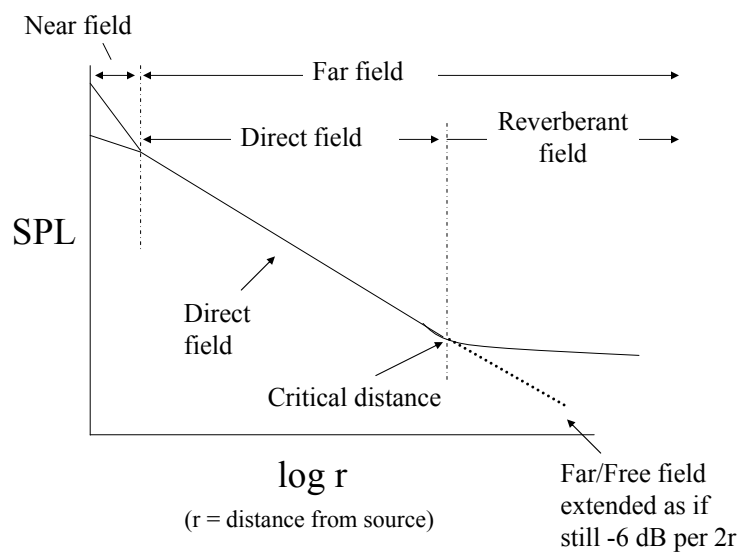
Engineering Noise Control Survey: Information to Record

- Same as survey, with some additions
- Room volume, surface characteristics, relative locations of sources and receivers (workers).
- Speed and production rate of machines
- Motion, speed, materials, and other characteristics of components.

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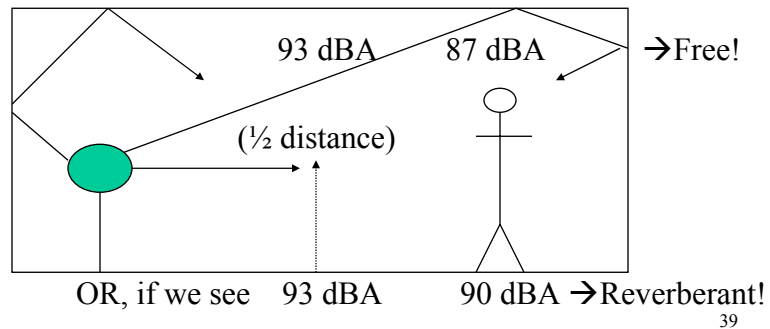
Fields

(Relative proportions of domains will vary)



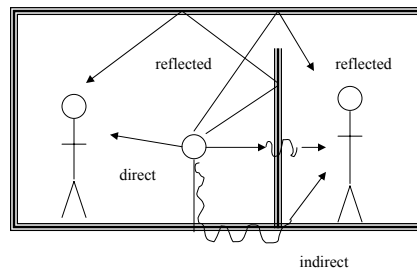
Determining Fields

- Measure at $\frac{1}{2}$ distance between source and receiver to see if free field rule applies



Sound Level and Objects in the Path

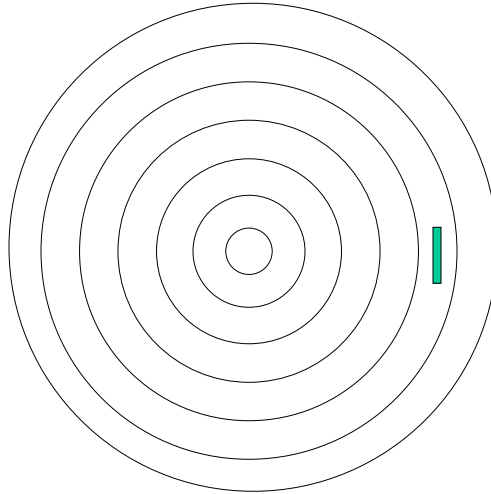
- When sound wave hits obstacle in its path, part of the sound will be reflected, part absorbed, and the remainder will be transmitted through the object, depending on the size and properties of the object and the wavelength of the sound.



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Sound Paths and Size of Object in Path

- Can go around objects without significant reflection if wavelength **greater** than the dimensions of the object



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Engineering Noise Control Survey: Determining Sources

- Sometimes obvious, but not always
- Area sources
 - 1st stage: Dominant sources (e.g., which machines)
 - 2nd stage: Component within each source
 - Need team
 - Operator
 - Mechanic
 - Engineers with specific knowledge that is useful
 - “Political” members (e.g., engineers, management)
 - Steps:
 - If possible, run one machine at a time and note SPLs at specific locations. If not, turn off as many as possible and separate mathematically, especially for dominant frequencies
 - Investigate components within sources

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Determining contribution of one source

- Background measurement should be made with the noise source in question turned off.
- Given total noise and background alone, solve for source.
- For example, total SPL= 93 and back= 85 dB
$$\text{SPL}_{\text{tot}} = 93 \text{ dB} = 10 \log(10^X + 10^{8.5})$$
$$X = 92.4$$

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Engineering Noise Control Survey: Determining Component Sources

- Far more difficult than identifying machines.
- Essential to have assistance of machine operator and mechanic.
- Engage and disengage components, if possible
- Caution: disengaging parts may change the loads on the engaged parts, changing the noise production somewhat. Look at frequencies.
- Compute the overall effects of reducing contribution from each component.

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Special Noise Engineering Surveys

- May need to determine frequency distribution
 - Sound absorbing materials
 - Transmission
 - Selection of hearing protectors
- Octave band, 3rd octave, Fourier transform (narrow band)
 - Octave band often sufficient

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Statistical Factors in Sound Survey

Drawing conclusions from sample data

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Number of observations Timing and duration of measurements

- If noise is relatively steady, then simple random selection of sampling times is sufficient
- If periods suspected, need stratified sampling. (I disagree: you need more random samples)
- Need stratified sampling is most exposure occurs at short intervals. Divide day into two groups: exposure intervals and rest of day. Take about the same number of samples for each of the two unless one more variable than the other. More variable needs more samples. Close to decision point requires more samples.
- There is cost-benefit trade off between duration and number of observations
 - i.e., do a 4-hour sample on each of 2 employees rather than one 8-hr sample
 - Caution: makes it more difficult to determine if some employees more heavily exposed

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Statistical Factors in Sound Survey Methods: Drawing conclusions from sample data

- Worker exposures vary with minute, hour, day, year and among different workers.
- Inferences made from small samples to draw conclusions about populations. Mean, standard deviation, and confidence interval useful.
- Hoping sample data is representative
- Noise levels and exposures vary non-randomly and randomly.
- Non-random factors make non-representative and must be avoided, controlled or measured
 - Calibration errors -- avoid
 - Systematic measurement errors -- avoid
 - Systematic changes in noise levels due to production changes and machinery changes – control or note
- Random factors cannot be controlled. Random sampling makes representation relatively easy to obtain.
- Data usually cannot inform you which part of variability is due to random and which part is non-random.

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Sampling Considerations

- Must be random sampling
- Randomize time, instruments (e.g., pumps), sampler, individuals to be sampled.
- However, may be assuming some employees are representative of others.
 - Need correctly assigned “homogenous” sampling groups.
 - Amounts to “stratified” sampling since employees aren’t selected completely at random
 - Randomly selected within each homogenous group
- Critical:
 - Number of observations
 - Timing and duration of measurements

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Selecting Subjects for OSHA Compliance Determination

- Ideally, sample large number that are selected randomly
- However, if fewer samples are possible:
 - If can judge most exposed, sample them (i.e., not randomly selected) and make conservative decision (overestimate mean exposure)
 - If not, sample workers from the group at random (Rappaport and others dispute how well IHs can judge exposures).
 - Sample size based on Leidel (see Tables 7.7a and 7.7b).
- Note: OSHA requires that EVERY overexposed individual be protected, so need high confidence.

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Sample Sizes Required (Number workers sampled)

Sample sizes required to have 95% confidence in identifying at least one employee in the top percentages of the distribution

Required n for top 10%

Size of Group	12	13-14	15-16	17-18	19-21	22-24	25-27	28-31	32-35	36-41	42-50	∞
Req'd n	12	12	13	14	15	16	17	18	19	20	21	29

Required n for top 20%

Size of Group		7-8	9-11	12-14	15-18	19-26	27-43	44-50	51- ∞
Req'd n		6	7	8	9	10	11	12	14

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Confidence Intervals

- Confidence interval generally is for the mean
 - Clear if multiple samples on one individual
 - Can use samples from multiple individuals to estimate a given individual's exposure if assume all have same true mean exposures.
- Can do confidence interval of point estimate
- Generally use 95% probability that mean is within the specified range.
- Since wish to know likelihood will exceed some value, use one-sided tests
- Sometime use cut-off for lower confidence limit

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Case of Variance Unknown

- If normal distribution and variance unknown, use Student's t-distribution (*not* exploiting Central Limit Theorem):

$$T = \frac{\bar{X} - \mu}{S / \sqrt{n}} \quad , \nu = n-1$$

- Confidence interval for $(1-\alpha)100\%$ is then:

$$\bar{x} - \frac{t_{\alpha/2}S}{\sqrt{n}} < \mu < \bar{x} + \frac{t_{\alpha/2}S}{\sqrt{n}} \quad , \nu = n-1$$

- Approximation improves as n gets larger

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Example 9.4

- Daily noise doses are 98%, 102%, 104%, 98%, 100%, 102%, and 96%. Find a 95% confidence interval for the average dose, assuming an approximately normal distribution.
- Solution:

$$\bar{x} = 100 \quad s = 2.83$$

Using Table A.4 (Student-t), find $t_{0.025} = 2.447$ for $\nu = 6$

$$\bar{x} - t_{\alpha/2} \left(\frac{s}{\sqrt{n}} \right) < \mu < \bar{x} + t_{\alpha/2} \left(\frac{s}{\sqrt{n}} \right)$$

$$100 - 2.447 \left(\frac{2.83}{\sqrt{7}} \right) < \mu < 100 + 2.447 \left(\frac{2.83}{\sqrt{7}} \right)$$

$$97.4 < \mu < 102.6$$

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9.6 Prediction Interval

- Instead of estimating the mean, may wish to predict possible value of a future observation.
- E.g., wish to know the confidence interval for a given individual.
- Confidence interval of the mean would have smaller range than a single part.
- Prediction intervals apply to a single point. They are affected by variance of the prediction of the mean and the variance of the future observation.

$$s_{pred}^2 = s^2 + \frac{s^2}{n} = s^2 \left(1 + \frac{1}{n}\right) \quad t = \frac{x_0 - \bar{x}}{s \sqrt{1 + \frac{1}{n}}}$$

$$\bar{x} - t_{\alpha/2} s \sqrt{1 + \frac{1}{n}} < x_0 < \bar{x} + t_{\alpha/2} s \sqrt{1 + \frac{1}{n}} \quad 55$$

Use of Tolerance Limits

- Useful to determine upper tolerance limit
 - Only a selected percentage would fall below the limit
 - Typically 75%, 90%, 95%, 99% of observations
 - E.g., John Smith's exposure would be below 85 dBA 90% of the time.
 - If use group data, value applies to the group. Not clear that translates to percentage of workers.
 - Example: probability of dose exceeding 50% is less than 5%

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9.7 Tolerance Limits

- Interested in boundaries of performance
- One method to determine confidence interval on a fixed proportion of the measurements (i.e., 95% fall within a fixed range).
- Tolerance interval or limits:
 - $\mu \pm k\sigma$
 - $\underline{x} \pm ks$
- For a normal distribution of measurements, gives $(1 - \gamma)\%$ confidence that the given limits contain at least the proportion $1 - \alpha$ of the measurements

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Tolerance Factors for Normal Distributions	$\gamma = 0.05$				$\gamma = 0.01$			
	n	$1 - \alpha$			n	$1 - \alpha$		
		<u>0.90</u>	<u>0.95</u>	<u>0.99</u>		<u>0.90</u>	<u>0.95</u>	<u>0.99</u>
2	32.019	37.674	48.430	2	160.193	188.491	242.300	
3	8.380	9.916	12.861	3	18.930	22.401	29.055	
4	5.369	6.370	8.299	4	9.398	11.150	14.527	
5	4.275	5.079	6.634	5	6.612	7.855	10.260	
6	3.712	4.414	5.775	6	5.337	6.345	8.301	
7	3.369	4.007	5.248	7	4.613	5.488	7.187	
8	3.136	3.732	4.891	8	4.125	4.936	6.468	
9	2.967	3.532	4.631	9	3.822	4.550	5.966	
10	2.839	3.379	4.433	10	3.582	4.265	5.594	

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Example

- Exposure doses are found to be 101, 97, 103, 104, 99, 98, 99, 101, 103% of allowed levels. Find the 99% tolerance limits that will contain 95% of the doses one might measure for this exposure, assuming a normal distribution.

- Solution:

$$n = 9 \quad \bar{x} = 100.56 \quad s = 2.46$$

From Table A.7, for $1-\gamma = 0.99$ and $1-\alpha = 0.95$

$$k = 4.550$$

Hence, the 99% tolerance limits are:

$$100.56\% \pm 4.550(2.46\%) = 100.56\% \pm 11.19\%$$

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Distinction Among Confidence Intervals, Prediction Intervals, and Tolerance Intervals

- Confidence intervals: population mean is the goal
- Tolerance: knowing where the majority of the population lies
- Prediction limits: when important to determine the bound of a single value

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Steps in Analyses

- 1) Tabulate the data
- 2) Plot the data (histogram)
- 3) Calculate the sample mean (simple arithmetic)
- 4) Calculate the sample standard deviation
- 5) Check the normality of the distribution
 - a. Chi-square goodness-of-fit
 - b. Try log-transform, if necessary
- 6) Set confidence interval for the mean
- 7) Determine one-sided upper confidence interval for the mean
- 8) One-sided tolerance limit of TWA distribution
- 9) Proportion of observations above a certain value
- 10) Predict the proportion of TWAs in a range

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Judgment in Using Statistics

- Do not ignore the obvious
- Be wary of results that depend on a few readings
- If statistics disagree with expectations, be able to explain or re-do.

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Report Preparation

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Report Preparation

- **Goals**
 - Restate objectives established before survey
 - Be complete: someone reading it years from now should be able to follow what you did and what the conditions were at the time.
 - Write succinctly and clearly
- **Potential audience**
 - Know who most important reader is and address them
 - Know purpose of report (OSHA compliance, Workman's Comp)
 - Some lawyer
 - An IH who is doing another survey or judging whether you should be asked back again (the Appendix is mostly for them)
- **Political constraints**
 - Consider local management attitudes and potential political constraints
 - Give credit to as many as possible
 - Avoid blunt criticism
 - But do not cover up by misleading words or by omissions
- **Report Format**

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Report Format

- Title page
- Summary/Acknowledgments*
 - Concise summary of report
 - Acknowledge help from plant personnel and management !
- Background/Introduction and Purpose
- Data Collection/Measurement Methods/Instrumentation
 - Much may be put in appendices
 - Carefully explain any deviations from standard practice
- Analysis of the Data
 - Show examples; most in appendices
- Results/Conclusions/Recommendations*
 - Give adequate supporting evidence for any conclusions/recommendations
- References
- Appendix

* Most likely to be read. Keep short (2-3 pages) and clear.

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Report Format

- Cover letter
 - How you came to be there (“at request of John Smith”)
 - Re-state mission (“determine which workers should be in HCP”)
 - Acknowledge help from plant personnel and management !
 - Thank for using your services
- Title/cover page
 - “Review of Noise Control Strategies for Bleed Line #2”
 - “Prepared by:”
 - Date
 - Prepared for ... Individual/Company/Address
- Executive Summary
 - Concise summary of report
- Introduction
 - Purpose (including who asked you to do what)
 - Background
 - Process
 - History of problem, including previous reports of surveys
 - Potential seriousness of the problem
 - List any information given to you by others
- Data Collection
 - Apparatus
 - Calibration
 - Measurement Methods/Test methods
 - Much may be put in appendices
 - Carefully explain any deviations from standard practice

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Report Format

- Analysis of the Data
 - How results computed
 - Show examples; most in appendices
 - Statistical treatment methods and why used
- Results
 - Concise tables
 - If trends or comparisons important, graph
- Discussion
 - Summary values (averages, std dev, range)
 - Compare to expectations
 - Compare to past measurements and typical levels in other plants
 - Discuss any extreme, anomalous, or contradictory findings
 - Put findings in context of OSHA and other standards
 - Give adequate supporting evidence for any conclusions/recommendations
- Conclusions
- Recommendations
- References
- Appendices

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Recordkeeping

- Records important for OSHA compliance, workman's' compensation or negligence suits
- For workman's' comp, for each employee
 - Level of exposure and duration over working life
 - Keep forever (okay, until the worker is long dead)

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Guidelines for Updating Survey Findings

- Frequency should depend on:
 - Severity or potential hazard
 - Possible significant changes to specific TWA due to changes in work assignments for workers
 - Possible significant changes due to production changes
 - Poor audiometric results
 - Legal requirements
 - Company HCP policies

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Royster's Recommendations

TWA (dBA)	Classification
≤ 84	5-yr unless change expected
85-89	2-yr, then 5 if static
90-94	2-yr, then 5 if static
95-99	Annual for first 3-yr, then every 5 if static
≥100	Same as above

Static: less than 25% of TWAs changed by one letter grade

And no classification changed by more than one letter

Note: hearing can decline in 6-12 months for ≥ 95 dBA ⁷⁰

The End

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Sound Level and Objects in the Path

- When sound wave hits obstacle in its path, part of the sound will be reflected, part absorbed, and the remainder will be transmitted through the object, depending on the size and properties of the object and the wavelength of the sound.
- Object must be larger than one wavelength to significantly disturb the sound. For example, at 10 kHz the wavelength is 3.4 cm - - so even a small object such as a measurement microphone will disturb the sound field - - hence sound absorption and insulation are readily achieved. But, at 100 Hz, the wavelength is 3.4 meters and sound insulation becomes much more difficult.

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Sound level and distance from body

- To estimate exposure, must sample what the ear gets
- Thus must be near ear, especially if in near field and highly directional noise
- However, reflections from body distort readings
- So measure above shoulder at height of ear
- Measure for each ear
- Use non-directional sensor

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Determining contribution of one source

- Background measurement should be made with the noise source in question turned off.
- Given total noise and background alone, solve for source.
- For example, total SPL= 93 and back= 85 dB
$$\text{SPL}_{\text{tot}} = 93 \text{ dB} = 10 \log(10^X + 10^{8.5})$$
$$X = 92.4$$

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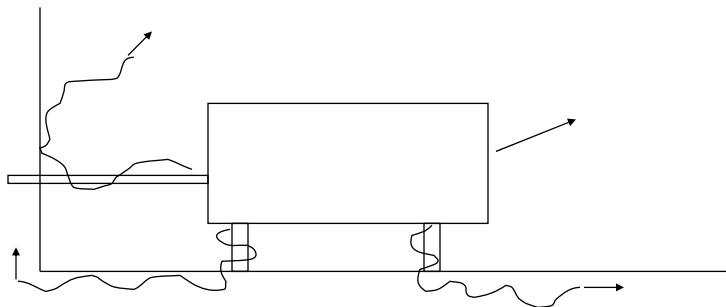
Acoustic Fields

- Direct Field (from direct path sound)
 - Near Field - 6dB effect does not hold
 - Free Field - well behaved
- Reverberant Field (from reflected path)
 - SPL somewhat constant
 - usually a factor of the absorption of the room walls
 - what is not absorbed is reflected
 - Critical distance (d_c) from source where reverberant field starts
- (Indirect path sound considered as “source” within that room, e.g. vibrating wall is considered the source, then fields within that room)

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Source Control - enclose

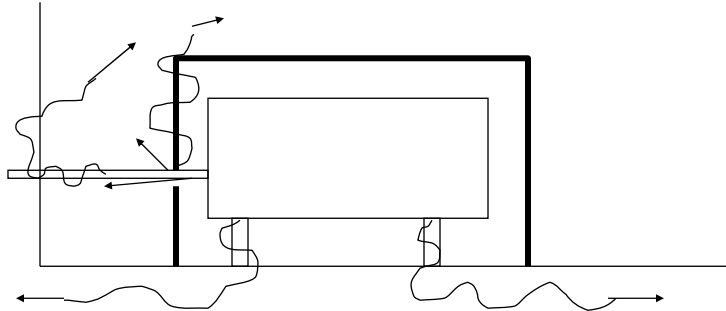
- What paths?



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Source Control - enclose

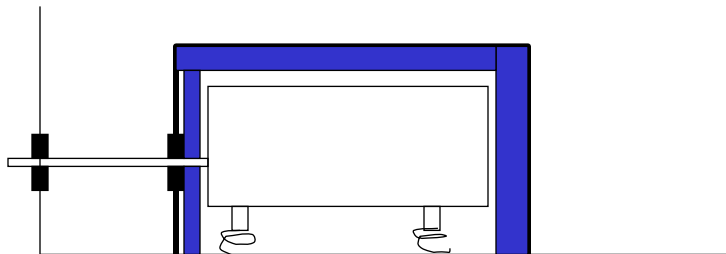
- Simple enclosure – what considerations?
 - Vibrations isolation and gaps filled!



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Source Control - enclose

- Watch for noise build-up inside, treat with absorptive material if safely feasible



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Path Control

- Reflected Path
 - Absorption
- Direct Path
 - Wall (transmission loss – TL)
 - Barrier (insertion loss – IL)
- Indirect Path
 - Vibration isolation

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Important Considerations in Noise Surveys

- Use wind screens but otherwise microphone unobstructed
- Calibrate before survey
- Measurement must correspond to noise at ear
- Minute-by-minute levels vary enormously, so sampling strategy important
 - Mean of sample levels should be same as true mean exposure
 - Random
 - Fixed times
 - Dosimeters (back up with sound level meter readings)

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Important Considerations in Noise Surveys

- Actual exposures greatly affected by work practices (e.g., lean close)
- Variability between individuals, jobs, plants, etc. can be great
- Day to day variability can be great
- Compute time-weighted average
- Document people, use of hearing protection, layout of work, sources, incidents, work rate

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Blanket Classification Scheme

- Assign one TWA to all workers in area
- Benefits:
 - Decision-making simplified
 - Enforcement simplified
 - Sound survey can be simpler
- Problem:
 - Falsely identify workers as highly exposed, leading workers to believe they are more highly exposed than they are
 - Use of hearing protectors in low noise area may interfere with communications

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