EVALUATION OF ADDITIONAL CRITERIA FOR SIGNIFICANT THRESHOLD SHIFT IN OCCUPATIONAL HEARING CONSERVATION PROGRAMS

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Julia D. Royster, Ph.D. CCC-A/SLP

Environmental Noise Consultants, Inc.
P.O. Box 30698, Raleigh, NC 27622-0698
phone (919) 782-1624
FAX (919) 781-2396

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16. Abstract (Limit: 200 words) As a supplement to a study of significant threshold shift (STS) criteria completed in 1992, two additional shift criteria were analyzed. Analyses were restricted to the first eight audiograms for male employees with at least eight tests. This involved a total of 2,903 employees across all fifteen datasets. The two STS criteria examined were called OSHA STS TWICE, and 15 decibels (dB) TWICE at 1 to 4 kilohertz (kHz). The first monitored a change of 10dB or more in the average of hearing thresholds at 2,000, 3,000, and 4,000 hertz (Hz) and persistence on the next audiogram. The second involved a change of 15dB or more at any test frequency from 1,000 through 4,000Hz and persistence on the next audiogram. The two criteria produced smaller percentages of employees tagged per year than any of the previously evaluated criteria. The 15dB TWICE criteria yield the overall highest percentages of true positive tags. The OSHA STS TWICE criterion achieved a higher percentage after positive tags in the control databases only, but its percent true positive tags in the noncontrol database was lower than for either of the 15dB TWICE criteria. When tags for all databases were pooled, the improvement of OSHA STS TWICE over OSHA STS was noted. The two 15dB TWICE criteria, however, yielded the highest percentages of true positive tags, with slightly higher results for the criterion 15 dB TWICE at 1 to 4kHz.

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PURPOSE

At the request of NIOSH, an investigation was carried out to supplement the study of significant threshold shift criteria completed in December 1992 (J.D. Royster, Evaluation of Different Criteria for Significant Threshold Shift in Occupational Hearing Conservation Programs, final report submitted in fulfillment of NIOSH requisition number 92023VID, NTIS document PB93-159143). The current report includes analyses of two additional shift criteria of interest to NIOSH and compares results for these criteria to results previously obtained for six other criteria.

METHOD

The method for the current project is identical to that of the prior study except for the shift criteria assessed.

Data Bases Evaluated

The same fifteen audiometric datasets from industrial hearing conservation programs were used in comparing shift criteria. As previously described in the earlier report, analyses were restricted to the first eight audiograms for male employees with at least eight tests. This involved a total of 2903 employees across all fifteen datasets.

Shift Criteria Investigated

Two criteria for significant threshold shift from baseline were specified by NIOSH for assessment, as abbreviated and defined below:

a) OSHA STS TWICE:
a change of 10 dB or more in either ear in the average of hearing thresholds at 2000, 3000, and 4000 Hz, which is present in one annual audiogram and is persistent in the same ear on the next audiogram, and

b) 15 dB TWICE at 1-4 kHz:
a change of 15 dB or more at any test frequency from 1000 through 4000 Hz in either ear which is present on one annual audiogram and is persistent at the same frequency (or frequencies) in the same ear on the next audiogram.

The criterion "15 dB TWICE at 1-4 kHz" is identical to the previously evaluated "15 dB TWICE" criterion except that thresholds at 500 Hz and 6000 Hz are not considered.

The criterion "OSHA STS TWICE" is identical to the previously evaluated "OSHA STS" criterion except that the current shift must be present on two consecutive audiograms before the criterion is triggered.

As in the previous report, shifts were tabulated three ways:

1) new tags -- the percent of employees tagged for the first time in a comparison of each test (2 through 8) back to the baseline test (test 1),

2) total tags -- the percent of employees tagged (either first or repeat) in a comparison of each test (2 through 8) back to the baseline test (test 1), and
3) percent ever tagged -- the percent of employees tagged at least once in comparisons of all tests (2 through 8) back to baseline (test 1).

Age corrections were not used.

Tags were classified as "true positive" if confirmed by the same shift criterion on the next test in the same ear and at the same frequencies or the same frequency combination.

RESULTS

Tables of Results

The percentages of employees who showed shifts by each of the two criteria in comparisons of tests 2-8 back to test 1 are shown tabulated in Tables 1 and 2. Each table presents the percentage of employees with new tags in each comparison, the percentage of total tags, the percentage of employees tagged at least once over tests 2-8, and the percentage of new tags which were classified as true positive on the basis of persistence on the following test. Each type of results is discussed separately below.

Percent of Employees Ever Tagged by Each Shift Criterion

The percent of employees tagged at least once over tests 2-8 is an indication of the total amount of effort hearing conservation program staff would have to expend in providing follow-up. Bar graphs illustrating the percentages of employees ever tagged in each data base are presented as Figures 1 and 2.

The results were averaged across the four control data bases and the eleven non-control databases, as presented in Figure 3. The two criteria being assessed in this report are shown at the top of Figure 3, together with the data for the criteria previously assessed in the 1992 report. The two new criteria produce smaller percentages of tags than any of the previously assessed criteria. Elimination of the test frequencies 500 Hz and 6000 Hz from the 15 dB TWICE at 1-4 kHz criterion reduced the percentages of employees ever tagged from 63% to 47% in non-control databases and from 24% to 15% in control databases. Requiring OSHA STS to persist on the next test before counting the shift as "OSHA STS TWICE" resulted in the smallest percentages of employees tagged by any criterion. The percentages of employees tagged by OSHA STS TWICE were just less than half the values tagged by OSHA STS: only 8% in control databases (reduced from 20%) and only 24% in non-control databases (reduced from 58%).

Total Percent of Employees Tagged in Each Test Comparison

The total percent of tags in each test comparison of tests 2-8 back to test 1 is shown in Figures 4-5, averaged across the control databases and across the non-control databases.

Percent New Tags Per Year

The percent of employees tagged for the first time each year is an indicator of the amount of follow-up effort which hearing conservation program staff would need to expend annually. These data are shown in Figures 6 and 7, averaged across the control databases and across the non-control databases. The mean percent new tags per year in control and non-control databases is compared for the two criteria under current assessment in Figure 8, compared to results previously obtained in 1992 for the other six criteria. The two criteria assessed in this report produce smaller percentages of employees tagged per year than any of the previously evaluated criteria.

Percent True Positive Tags

The first tag for an employee by each shift criterion was classified as a true positive or as a false positive according to whether the tag persisted on the following audiogram (in the same ear and at the same test frequency or frequency combination). First tags which occurred on test 8 could not be classified because test 9 results were not available for confirmation. Therefore, this analysis is based on only those tags which first occurred on tests 2-7.

The percentages of first tags classified as true positive within each database for each shift criterion are shown as Figures 9 and 10. Note that the numbers of tags on which these percentages are based varies a lot depending on the size of the database and the hearing trends shown. For example, for the OSHA STS TWICE criterion, 100% of the first tags for Database 6 were true positive, but there were only 2 tags (2 of 2 = 100%). The percentages of true positive first tags within each database were averaged across control and non-control databases to produce the data shown in Figure 11, which also presents for comparison the data for the criteria previously evaluated in the 1992 report. In this figure each database contributes equally to the average for its group (control versus non-control).

In addition, all first tags across all databases were pooled to yield the data presented in Table 3 and Figure 12 for the percentages of all first tags classified as true positive (current criteria compared to 1992 criteria). In this analysis each tag counts equally; therefore, the larger databases are more likely to contribute more tags toward the resulting percentages.

Comparison of Figures 11 and 12 shows similar results. The two 15 dB TWICE criteria (both at .5-6 kHz and at 1-4 kHz) yield the overall highest percentages of true positive tags. The OSHA STS TWICE criterion achieved a higher percentage of true positive tags in the control databases only, but its percent true positive tags in the non-control databases was lower than for either of the 15 dB TWICE criteria. When tags for all databases were pooled (Figure 12), the improvement of OSHA STS TWICE over OSHA STS can be seen. However, the two 15 dB TWICE criteria still yield the highest percentages of true positive tags, with slightly higher results for the criterion 15 dB TWICE at 1-4 kHz.

Timing of Tag Occurrences

The two criteria under current assessment were compared in terms of how soon they tagged employees for follow-up. If an employee is eventually tagged by each of these two

criteria, the criterion which provides the earliest tag is preferable because the employee will receive follow-up sooner, thereby allowing the potential for hearing loss progression to be halted sooner.

This analysis includes only those employees who were tagged by one or both of the two criteria under current assessment. If the employee was tagged by both criteria on the same test comparison, then both criteria were credited with tagging that employee earliest. Otherwise, only the criterion which yielded the first tag was credited with tagging that employee earliest. If only one criterion tagged the employee (that is, if the other criterion did not tag the employee at all) then the criterion which did tag the individual was credited with the earliest (and only) tag.

The results are shown as Figure 13. In both control and non-control databases, the 15 dB TWICE at 1-4 kHz criterion resulted in more than twice as many early tags as the OSHA STS TWICE criterion. One reason for this large discrepancy is that nearly half the employees tagged by 15 dB TWICE at 1-4 kHz were never tagged by OSHA STS TWICE, as shown in Figure 14. Conversely, only a handful of employees were missed by 15 dB TWICE at 1-4 kHz but tagged by OSHA STS TWICE. There are only two ways for this to occur. One is for the employee to show an STS composed of 10-dB shifts at each frequency. The second is for the STS to involve variable shifts by frequency, such as shifts of 10 dB at 2 and 3 kHz and 15 dB at 4 kHz on one test, then shifts of 10 dB at 2 and 4 kHz and 15 dB at 3 kHz on the next test.

ADVANTAGES AND DISADVANTAGES OF DIFFERENT SHIFT CRITERIA

For comparison to the criteria assessed in the 1992 report, a table of advantages and disadvantages of various shift criteria is shown as Table 3. The two criteria under current assessment will be discussed further.

Requiring persistence of OSHA STS on the next audiogram to create the criterion OSHA STS TWICE had three main results compared to ordinary OSHA STS:

1) it reduced the percent of employees tagged to very small numbers -- less than 4% new tags per year in non-control databases (see Figure 8) and less than 25% of employees ever tagged across tests 2-8 in non-control databases (see Figure 3),
2) it increased the percent of first tags which were classified true positive (see Figures 11 and 12) to be comparable to the 15 dB TWICE and 15 dB TWICE at 1-4 kHz criteria, and
3) it reduced the numbers of employees tagged soonest (see Figure 13).

In short, OSHA STS TWICE is unsatisfactory as a significant threshold shift criterion because it not sensitive enough to the development of noise-induced hearing loss. It identifies too few employees. The frequency-averaging involved, which combines test frequencies which differ in susceptibility to noise-induced permanent threshold shift, makes this criterion (like ordinary OSHA STS) insensitive to both early incipient NIHL and late NIHL progressing deeper into the speech frequencies. It shares all the disadvantages of OSHA STS and adds the further disadvantages of identifying fewer employees and tagging them later.

The criterion 15 dB TWICE at 1-4 kHz differs from the criterion previously evaluated in 1992, 15 dB TWICE, by excluding shifts at 500 Hz and 6000 Hz. The 500 Hz test frequency is unlikely to be affected by noise-induced hearing loss. It may, however, serve as an indicator of excess ambient noise in the audiometric test booth and as an indicator of the presence of medical ear conditions such as conductive ear pathologies. The 6000 Hz test frequency is one of the three high frequencies (3, 4, and 6 kHz) most likely to be affected soonest and to the greatest degree by noise-induced hearing loss. It is more susceptible than other test frequencies to measurement variability if there is inconsistent earphone placement.

Eliminating 500 and 6000 Hz from the criterion 15 dB TWICE at 1-4 kHz had one main result: it reduced the percentages of employees identified to less than the percentages for ordinary OSHA STS (see Figures 3 and 8). Interestingly, eliminating 500 and 6000 Hz did not increase the percent true positive tags by any practically important amount (see Figures 11 and 12). The shifts at 500 Hz and 6000 Hz which meet the 15 dB TWICE criterion are reliable shifts, not spurious ones.

Ordinary OSHA STS does not yield a high percent of tags, as recently documented in comments to submitted to OSHA (see references). Therefore, it is undesirable to select a criterion which identifies even fewer employees for follow-up than OSHA STS. Inclusion of 6000 Hz is desirable from the standpoint of identifying early noise-induced hearing damage. Therefore, the original criterion 15 dB TWICE is preferable to the currently evaluated criterion 15 dB TWICE at 1-4 kHz because it identifies a higher number of employees and provides a warning of noise-induced shifts at 6000 Hz, a noise-susceptible test frequency. The 15 dB TWICE criteria (both at 500-6000 Hz and at 1000-4000 Hz) yield the highest percentages of true positive first tags of any of the shift criteria evaluated.

REFERENCES

Coalition to Protect Workers' Hearing: **A statement regarding 29 CFR Parts 1904 and 1952 Occupational Injury and Illness Recording and Reporting Requirements: Proposed Rule** *(*testimony submitted to OSHA Docket R-02, US Department of Labor*)*. Washington, DC: American Speech-Language-Hearing Association, 1996.

American Industrial Hygiene Association: **AIHA position statement: recommended criterion for recording occupational hearing loss on OSHA Form 300**. *Am Ind Hyg Assoc J* 1996, **57**:661-662.

TABLES

TABLE 1. RESULTS FOR THE CRITERION "OSHA STS TWICE"

DATA BASE	PERCENT NEW TAGS PER YEAR							PERCENT EVER TAGGED	PERCENT TOTAL TAGS EACH YEAR							PERCENT TRUE POSITIVE TAGS
	1-2	1-3	1-4	1-5	1-6	1-7	1-8		1-2	1-3	1-4	1-5	1-6	1-7	1-8	
1	0.0	0.0	2.0	0.0	0.0	2.0	2.0	6.1	0.0	0.0	2.0	1.0	0.0	3.1	5.1	75.0
2	0.0	2.1	1.4	0.9	1.6	2.7	1.9	10.6	0.0	0.2	3.1	2.6	4.1	7.2	8.0	67.4
5	0.0	2.4	1.2	3.6	0.0	0.0	1.8	9.0	0.0	2.4	3.6	4.8	4.2	6.6	7.2	83.3
6	0.0	0.0	0.0	2.3	0.0	2.3	2.3	6.8	0.0	0.0	0.0	2.3	2.3	4.5	6.8	100.0
3	0.0	6.5	4.3	0.0	4.3	6.5	2.2	23.9	0.0	6.5	10.9	6.5	10.9	19.6	19.6	80.0
4	0.0	7.7	1.6	0.5	1.4	1.9	1.4	14.4	0.0	7.7	6.5	3.7	4.2	8.1	7.2	53.6
7	0.0	2.4	4.9	0.0	0.0	2.4	4.9	14.6	0.0	2.4	4.9	2.4	2.4	7.3	9.8	25.0
8	0.0	4.5	0.0	2.3	2.3	6.8	2.3	18.2	0.0	4.5	2.3	2.3	2.3	11.4	11.4	57.1
9	0.0	24.3	9.5	4.1	1.4	4.1	1.4	44.6	0.0	24.3	25.7	20.3	18.9	35.1	35.1	53.1
10	0.0	3.3	2.8	0.8	1.2	4.1	6.9	19.1	0.0	3.3	4.5	2.8	3.3	8.1	14.6	60.0
11	0.0	6.7	10.7	1.3	1.3	5.3	4.0	2.7	0.0	6.7	16.0	9.3	13.3	21.3	24.0	57.9
12	0.0	0.0	8.5	4.3	6.4	2.1	6.4	27.7	0.0	0.0	8.5	4.3	8.5	4.3	10.6	10.0
15	0.0	2.5	0.8	0.3	0.6	0.3	3.7	11.2	0.0	2.5	2.2	2.0	2.0	5.3	7.6	63.0
16	0.0	0.0	4.3	1.4	4.3	11.4	15.7	8.6	0.0	0.0	4.3	5.7	8.6	15.7	30.0	93.3
17	0.0	8.8	7.9	0.9	6.1	7.9	9.6	74.6	0.0	8.8	13.2	8.8	14.0	21.9	28.9	69.4

TABLE 2. RESULTS FOR THE CRITERION "15 dB TWICE at 1-4 kHz"

DATA BASE	PERCENT NEW TAGS PER YEAR							PERCENT EVER TAGGED	PERCENT TOTAL TAGS EACH YEAR							PERCENT TRUE POSITIVE TAGS
	1-2	1-3	1-4	1-5	1-6	1-7	1-8		1-2	1-3	1-4	1-5	1-6	1-7	1-8	
1	0.0	3.1	4.1	2.0	0.0	4.1	4.1	19.4	0.0	3.1	7.1	8.2	9.2	10.2	14.3	80.0
2	0.0	4.2	2.3	2.0	3.5	3.1	4.9	20.0	0.0	4.2	5.6	6.8	10.0	12.7	16.0	76.7
5	0.0	2.4	1.8	3.6	2.4	1.8	1.2	13.3	0.0	2.4	4.2	7.8	8.4	10.2	11.4	85.0
6	0.0	0.0	0.0	4.5	0.0	4.5	0.0	9.1	0.0	0.0	0.0	4.5	0.0	4.5	4.5	25.0
3	0.0	8.7	8.7	4.3	4.3	8.7	0.0	34.8	0.0	8.7	17.4	19.6	21.7	30.4	23.9	75.0
4	0.0	15.1	4.2	1.9	4.2	4.2	2.8	32.3	0.0	15.1	15.3	14.2	16.7	18.8	20.2	68.5
7	0.0	2.4	4.9	9.8	12.2	2.4	2.4	34.1	0.0	2.4	7.3	17.1	22.0	17.1	17.1	46.2
8	0.0	27.3	0.0	2.3	6.8	2.3	4.5	43.2	0.0	45.9	43.2	43.2	45.9	48.6	52.7	73.1
9	0.0	45.9	9.5	8.1	2.7	4.1	2.7	73.0	0.0	7.7	13.4	15.4	16.7	22.4	32.1	66.7
10	0.0	7.7	8.5	4.5	3.7	6.1	9.3	39.8	0.0	4.3	12.8	14.9	38.3	34.0	40.4	76.2
11	0.0	20.0	8.0	12.0	9.3	5.3	2.7	57.3	0.0	27.3	15.9	15.9	20.5	20.5	27.3	58.8
12	0.0	4.3	8.5	4.3	21.3	6.4	6.4	51.1	0.0	20.0	22.7	32.0	41.3	42.7	45.3	78.0
15	0.0	5.3	3.9	3.7	2.2	7.6	5.6	28.4	0.0	5.3	7.9	10.1	10.7	18.8	22.5	81.5
16	0.0	2.9	8.6	5.7	5.7	15.7	7.1	45.7	0.0	2.9	11.4	15.7	20.0	34.3	42.9	88.9
17	0.0	14.9	10.5	5.3	9.6	0.9	9.6	74.6	0.0	14.9	20.2	21.1	27.2	33.3	43.9	67.2

TABLE 3. NUMBERS OF CLASSIFIABLE FIRST TAGS (THOSE OCCURRING IN COMPARISONS OF TESTS 2-7 BACK TO TEST 1) ACROSS ALL 15 DATA BASES (N=2903), AND NUMBERS AND PERCENTS OF FIRST TAGS CLASSIFIED AS TRUE POSITIVE FOR EACH OF 8 SHIFT CRITERIA.

CRITERION	NUMBER OF CLASSIFIABLE TAGS	NUMBER OF TRUE POSITIVE TAGS	PERCENT TRUE POSITIVE TAGS
OSHA STS TWICE	356	203	57.0%
15 dB TWICE 1-4kHz	726	532	73.3%
OSHA STS	958	412	43.0%
15 dB TWICE	1056	749	70.9%
10 dB AVG. 3-4 kHz	1175	524	44.6%
AAO-HNS SHIFT	1291	578	44.8%
15-dB SHIFT	2126	858	40.4%
NIOSH SHIFT	2268	1045	46.1%

TABLE 4. ADVANTAGES AND DISADVANTAGES OF EACH CRITERION FOR SIGNIFICANT THRESHOLD SHIFT

	OSHA STS TWICE	15 dB TWICE at 1-4 kHz	OSHA STS	15 dB TWICE	10dB AVG. 3-4 kHz	AAO-HNS SHIFT	15-dB SHIFT	NIOSH SHIFT
ADVANTAGES								
tags a moderate percentage of employees				x	x	x		
gives high percentage true positive tags		x		x				
tags employees earliest								x
no calculation of frequency-averages required		x		x			x	x
averages noise-susceptible frequencies separately or examines each frequency separately		x		x	x	x	x	x
includes all noise-susceptible frequencies				x		x	x	x
no special retesting required to assess persistence	x	x		x				
DISADVANTAGES								
tags a low percentage of employees	x	x	x					
tags such a high percentage of employees that follow-up would be impractical							x	x
tags employees early in fewer cases	x	x		x				
requires calculations of averages	x		x		x	xx		
low-frequency average is unlikely to be affected by noise						x		
averages together frequencies which vary in susceptibility to noise	x		x					
uses a shift size within the range of normal audiometric variability in HCPs								x

FIGURES

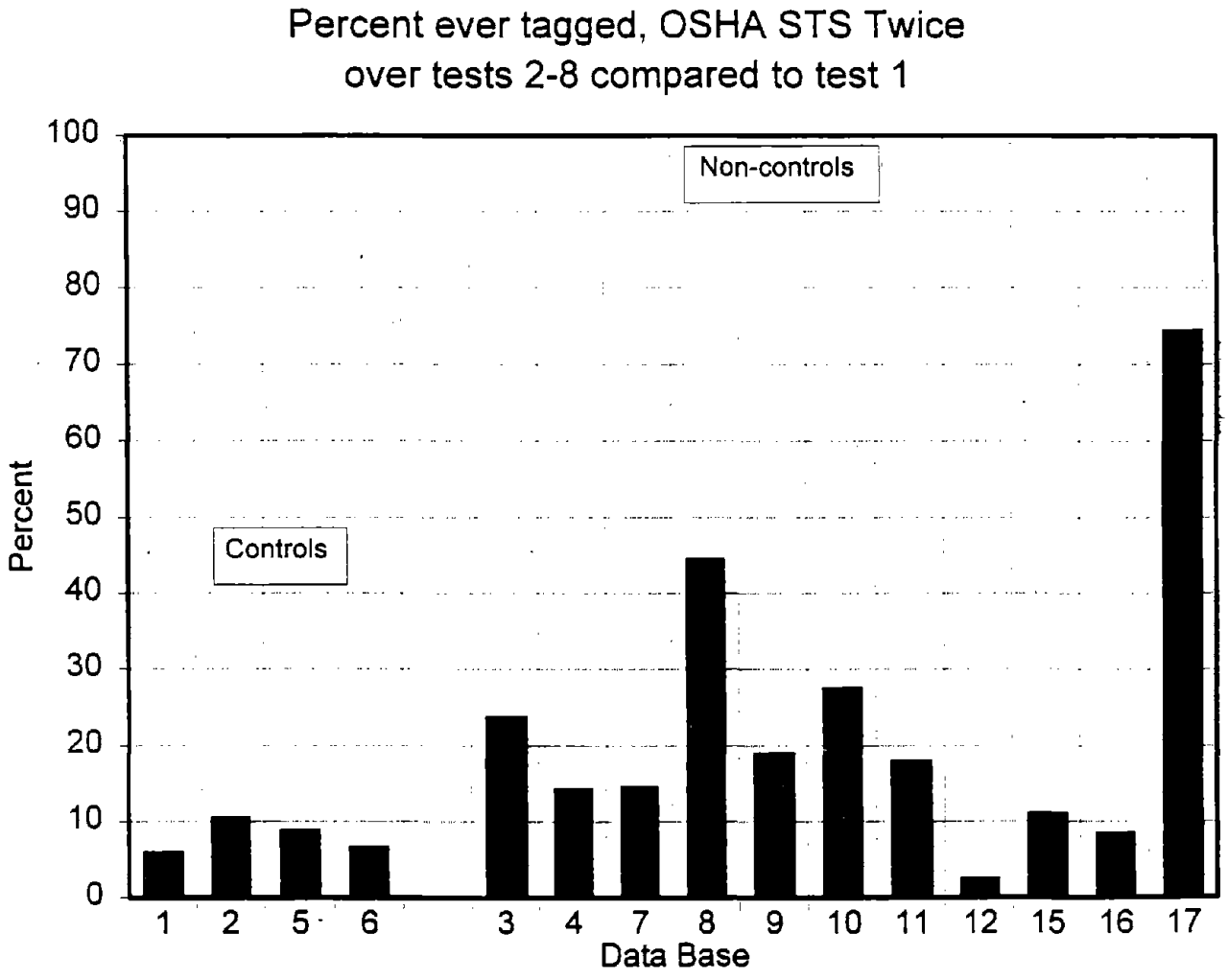

Percent ever tagged, OSHA STS Twice
over tests 2-8 compared to test 1
Non-controls
Controls
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 5 6 3 4 7 8 9 10 11 12 15 16 17
Data Base

FIGURE 2

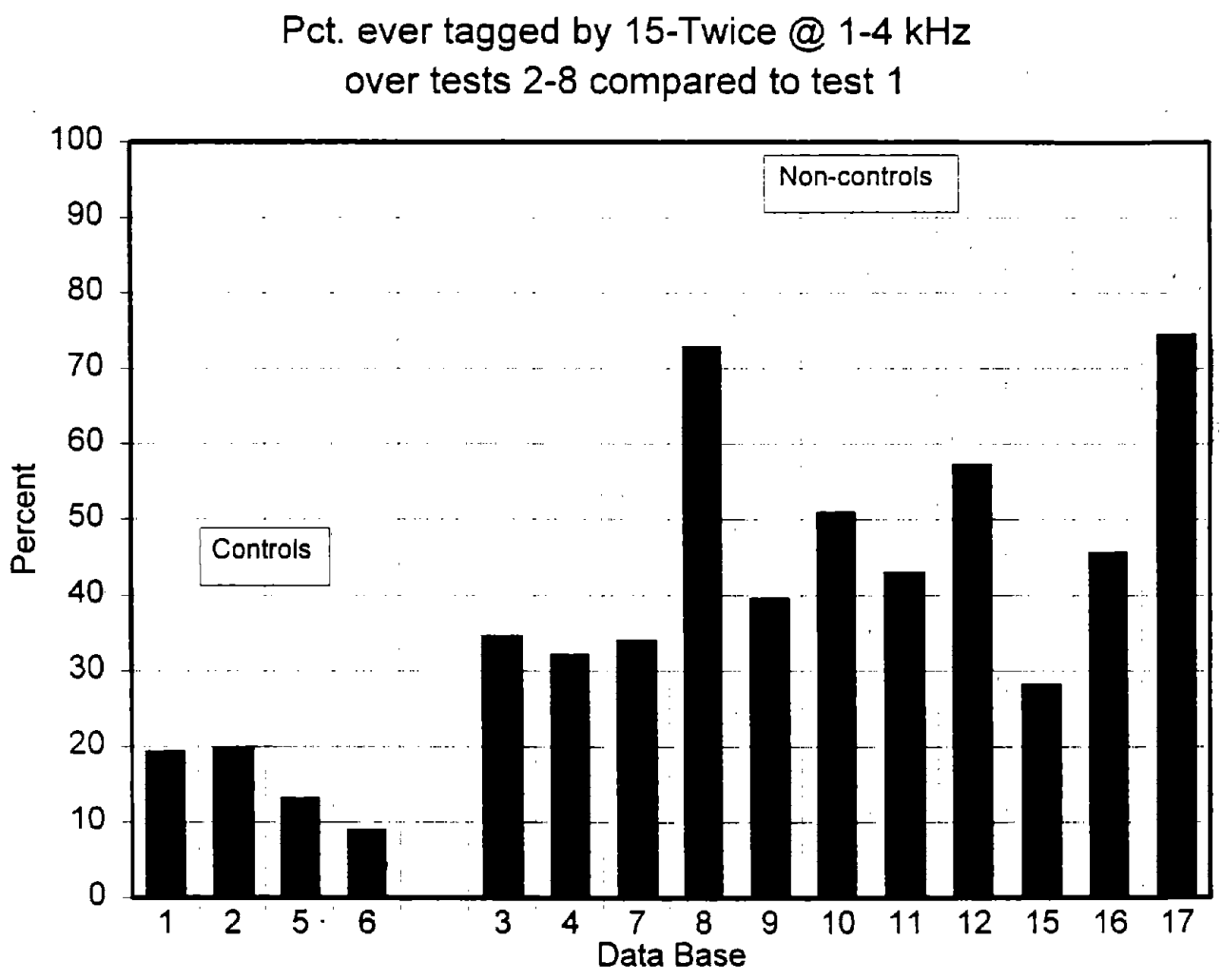

Pct. ever tagged by 15-Twice @ 1-4 kHz
over tests 2-8 compared to test 1
Non-controls
Controls
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
5
6
3
4
7
8
9
10
11
12
15
16
17
Data Base

FIGURE 3

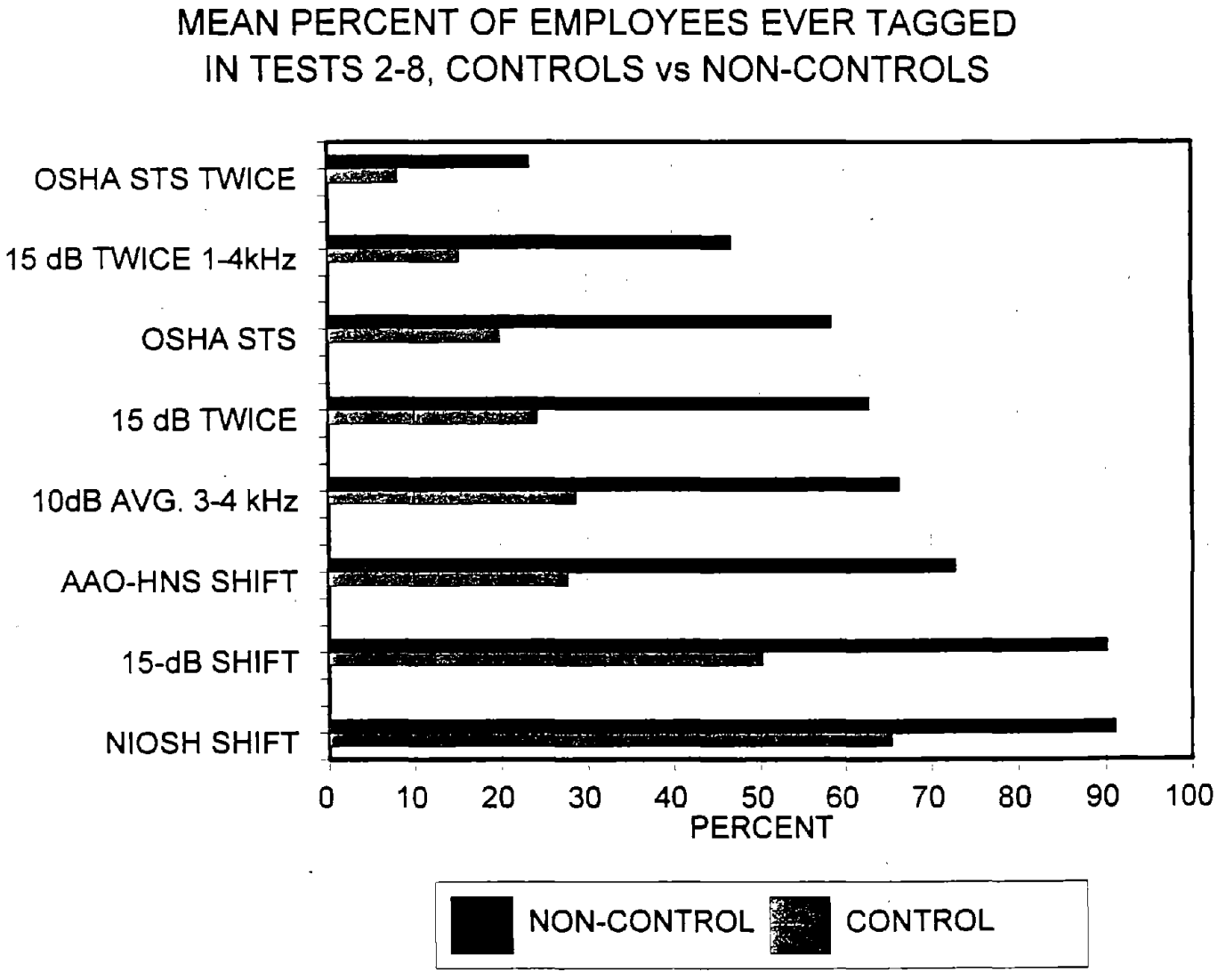

MEAN PERCENT OF EMPLOYEES EVER TAGGED
IN TESTS 2-8, CONTROLS vs NON-CONTROLS
OSHA STS TWICE
15 dB TWICE 1-4kHz
OSHA STS
15 dB TWICE
10dB AVG. 3-4 kHz
AAO-HNS SHIFT
15-dB SHIFT
NIOSH SHIFT
0
10
20
30
40
50
60
70
80
90
100
PERCENT
NON-CONTROL
CONTROL

FIGURE 4

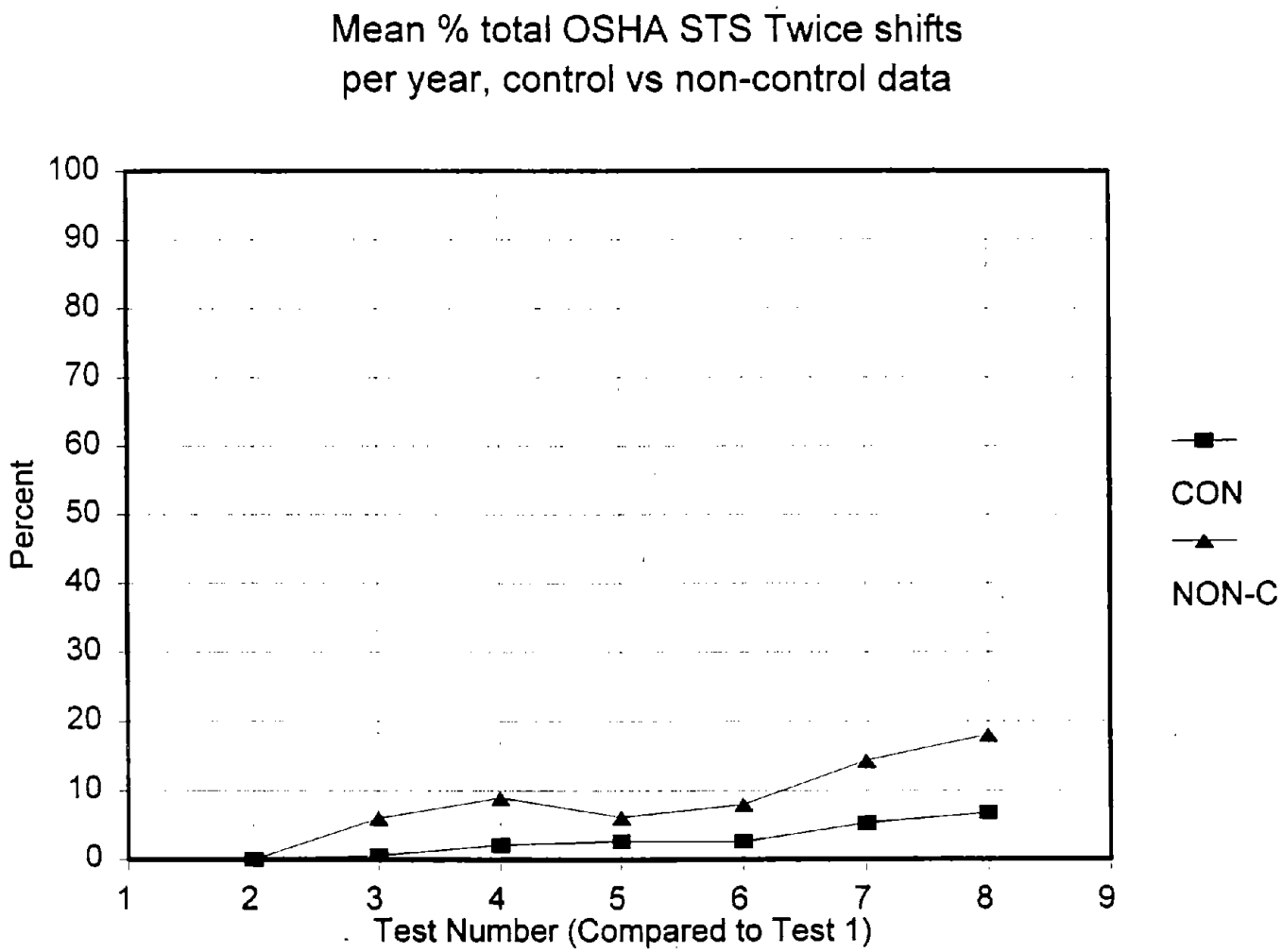

Mean % total OSHA STS Twice shifts per year, control vs non-control data
100
90
80
70
60
50
40
30
20
10
0
Percent
1
2
3
4
5
6
7
8
9
Test Number (Compared to Test 1)
CON
NON-C

FIGURE 5

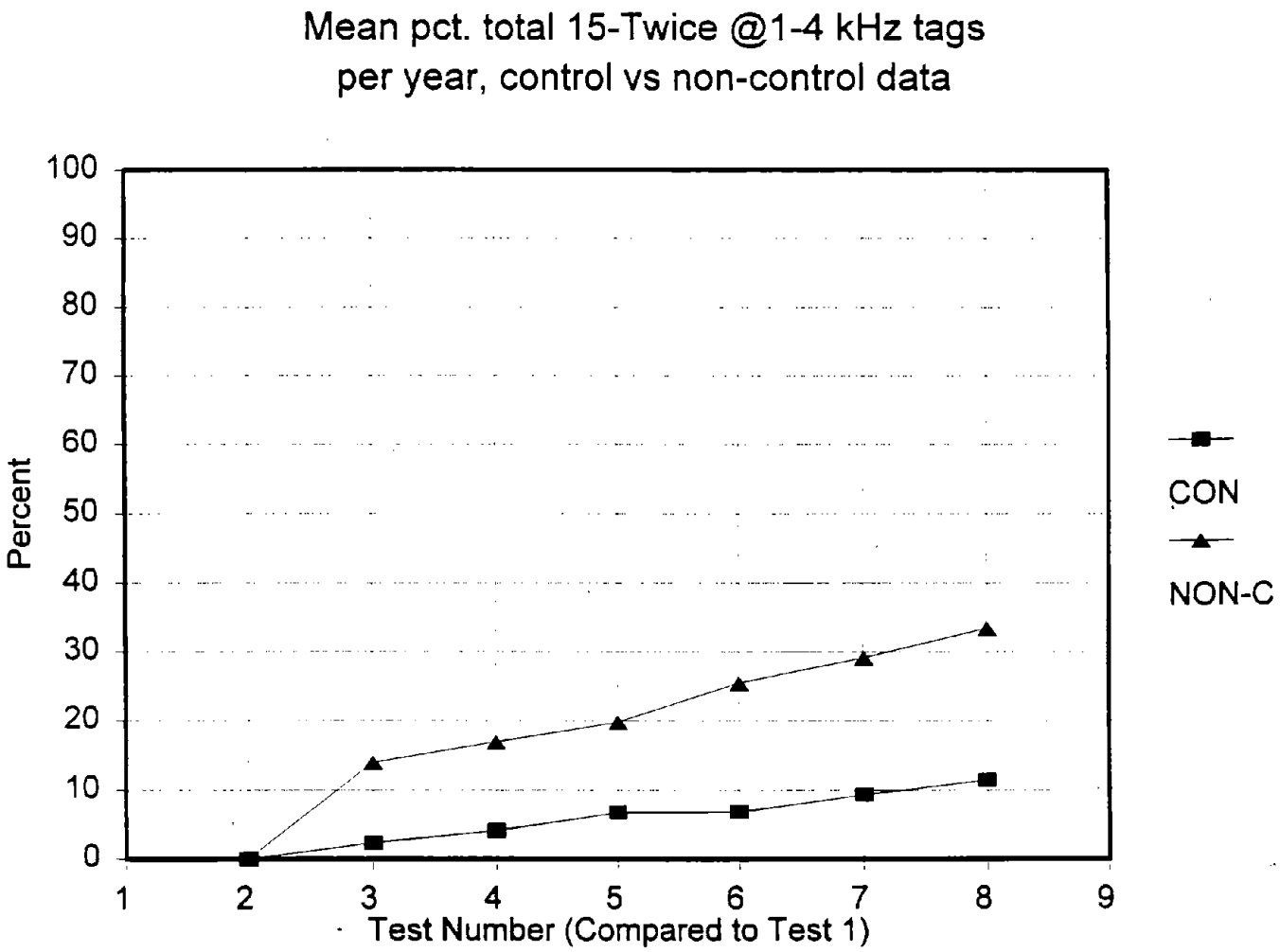

Mean pct. total 15-Twice @1-4 kHz tags per year, control vs non-control data
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
Test Number (Compared to Test 1)
CON
NON-C

FIGURE 6

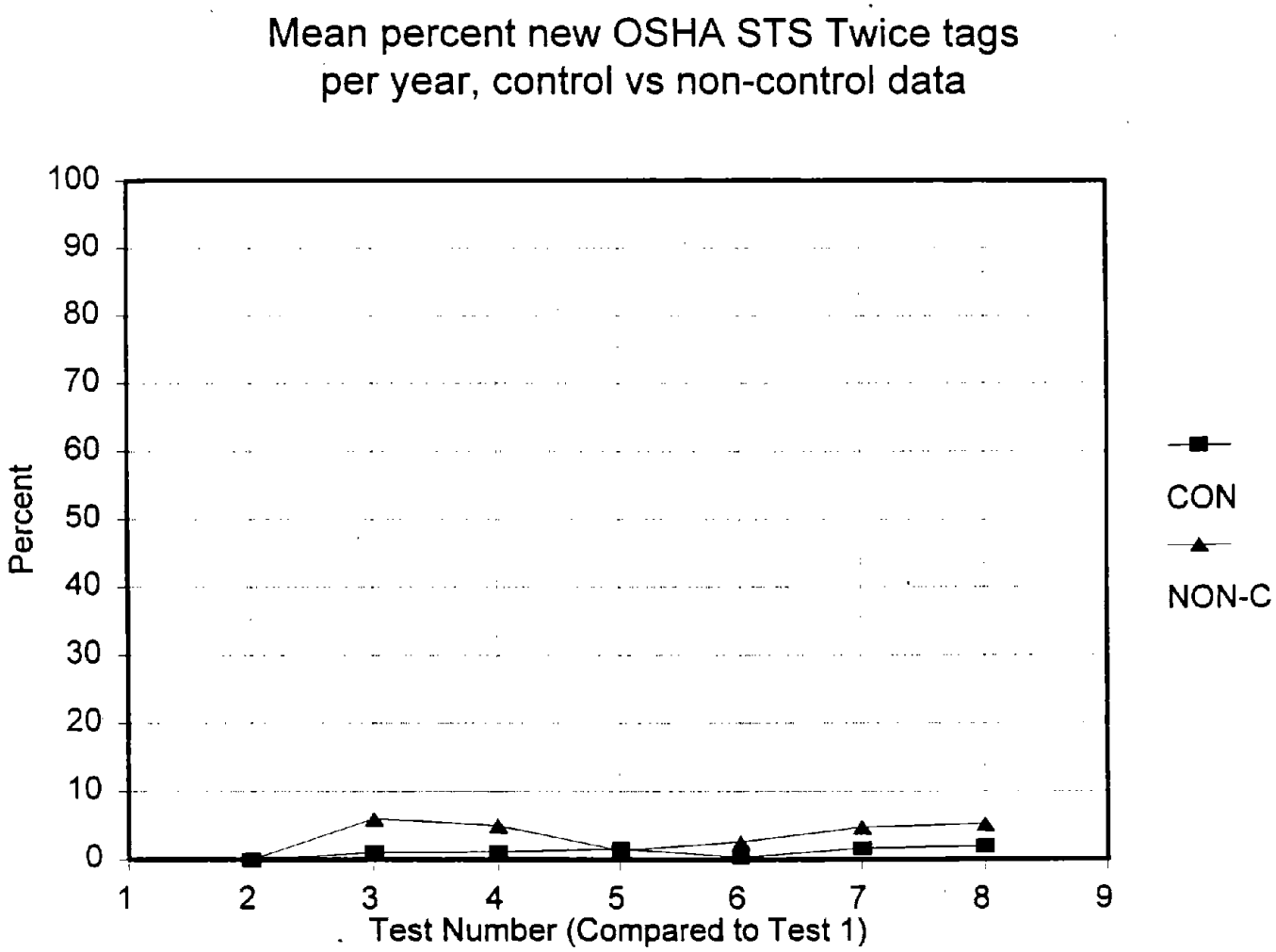

Mean percent new OSHA STS Twice tags per year, control vs non-control data
100
90
80
70
60
50
40
30
20
10
0
Percent
1
2
3
4
5
6
7
8
9
Test Number (Compared to Test 1)
CON
NON-C

FIGURE 7

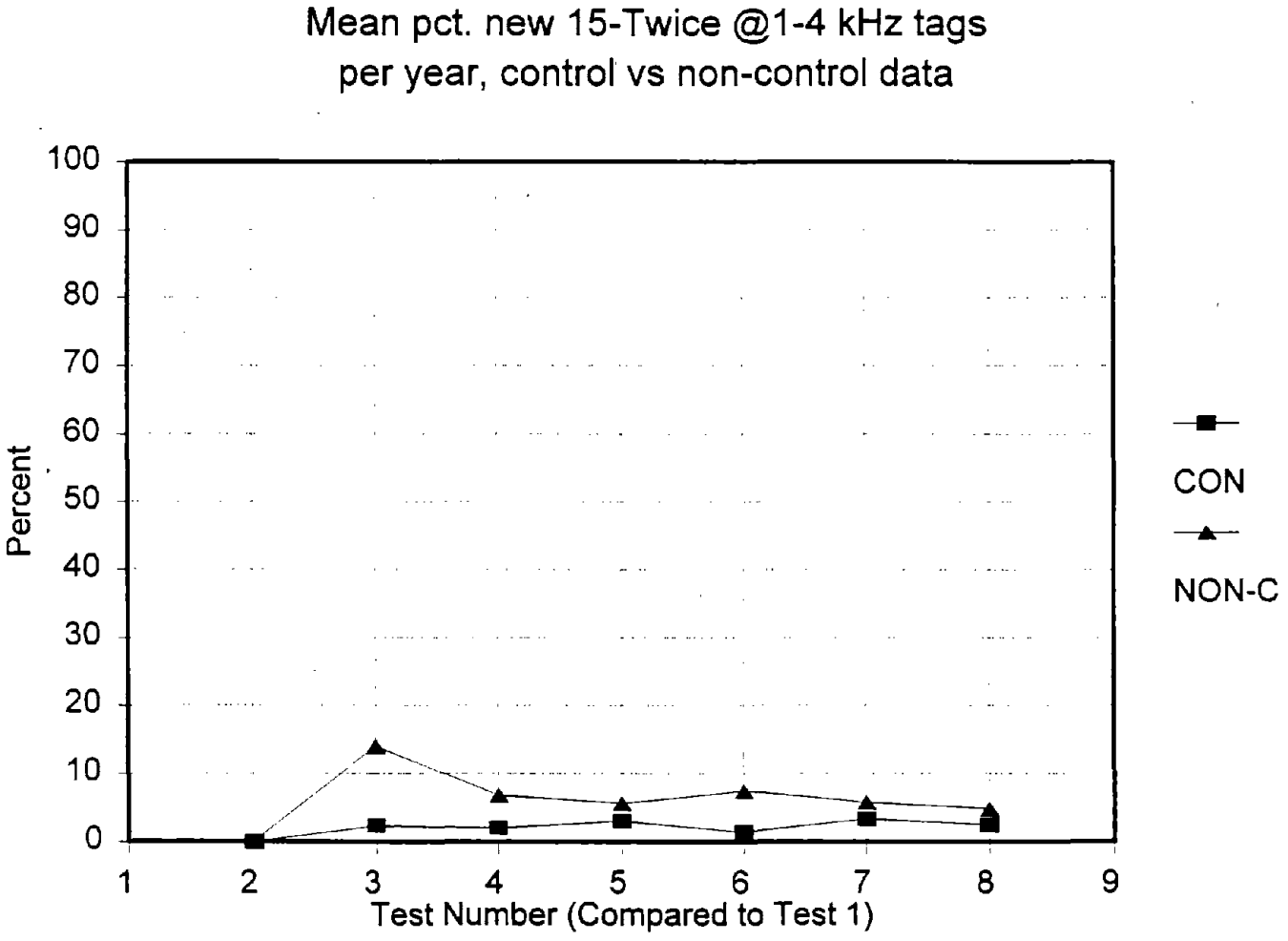

Mean pct. new 15-Twice @1-4 kHz tags per year, control vs non-control data
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
Test Number (Compared to Test 1)
CON
NON-C

FIGURE 8

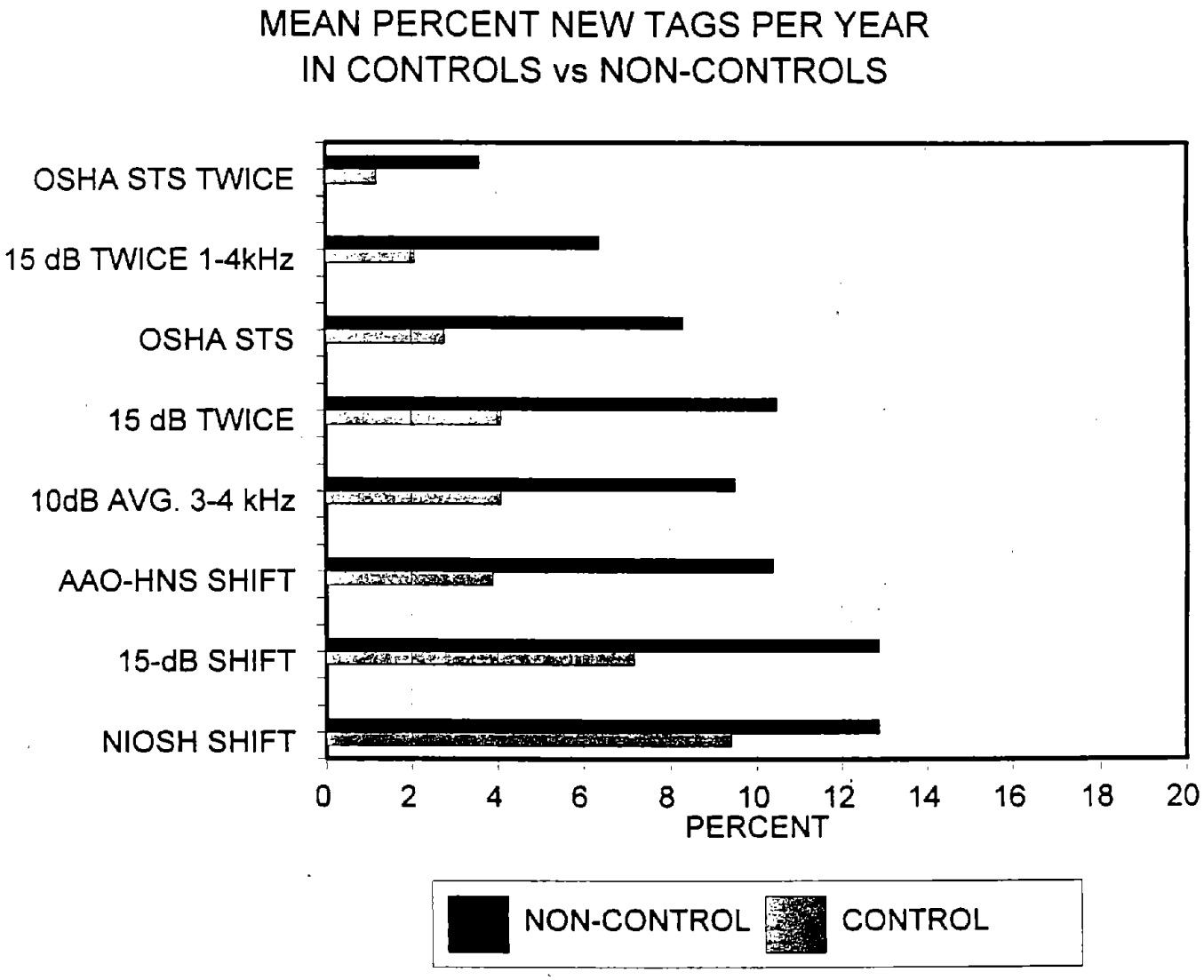

MEAN PERCENT NEW TAGS PER YEAR
IN CONTROLS vs NON-CONTROLS
OSHA STS TWICE
15 dB TWICE 1-4kHz
OSHA STS
15 dB TWICE
10dB AVG. 3-4 kHz
AAO-HNS SHIFT
15-dB SHIFT
NIOSH SHIFT
0
2
4
6
8
10
12
14
16
18
20
PERCENT
NON-CONTROL
CONTROL

FIGURE 9

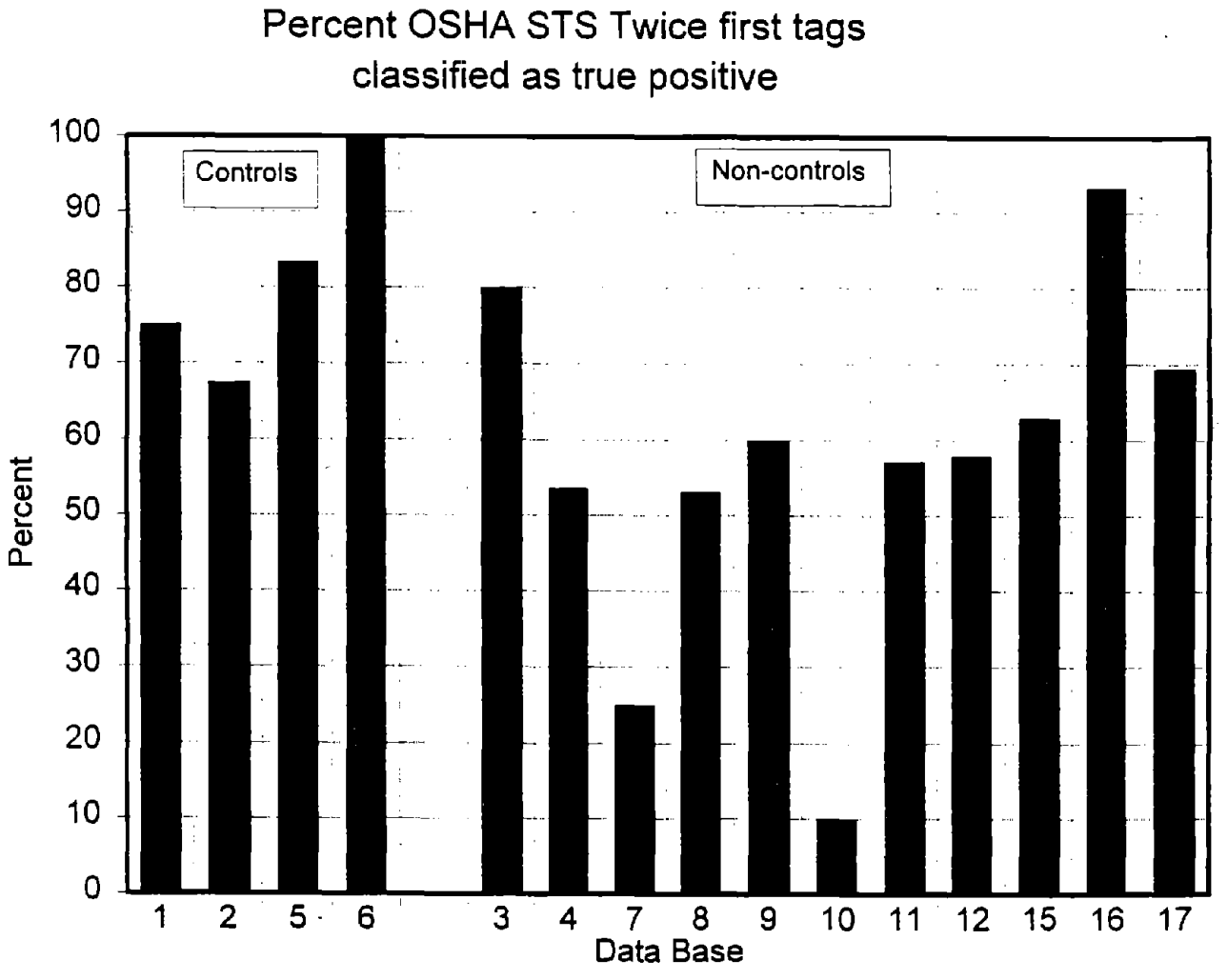

Percent OSHA STS Twice first tags
classified as true positive
Controls
Non-controls
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
5
6
3
4
7
8
9
10
11
12
15
16
17
Data Base

FIGURE 10

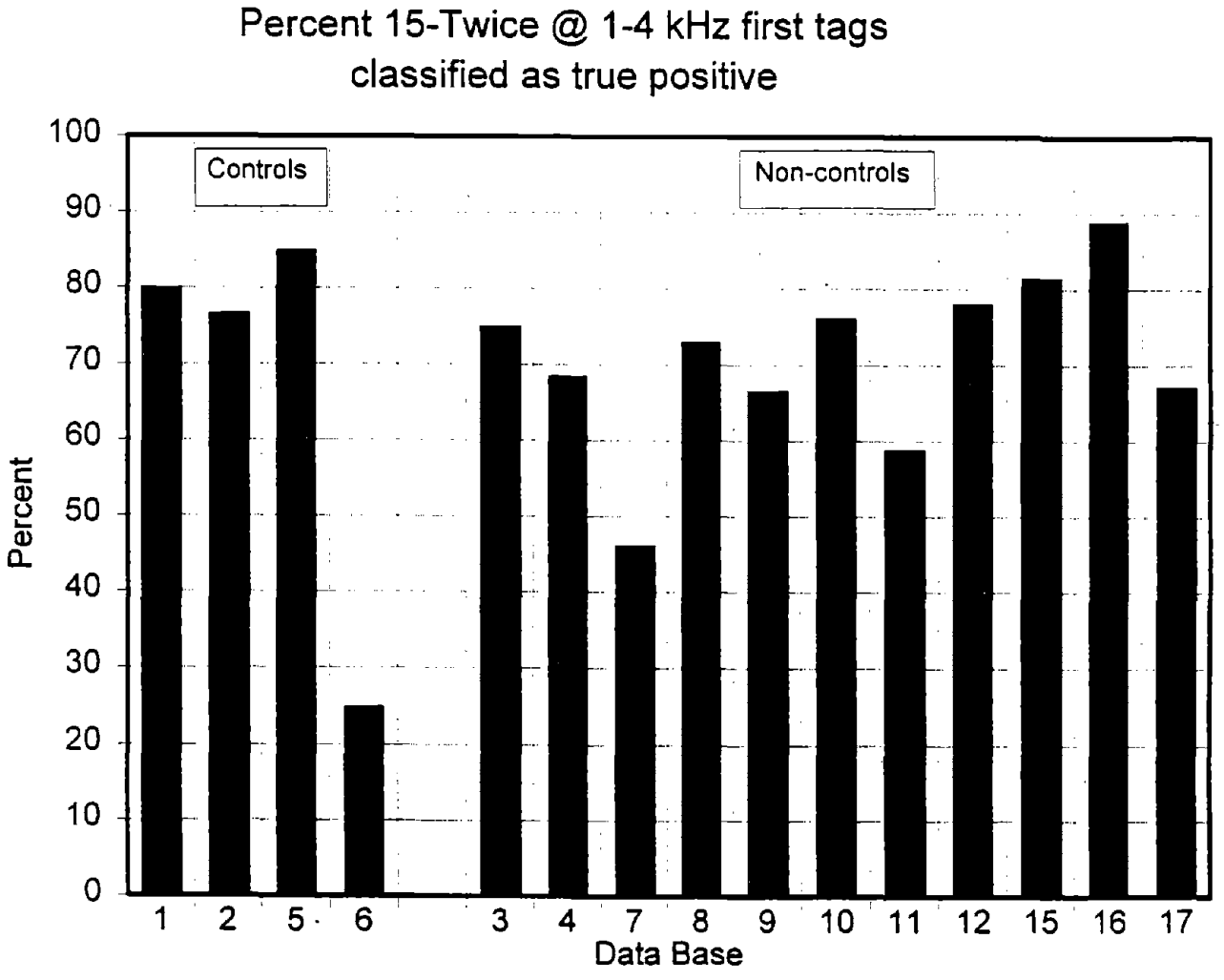

Percent 15-Twice @ 1-4 kHz first tags
classified as true positive
Controls
Non-controls
Percent
100
90
80
70
60
50
40
30
20
10
0
1
2
5
6
3
4
7
8
9
10
11
12
15
16
17
Data Base

FIGURE 11

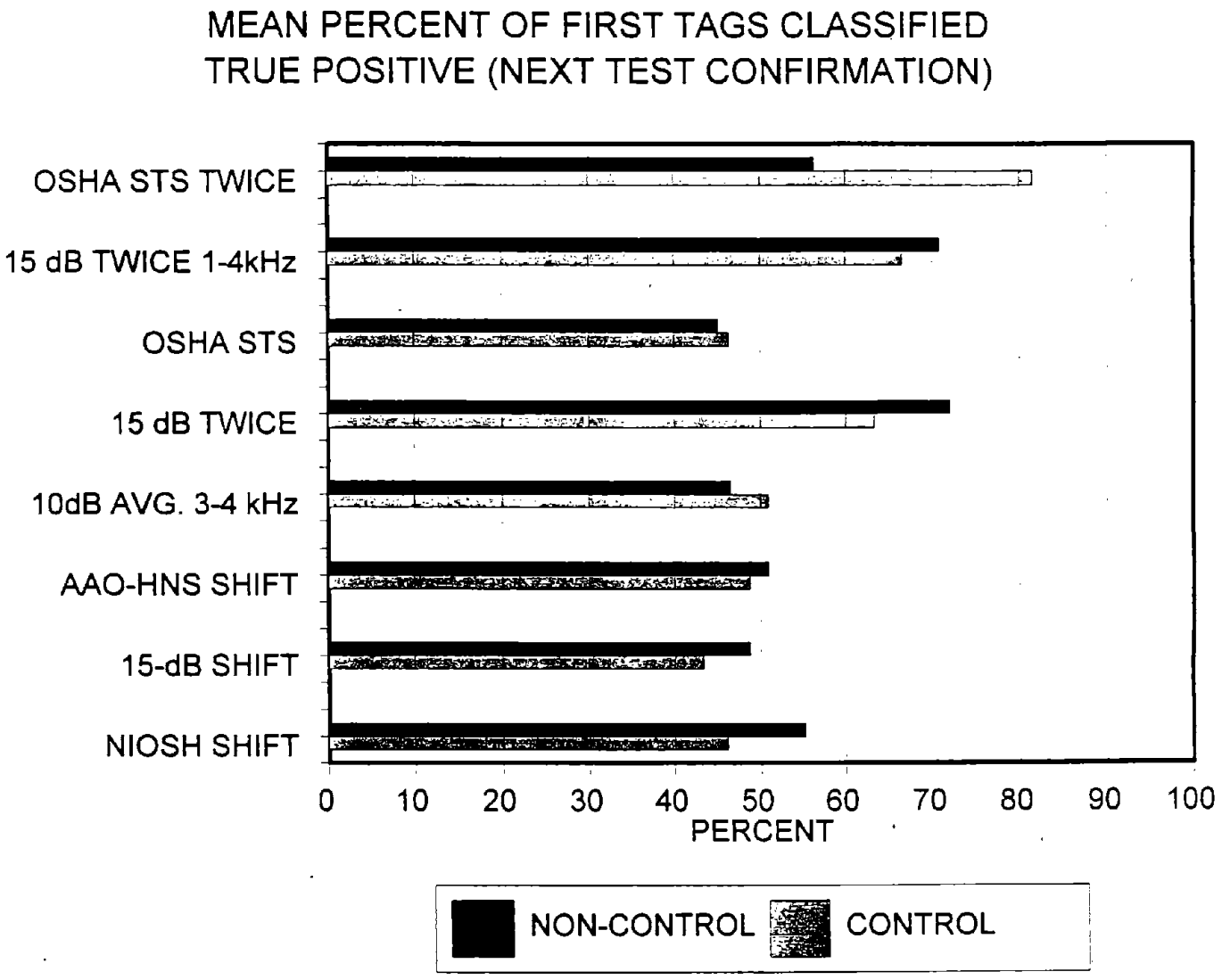

MEAN PERCENT OF FIRST TAGS CLASSIFIED
TRUE POSITIVE (NEXT TEST CONFIRMATION)
OSHA STS TWICE
15 dB TWICE 1-4kHz
OSHA STS
15 dB TWICE
10dB AVG. 3-4 kHz
AAO-HNS SHIFT
15-dB SHIFT
NIOSH SHIFT
0
10
20
30
40
50
60
70
80
90
100
PERCENT
NON-CONTROL
CONTROL

FIGURE 12

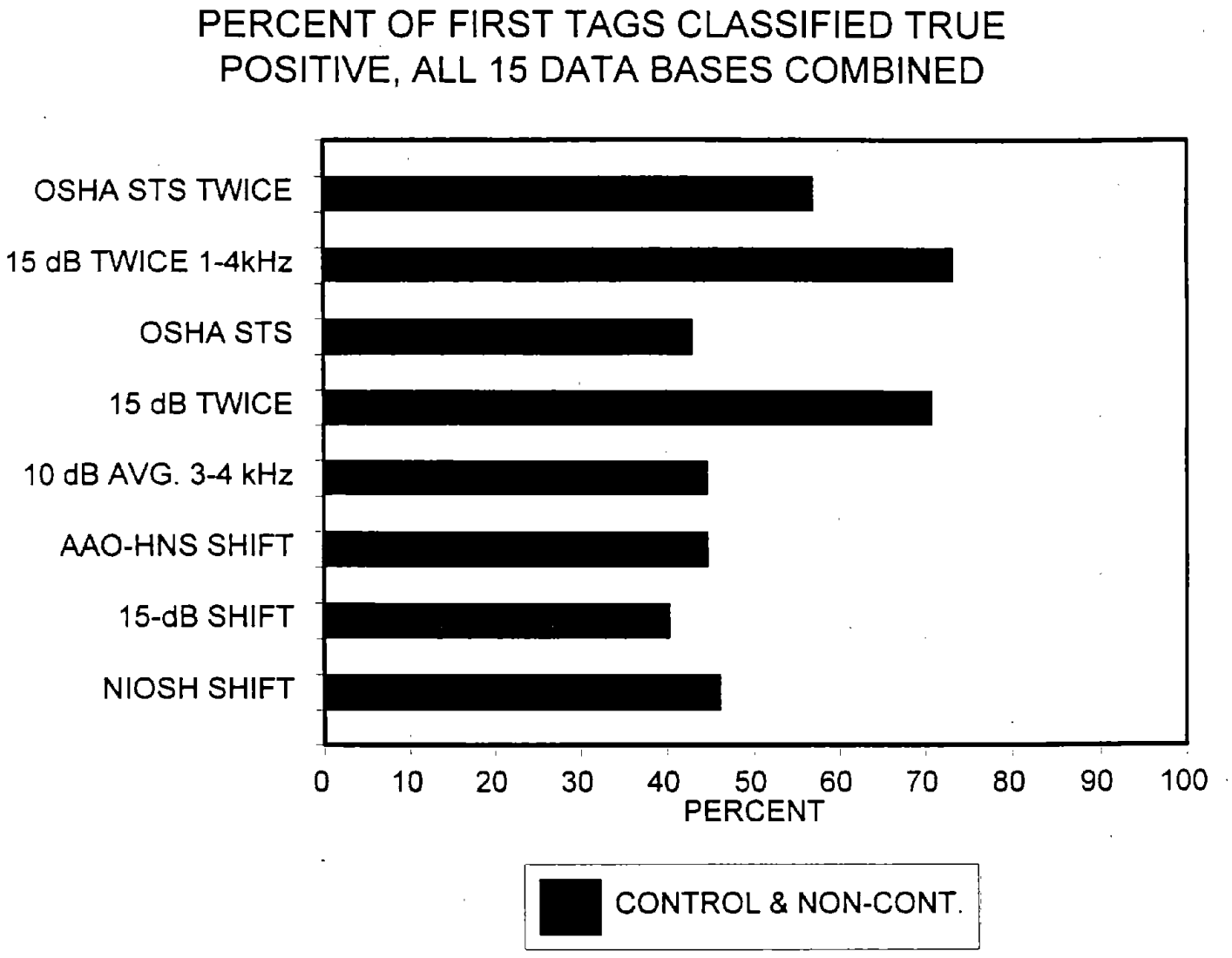

PERCENT OF FIRST TAGS CLASSIFIED TRUE POSITIVE, ALL 15 DATA BASES COMBINED
OSHA STS TWICE
15 dB TWICE 1-4kHz
OSHA STS
15 dB TWICE
10 dB AVG. 3-4 kHz
AAO-HNS SHIFT
15-dB SHIFT
NIOSH SHIFT
0
10
20
30
40
50
60
70
80
90
100
PERCENT
CONTROL & NON-CONT.

FIGURE 13

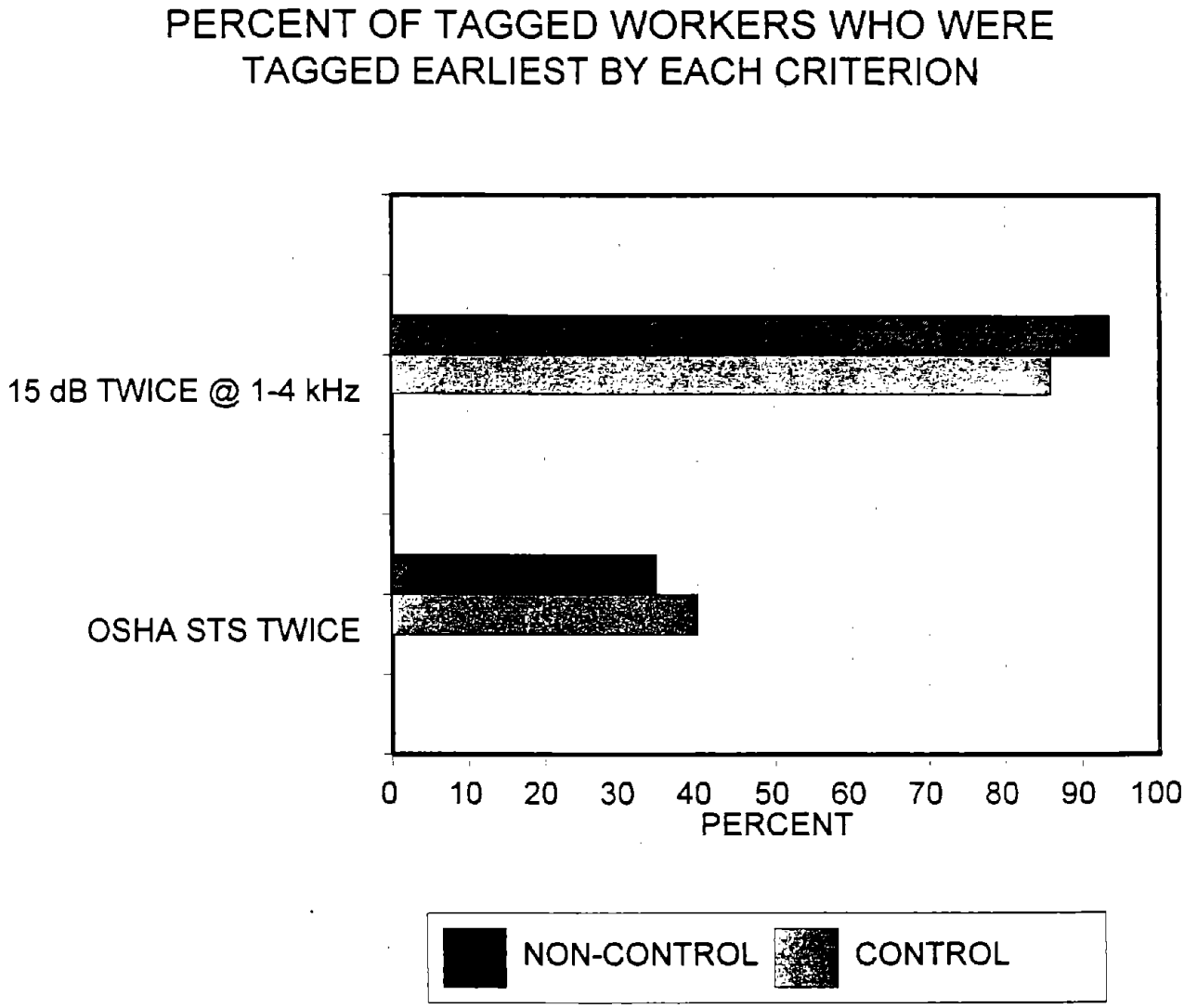
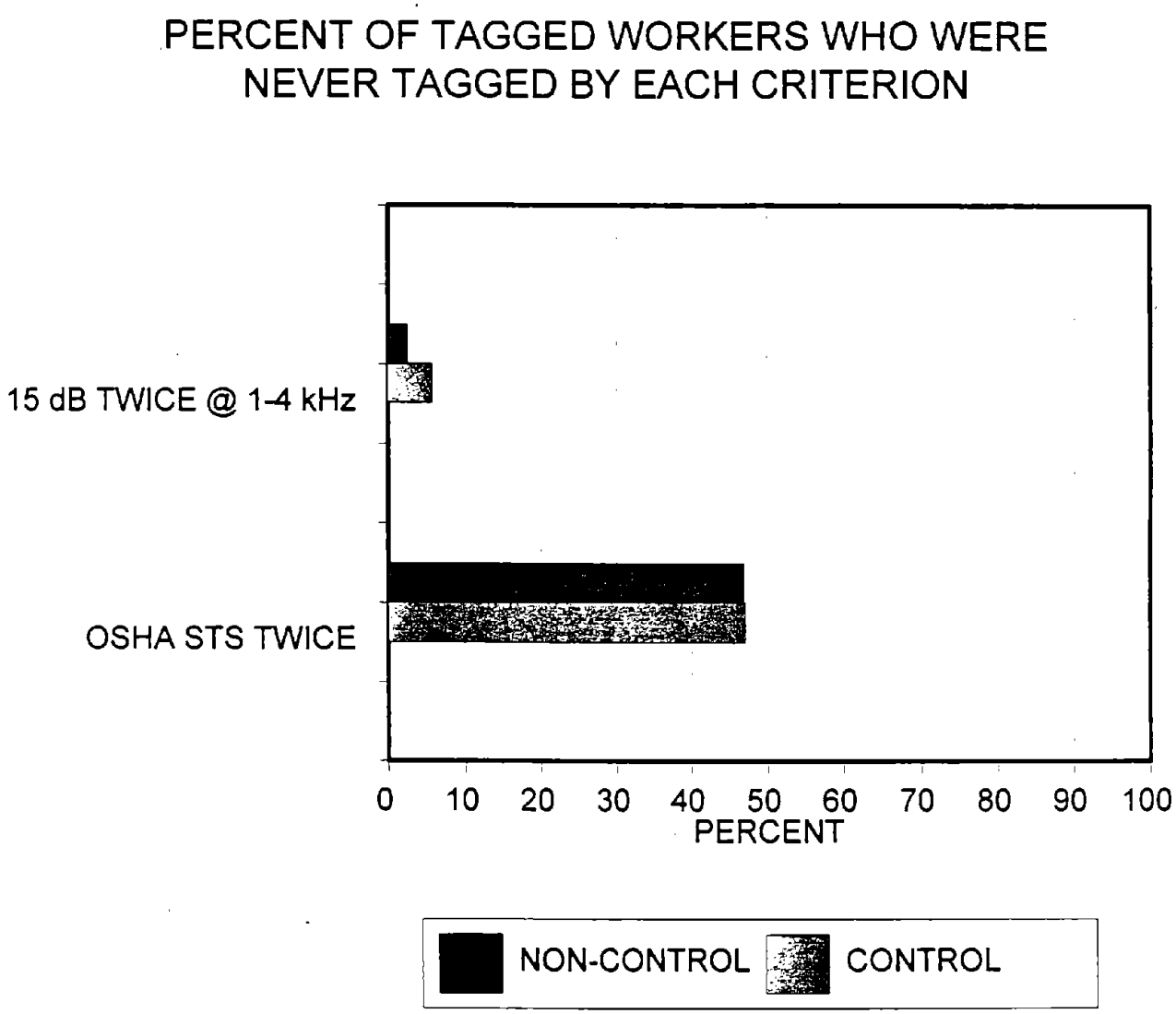

PERCENT OF TAGGED WORKERS WHO WERE TAGGED EARLIEST BY EACH CRITERION
15 dB TWICE @ 1-4 kHz
OSHA STS TWICE
0
10
20
30
40
50
60
70
80
90
100
PERCENT
NON-CONTROL
CONTROL

FIGURE 14


PERCENT OF TAGGED WORKERS WHO WERE NEVER TAGGED BY EACH CRITERION
15 dB TWICE @ 1-4 kHz
OSHA STS TWICE
0
10
20
30
40
50
60
70
80
90
100
PERCENT
NON-CONTROL
CONTROL