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### Counting Coin and Paper Currency: Were Reported Health Problems Related to the Work Environment?

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## Case Studies

# Counting Coin and Paper Currency: Were Reported Health Problems Related to the Work Environment?

*Dawn Tharr, Column Editor*

Reported by Max Kiefer and Lisa Delaney

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at a resort and casino. NIOSH was asked to evaluate workplace exposures during coin counting operations and determine if health problems that some employees had reported were related to the work environment. Reported symptoms included eye, nose, and throat discomfort, as well as respiratory problems.

In response to this request, NIOSH investigators visited the site, during which they conducted environmental monitoring to evaluate worker exposure to contaminants during counting of coin and paper currency, to assess surfaces for metal contamination, and to measure noise levels in the work areas.

## Background

### *Casino*

The resort and casino employed approximately 450 workers and began operations in 1996. The single-story casino adjoined a hotel and restaurant. Gaming activities took place in a large open area containing approximately 600 slot machines and tables for various card and other casino games. The casino operated 24 hours a day, 365 days a year. Various slot machines were designed for different currency denominations including nickels, quarters, half-dollars, coin dollars, and paper currency. Additionally, there were casino-specific “tokens” that could be used in some of the machines and gaming activities.

### *Counting Process*

Casino proceeds were counted primarily during the first shift (12:00 a.m. to 8:00 a.m.). Although there was some coin counting during the day shift, paper currency was only counted during the first shift. A crew of eight workers was responsible for counting tasks, with three to four workers assigned to paper currency counting, and the remainder assigned to coin counting. Money was first collected from the slot machines; this activity entailed a major portion of the work shift. At the start of the shift, the count crew systematically removed paper and coin currency from each slot machine on the casino floor. A row of machines was isolated from customers, and a worker opened the machine, removed the coin container, and installed a replacement container. Each container was identified to correlate with a specific machine.

After collection, money was transported on a cart to the vault area, where coins were taken to the Hard Count room, and paper currency was taken to the Soft Count room. Access to the vault was restricted, and the area was under video surveillance. Each counting room was constructed of concrete block with a concrete floor and a suspended ceiling (ceiling height was 9 feet). The paper count room had a large glass window to allow for observation from outside the room, and was approximately 144 square feet (ft<sup>2</sup>) in size. There were two paper-counting machines in this room. The coin count room was much larger (approximately 480 ft<sup>2</sup>) and contained six top-loading machines that counted and rolled coins. There had been no changes to the style of counting machine used at

the casino. The coin-counting machines count up to 3,000 coins and wrap 40 rolls of coins per minute. The paper counting machines count up to 1,000 notes per minute of mixed currency.

### *Air Quality Concerns*

Employee concerns about their work environment and exposure to dust from counting were primarily noted by the first-shift counting crew, who did the bulk of the counting; no problems were reported by the day-shift crew. In response, the ventilation system was evaluated, and a recommendation was proposed for coin workers to wear respirators during counting. To address worker concerns and ensure that this activity was evaluated, and because there was a lack of information in the literature on the potential for exposure to metals and other contaminants during counting, the company safety officer requested that NIOSH conduct an HHE.

## Methods

Upon receipt of the HHE request, additional information regarding the reported health problems and suspected environmental contaminants were obtained. Prior to the site visit, literature reviews were conducted to obtain information from previous casino evaluations. After arriving at the casino and meeting with employees and management representatives, NIOSH investigators reviewed the work areas where currency counting occurred, and an environmental monitoring strategy was finalized. The specific monitoring methodology used during this HHE is described below.

### Air Sampling

Full-shift personal breathing zone (PBZ) exposures to total dust and metal dust in the Hard and Soft Count rooms were monitored using SKC<sup>®</sup> Universal Samplers (PCXR4) sampling pumps. Three soft count and four hard count workers were monitored on January 26, 2001; three hard count and two soft count workers were monitored on January 27, 2001. Flow rates of approximately 2 liters per minute (L/m) were used to obtain the samples. The sampling pumps were pre- and postcalibrated with a primary standard (BIOS<sup>®</sup>) to verify flow rate. The filters were placed as close as possible to the workers' breathing zones, and were connected via Tygon<sup>®</sup> tubing to the sampling pumps. Count workers wore the sampling pumps and filters for the entire work shift. Management and employee representatives indicated that counting activity was higher on Day 1 (representative of a busy summer night) and normal for the winter season on Day 2 of the sampling. After collection, the samples were sent to the NIOSH contract laboratory for analysis.

The samples were collected on tared 37-millimeter (mm), 5-micrometer ( $\mu\text{m}$ ) pore size, polyvinyl chloride (PVC) filters in the closed-face mode, and were analyzed gravimetrically to determine the total dust concentration according to NIOSH Method 0500. An element-specific analysis was also conducted on the samples, according to NIOSH Method 7300, to differentiate and quantify 27 metal species, with an emphasis on nickel, copper, and zinc. With this technique, the sample filters are microwave-digested in an acid mixture and analyzed with an inductively coupled plasma emission spectrometer.<sup>(1)</sup>

### Surface Sampling

Surface wipe samples were collected to determine the presence and extent of metal dust surface contamination in certain areas of the casino. These samples were collected with commercially available premoistened Wash 'n Dri<sup>™</sup> hand wipes according to the monitoring protocol described in the NIOSH *Manual of*

*Analytical Methods*, 4th edition.<sup>(2)</sup> For analytical purposes, a companion sample was collected adjacent to the first area sampled using another manufacturer's sampling media (Ghost Wipes). A clean pair of disposable gloves was worn during the collection of each sample to prevent cross-contamination. Using a template, 100 square centimeters of surface area were wiped with each hand wipe. The samples and field blanks were sealed in labeled sample containers and sent via overnight Express Mail to the NIOSH contract laboratory for metals analysis. The samples were analyzed according to NIOSH Method 7300 by first digesting the sample in an acid mixture, and then using an inductively coupled plasma spectrometer to measure 27 different metals.

### Noise Monitoring

To continuously monitor noise exposures, Quest<sup>®</sup> Electronics Model M-27 Noise Logging Dosimeters were worn by employees during their work shift. The dosimeters were calibrated before the work shift according to the manufacturer's instructions. The dosimeters were attached to the employees' belts, and small remote microphones were fastened to their lapels or shoulders (facing forward) at a midpoint between the ear and the outside of the shoulder. The dosimeters were worn for an entire shift. At the end of a work shift, the dosimeters were removed and paused to stop data collection. The information stored in each dosimeter was then recorded to obtain information regarding the extent of exposure to noise.

### Temperature and Relative Humidity (RH)

Dry bulb temperatures and percent relative humidity (%RH) measurements were obtained using a TSI Thermoanemometer containing RH and temperature sensors built into the sampling wand. RH is determined by a capacitive sensor, and a thermistor is used for the temperature measurements. The RH sensor can resolve to 0.1 percent RH with a

response time of approximately 50 seconds (range 0 to 100%). The temperature thermistor is accurate to within 0.5°C and has a range of 0 to 60°C. Both sensors had been factory-calibrated prior to use.

### Evaluation Criteria

#### Metals

Metals comprise the majority of the known elements and have widespread natural occurrence in the environment. Aluminum, for example, is the third most abundant element in the earth's crust.<sup>(3)</sup> Metals have a wide range of properties, uses, and toxicity. Some metals are essential for life, while others have no known biological function. Other metals are capable of producing disease. Some metals that are essential nutrients can be toxic at higher concentrations. Allowable daily intake (food), maximum contaminant level (drinking water), and industrial exposure (e.g., NIOSH Recommended Exposure Limits [RELs]) guidelines and regulations have been established for a number of metals.

Inhalation is usually the exposure pathway of concern in industry. However, some metals (e.g., nickel, beryllium, and arsenic) can cause skin effects, or, if the metal is in a certain form (e.g., alkyl lead), can be absorbed through the skin.<sup>(4)</sup> Both the toxicity and mode of toxicity of a metal are influenced significantly by its chemical state as well as its species. The elemental form of a metal, for instance, rarely interacts with biological systems.<sup>(4)</sup> Metal hydrides (e.g., arsine) are generally far more acutely toxic than other forms. Soluble salts of metals are usually more readily absorbed, and they may possibly be more hazardous. The toxic properties of methyl mercury are very different from inorganic mercury.

Despite these differences, there are some toxicological similarities among metals. Many absorbed metals will accumulate in the kidneys and the bones, and many have long half-lives.<sup>(3)</sup> Inhalation of high concentrations of metals is irritating and may result in severe respiratory tract damage, including bronchitis,

chemical pneumonitis, and pulmonary edema.

#### *Coin Composition*

Except for pennies, modern U.S. Mint legal tender coins that are currently in circulation are composed of a copper core with a nickel alloy coating.<sup>(5)</sup> Quarters and half-dollars contain 8.3 percent nickel with the balance copper; nickels contain 25 percent nickel with the balance copper; Susan B. Anthony dollars contain 12.5 percent nickel with the balance copper. Sacajawea dollars contain 6 percent zinc, 3.5 percent manganese, and 2 percent nickel, with the balance copper. Dimes, which are not used at the casino, are composed of 8.3 percent nickel and copper.

#### *Particulates/Currency Dust*

Regulatory standards exist for respirable particulates of many specific dusts (e.g., silica) and for a more general category termed “particulates not otherwise classified” (PNOC). Dusts considered to be physical irritants for which no substance-specific toxicological data are available are generally placed in this category by the Occupational Safety and Health Administration (OSHA) for enforcement purposes.<sup>(1)</sup> Except for the metal content, the specific components of the dust present at the casino were not characterized. As such, dust of this type is typically classified as PNOC. This is because the monitored dust originated from a variety of sources, although the majority was probably generated from the paper currency in the Soft Count room.

The OSHA limit for respirable PNOC, sometimes referred to as “inert” or “nuisance” dust, is 15 milligrams per cubic meter ( $\text{mg}/\text{m}^3$ ). Note that the term “inert” is not appropriate, as all dusts will elicit some cellular response in the lung if inhaled in sufficient amounts.<sup>(2)</sup> The respirable fraction is considered to be the portion of inhaled dust that penetrates to the nonciliated portions of the lung.<sup>(6)</sup> In general, particles greater than 7 to 10 micrometers in diameter ( $\mu\text{m}$ ) are all removed in the nasal passages

and have little probability of penetrating to the lung. Particles smaller than this can reach the air-exchange regions (alveoli, respiratory bronchioles) of the lung and are considered more hazardous. The American Conference of Governmental Industrial Hygienists (ACGIH<sup>(8)</sup>) has established a threshold limit value (TLV<sup>(8)</sup>) of  $10 \text{ mg}/\text{m}^3$  (total dust) for PNOC as a full-shift time-weighted average (TWA).<sup>(2)</sup> NIOSH has not established an REL for PNOC. The NIOSH REL for cellulose, a primary constituent of paper, is  $10 \text{ mg}/\text{m}^3$  as a total dust, and  $5 \text{ mg}/\text{m}^3$  for the respirable fraction.<sup>(7)</sup> The basis for the cellulose REL is to protect against eye, skin, and physical irritation. Information provided by the Department of Treasury, Bureau of Engraving and Printing, indicates that paper currency dust is evaluated as a PNOC by this agency.<sup>(8)</sup> Additional data provided by the Bureau of Engraving and Printing indicates that fibers present in paper currency are composed primarily of cotton and flax.

#### *Surface Contamination*

Standards defining “acceptable” levels of workplace surface contamination have not been established for most substances. However, wipe samples can provide information regarding the effectiveness of housekeeping practices, the potential for exposure to contaminants by other routes (e.g., surface contamination on a table that is also used for food consumption), the potential for contamination of worker clothing and subsequent transport of the contaminant, and the potential for nonprocess-related activities (e.g., custodial sweeping) to generate airborne contaminants.

## **Results**

#### *Workplace Observations*

No skin problems (e.g., irritation, dermatitis) were reported to the NIOSH investigators by any of the count workers. Employee health concerns appeared to be primarily respiratory in nature, with some reports of “scratchy” eyes, and were perceived to be associated with ex-

posure to dust from the counting operations. Workers also reported that the presence of visible dirt on their hands after handling coins heightened their concern regarding exposure. According to information provided at the opening conference, day-shift count employees had not reported any health issues associated with their work environment. Workers were concerned with maintaining a comfortable work climate from a temperature and relative humidity standpoint. Because of concerns with temperature control, the door to the Paper Counting room is often open, with a comfort fan in the doorway. Discussions with count employees indicated that during the hotter times of the year, the room temperature is very warm and stagnant, and that any generated dust tends to remain airborne in the room for extended periods.

Smoking is restricted to the “smoking” break room, which is equipped with an exhaust fan. However, tobacco smoke was present elsewhere in areas served by the same air handling system, indicating that smoke is not effectively isolated. Smoking and food and beverage consumption are not permitted in the counting areas.

Both coin and paper count workers wear uniforms provided by the casino while on duty. No respirators are worn by any workers during counting activities. Typically, four employees will work in the paper count room at different tasks (e.g., sorting, counting, unloading, stacking). There are two table-top paper-counting machines where considerable manual handling and sorting of the various denominations take place. Six top-loading counting machines are located in the coin room, and there are generally three or four workers assigned to this room. Workers rotate tasks periodically, although one person, because of preference, has always worked in the paper count room.

Considerable manual handling of coins occurs, as each container must be weighed and recorded; some coin containers weighed over 70 pounds during the NIOSH survey. Each container contains only one denomination

(e.g., nickels). The worker will remove the container from a cart, pour the coins into a tared container on the scale, record the weight, and then pour the coins back into a container on the cart. Other workers will then pour the coins into the top-loading coin counters where they will be counted and wrapped or bagged. This often requires awkward postures as it is necessary to extend the arms either horizontally or vertically to unload the containers, and the wrapped coins/bags are dispensed at the floor level, requiring employees to remain in a stooped or squatting position. Actual coin-counting activities encompassed approximately two hours of the work shift on January 26, 2001, and 45 minutes on January 27, 2001. Paper currency counting comprises a much larger proportion of the work shift.

Opportunities for dust generation occur from machine operation and maintenance activities, and a buildup of dust was observed on the paper-counting machines. The coin-counting machines are cleaned on a monthly basis; compressed air is used to blow dust out of the machines. Workers reportedly wear disposable latex gloves when cleaning the machines.

#### *Temperature and Relative Humidity (RH)*

Temperature and RH measurements were taken periodically throughout the work shift on January 26 and 27, 2001. Outdoor conditions were below freezing with occasional snow. The results of the monitoring are shown in Table I.

As noted in the table, temperatures were higher in the Soft Count room than in the Hard Count room, and the measured RH in all areas was well below the desirable range of 30 to 60 percent.

#### *Ventilation*

Both counting rooms are ventilated from a central heating, ventilating, and air-conditioning (HVAC) system that also services the employee break rooms (one smoking and one nonsmoking) and the administrative offices. Supply air discharges into each room via

ceiling-mounted diffusers, and return air enters into a common return air plenum (space above the suspended ceiling) through a ceiling-mounted grille. There are two supply air grilles in the Hard Count room, and one in the Soft Count room. The air handler units are roof-mounted. The areas above the suspended ceilings were inspected in both the Soft and Hard Count rooms, and they were found to be clean with no readily identifiable source of contaminants. There is approximately 4.5 feet of plenum space between the suspended ceiling and the true ceiling. The exhaust system in the Soft Count room is likely counterproductive, as the exhaust grille is very close to the supply diffuser (possibly creating short-circuiting). Additionally, the exhaust discharges directly into the return air plenum and not directly outside. None of the coin machines are equipped with local exhaust ventilation. According to casino representatives, an engineering design to ventilate the machines had been proposed.

#### *Air Sampling*

The results of the air sampling are shown in Table II. All PBZ samples were collected over the employees' full work shift. On January 26, 2001, PBZ samples for metals and total weight were collected from three soft count and four hard count workers. All workers were right-handed, and the sampling cassettes were positioned on the left lapels of the monitored employees. On January 27, 2001, PBZ samples were collected from three hard count and two soft count workers.

**TABLE I**

Temperature and relative humidity monitoring January 26–27, 2001

Location	Time	Temp, °F	% Relative humidity
Main vault area	3:30 a.m., 1/26/2001	74	11
Hard Count room	4:30 a.m., 1/26/2001	73	12
Soft Count room	5:40 a.m., 1/26/2001	76	10
Hard Count room	7:30 a.m., 1/27/2001	73	11
Soft Count room	7:35 a.m., 1/27/2001	76	10

As shown in Table II, all measured PBZ concentrations of nickel, copper, and zinc were below applicable NIOSH RELs during the monitoring period. The highest measured concentrations were from a full-shift PBZ sample collected in the Hard Count area on January 26, 2001. A TWA copper concentration of 24 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), a TWA nickel concentration of 7  $\mu\text{g}/\text{m}^3$ , and a TWA zinc concentration that was between the limit of detection (LOD) and limit of quantitation (LOQ) were measured in this sample. All measured zinc concentrations were either below the LOD or between the LOD and the LOQ. The NIOSH RELs for copper dust, nickel, and zinc are 1,000  $\mu\text{g}/\text{m}^3$ , 15  $\mu\text{g}/\text{m}^3$ , and 5,000  $\mu\text{g}/\text{m}^3$ , respectively. Trace (between the LOD and LOQ) concentrations of some other metals were found on some samples, but most were below the LOD. The measured total dust, or gravimetric, concentrations were below guidelines established by the ACGIH and OSHA. NIOSH has not established an REL for total dust.

Although all concentrations were below applicable criteria, one PBZ sample from the Hard Count room on each day monitored showed concentrations of copper and nickel that were much higher than the other samples collected from workers in this area. These two samples were collected from different workers; thus, it does not appear that it was one particular employee's work practices that contributed to the higher results. This variability could be explained by the low concentrations measured during this survey. At low levels, a small change in

**TABLE II**  
Personal air sampling results: Metals January 26–27, 2001

Task	Time (min)	Results			
		Gravimetric (mg/m <sup>3</sup> )	Copper (μg/m <sup>3</sup> )	Nickel (μg/m <sup>3</sup> )	Zinc (μg/m <sup>3</sup> )
January 26, 2001					
Soft count	0:55-8:35 (460)	0.04	(0.4)	< 0.2	< 0.5
Soft count	1:06-8:33 (447)	0.29	0.5	< 0.2	(0.5)
Soft count	1:19-8:37 (437)	0.14	(0.4)	(0.2)	< 0.6
Hard count	0:59-8:36 (457)	0.21	24.2	7.0	(2.2)
Hard count	1:01-8:33 (452)	0.06	1	(0.3)	< 0.5
Hard count	1:07-8:33 (446)	0.04	0.8	(0.3)	< 0.6
Hard count	1:03-8:33 (451)	0.23	1.5	(0.4)	< 0.6
January 27, 2001					
Soft count	1:00-8:34 (454)	0.13	(0.2)	< 0.2	< 0.6
Soft count	1:04-8:34 (449)	0.06	(0.3)	< 0.2	< 0.5
Hard count	0:57-8:30 (453)	0.04	0.6	(0.2)	< 0.5
Hard count	0:59-8:27 (448)	0.26	15	4.4	(1.0)
Hard count	1:02-3:14 (131)*	0.14	(0.4)	< 0.8	< 1.9
NIOSH REL		**	1000	15	5000

1,000 micrograms = 1 milligram.

mg/m<sup>3</sup> = milligrams of contaminant per cubic meter of air sampled.

μg/m<sup>3</sup> = micrograms of contaminant per cubic meter of air sampled.

< = less than the detectable limit of the analytical method.

( ) = values in parentheses indicate that the concentration measured was between the analytical limit of detection (LOD) and the limit of quantification (LOQ).

REL = Recommended Exposure Limit.

\* = Sampling pump failed at 3:14 a.m.

\*\* = NIOSH does not have an REL for total particulate not otherwise classified (PNOC).

The OSHA permissible exposure limit (PEL) and ACGIH<sup>®</sup> threshold limit value (TLV<sup>®</sup>) for PNOC are 15 mg/m<sup>3</sup> and 10 mg/m<sup>3</sup>, respectively.

deposited contaminant can significantly affect the reported concentration. Under these conditions, a small difference in deposited metal on the filter (e.g., from a short-term event such as disturbing dust on a machine or surface) could influence the analytical results to a much greater degree than if there were higher concentrations present.

A bulk sample of metal dust was collected from coin machine #3 on January 26, 2001. Analysis of this material indicated that the sample composition was primarily copper (42%), nickel (11%), zinc (6.3%), and iron (3.4%). Smaller concentrations of manganese, magnesium, cobalt, chromium, aluminum, and titanium were also detected in the sample.

#### Surface Sampling

Sixteen total surface samples for metals analyses were collected in the Hard Count room, Soft Count room, and both break rooms. The results of the surface sampling are depicted in Table III, reported as the amount of metal detected in micrograms per 100 square centimeters of surface area sampled (μg/100 cm<sup>2</sup>). As previously noted, two different types of sampling media were used to collect the samples in order to help assess the collection and analytical characteristics of the two types of sampling media. The results are not comparable since the deposition of contaminants on a surface is not expected to be uniform. As shown in the table, various levels of metals were found in the areas sampled;

the highest amounts were detected in the coin count room. A sample collected from a support beam on the east side of the Hard Count room showed a copper concentration of 30 to 41 μg/100 cm<sup>2</sup>, a nickel concentration of 10 to 12 μg/100 cm<sup>2</sup>, and a zinc concentration of 2.3 to 3.1 μg/100 cm<sup>2</sup>. Similar levels were found on the supply air diffuser in the Hard Count room. Only very low levels of metals were detected in the Soft Count room and in the employee break rooms.

#### Noise Monitoring

Personal noise dosimetry was conducted on January 26 and 27, 2001, the results of which are reported in Table IV. On January 26, 2001, three hard count and two soft count workers were evaluated, and dosimetry was conducted on three hard count and one soft count worker on January 27, 2001. The workers wore the dosimeters for the duration of the work shift.

As shown in the table, the dosimeters provide results that can be compared to different evaluation criteria. All results are reported in dB(A). The section reporting TWA dB(A) describes the results using three different measurement criteria as an 8-hour TWA regardless of the sample time length. For example, with samples collected for less than 480 minutes, the dosimeter will assume that noise exposure was zero for the remainder of the unsampled period. The OSHA Action Level (AL) column refers to the OSHA AL of 85 dB(A), which calls for measuring noise with a threshold level (the sound level below which the instrument “assumes” there is no noise) of 80 dB(A) and a 5-dB exchange rate (the dose will either double or halve with each 5-dB increase or decrease). The OSHA permissible exposure limit (PEL) column refers to the OSHA PEL of 90 dB(A), which calls for measuring noise using a threshold of 90 dB(A) and a 5-dB exchange rate. The NIOSH REL column refers to the NIOSH REL of 85 dB(A) as measured with no threshold and a 3-dB exchange rate. The level average (LAVG) dB(A) column refers to the above-described

**TABLE III**  
Surface sampling results: Metals, January 26, 2001

Location	Contaminant	Concentration ( $\mu\text{g}/100\text{ cm}^2$ )		Comments
		Ghost wipe*	Wash 'n' Dri™*	
Soft count workstation	Copper	0.09	0.04	
	Nickel	0.02	0.04	
	Zinc	0.05	< LOD	
Hard count computer table	Copper	1.6	0.44	
	Nickel	0.11	0.88	
	Zinc	0.42	0.11	
Coin room support iron, east side	Copper	41	30	Trace lead and silver. Settled dust build-up on iron.
	Nickel	10	12	
	Zinc	2.3	3.1	
Top of coin machine # 3270	Copper	3.7	3	
	Nickel	0.97	0.86	
	Zinc	0.22	0.98	
Break room (smoking) adjacent MW oven	Copper	0.47	0.02	
	Nickel	0.01	0.004	
	Zinc	< LOD	< LOD	
Break room (smoking) lunch table	Copper	0.34	0.03	
	Nickel	0.01	< LOD	
	Zinc	0.01	0.68	
Break room (nonsmoking) lunch table	Copper	0.01	0.02	
	Nickel	0.003	< LOD	
	Zinc	< LOD	0.78	
Coin room supply diffuser	Copper	33	43	Trace lead, chromium, and silver.
	Nickel	8.9	3.18	
	Zinc	1.72	13	

$\mu\text{g}/100\text{ cm}^2$  = micrograms of contaminant per 100 square centimeters of surface area sampled.

< LOD = below the limit of detection when the sample was adjusted for the concentration detected on the field blank.

\*Two types of media were used (Ghost Wipes and Wash 'n Dri™ wipes) for analytical purposes to collect the samples. Results are not directly comparable since deposition on surfaces is not expected to be uniform.

criteria, but provides the level measured for the actual time measured, and does not extrapolate to an 8-hour shift. LAVG is always greater than the TWA measurement for sample times less than eight hours, and is always greater than the TWA result for sample times exceeding eight hours. Because of equipment problems, the NIOSH REL LAVG data were not available. The maximum level column refers to the maximum noise level measured during the monitoring period.

These results show that none of the monitored employees exceeded OSHA or NIOSH criteria for noise exposure. No hearing protection is worn by employees, and these results suggest that hearing protection is not required.

The primary source of noise in the coin room is the transfer of coins from a container into the machine or another container. Coin receptors on the machine are constructed of metal, and there is considerable metal-to-metal contact, which creates the noise.

### Discussion

All air sampling results indicate that worker exposure to metals from the coin-counting activities were within acceptable limits during the monitoring period. One full-shift sample for nickel ( $7\ \mu\text{g}/\text{m}^3$ ) was one-half of the NIOSH REL, indicating that there is the potential for exposure to metals during coin counting. Both the nickel and copper concentra-

tions measured on this sample, although below the REL, were much higher than those found on most of the other samples collected from either hard or soft count employees. However, at these low measured concentrations, a short-term event, such as disturbing metal-containing dust, could affect the result to this degree. Although NIOSH has not established an REL for PNOC, the total gravimetric results were below criteria established by OSHA and ACGIH, and are not suggestive of an airborne dust hazard. The bulk sample results were not surprising; they indicated that the proportion of metals in the dust sample were consistent with the composition of the coins used at the casino.

**TABLE IV**  
Personal noise dosimetry results January 26–27, 2001

Activity	Date	Sample time (minutes)	TWA dB(A)			LAVG dB(A)		Max level dB(A)
			OSHA AL	OSHA PEL	NIOSH REL	80/5	90/5	
Opened bill holders in Soft Count room	1/26/01	458	77.7	69.3	77.8	78	69.6	110
Collected change from slots; 5:30 a.m.: Assisted in hard count	1/26/01	458	77.3	69.3	77.7	77.6	69.6	109
Soft count	1/26/01	448	70.2	57.8	73.5	70.6	58.2	105
Hard count beginning 4:35 a.m.	1/26/01	497	78.3	73.6	78.9	78.7	74	108.7
Soft count	1/27/01	452	75.4	66.9	79	75.8	67.3	124.1
Hard count beginning 4:35 a.m.	1/27/01	456	75.8	66.4	76.4	76.2	66.7	102.7
Hard count	1/27/01	445	70.8	62.8	74.5	71.3	63.3	
Hard count	1/27/01	450	73.8	65.1	75.7	74.2	65.6	108.3
Collected change from slots; 7 a.m.: Assisted in hard count	1/26/01		No data due to malfunction of the dosimeter					

dB(A) = decibel on the A-weighted scale.

OSHA AL = OSHA Action Limit for the hearing conservation standard, 85 dB(A).

OSHA PEL = OSHA Permissible Exposure Limit, 90 dB(A).

NIOSH REL = NIOSH Recommended Exposure Limit, 85 dB(A).

TWA = Time-weighted average for an 8-hour work shift.

LAVG = the average dB(A) level for the actual time period sampled.

Because there are no standards defining acceptable levels of surface contamination, and it is not possible to accurately determine worker dose from a measurement of surface contamination, interpretation of the results is generally qualitative and based on professional judgment. The surface sampling results from this HHE suggest that additional cleaning is warranted in the coin count room, including the supply air diffuser, the metal support beam, and the coin-counting machines. A more rigorous cleaning regimen is warranted to ensure that metal dust is routinely removed and does not accumulate. This is a prudent precautionary measure that will ensure that contamination will not build up to the point that it becomes an exposure concern. The area should be cleaned with a vacuum equipped with a high-efficiency particulate air filter, or by wiping down the area with a damp cloth. Dry sweeping or compressed air should not be used.

The concentration of metals detected in the break rooms (both smoking and non-smoking) and other areas was very low and does not suggest the need for additional action.

The noise monitoring results indicate that exposure to noise during counting activities is below established occupational criteria. However, there are opportunities to reduce the noise levels in the coin counting room, particularly short-term impact noises during the transfer of coins from the container to the counter. This could be accomplished by lining the top-loading chute with a dampening material to prevent the “metal-to-metal” contact that occurs when dispensing coins into the counter.

The observed manual lifting activities involving substantial loads (up to 70 pounds) and inefficient worker positions should be addressed to prevent musculoskeletal injuries. It is possible that some of the lifting tasks could

be eliminated (e.g., an extra coin-dispensing step during the weighing of coins); these should be evaluated in a comprehensive fashion.

As only a limited review of the ventilation system was conducted, only general comments can be made. However, the HVAC system supporting the count areas appeared to be insufficient to maintain conditions in an appropriate comfort range. The ventilation in the Soft Count room does not appear to be able to accommodate the number of people working in this room; conditions are cramped with four people and the paper carts, and it is likely that the heat load is too high for the existing ventilation system. Short-circuiting of the ventilation system likely occurs, as the room exhaust (which discharges into the return air plenum) is adjacent to the supply air diffuser. An adjacent room used for miscellaneous storage is much larger, and converting this room to accommodate

paper counting may help to alleviate the crowded conditions and favorably improve ventilation (this was a suggestion by some of the casino employees).

Temperatures ranging from 73°F to 76°F were measured in the work areas during the NIOSH survey. The RH in the work areas was lower than desirable (10%–11%), which could account for some of the eye and nasal irritation that has been experienced by workers. The presence of environmental tobacco smoke could also be a contributor to the health complaints.

### Conclusions

Measured exposures to nickel, copper, and zinc during currency counting activities were below applicable exposure criteria, and did not show an inhalation hazard for the sampled employees. The surface sampling results indicate that additional cleaning in the coin-counting room is warranted to ensure that metal dust does not accumulate. Exposure to noise did not exceed applicable criteria in either the Hard Count or Soft Count work areas. The ventilation system does not appear to adequately provide sufficient quantities of conditioned air to the Hard and Soft Count rooms. Of the two rooms, the Soft Count room was the most severely underventilated. RH levels were well below acceptable comfort criteria, which may account for some of the eye and nasal irritation reported by workers. Tobacco smoke was detected in nonsmoking areas, indicating that smoke is not being effectively isolated and ventilated. As the air sampling did not identify excessive exposure to contaminants from the counting activities, it is possible that many of the health complaints could be resolved by improving the general indoor environmental quality in the counting area. This could be accomplished by ensuring that a sufficient amount of conditioned air (temperature and RH within acceptable ranges) is provided to each room, isolating tobacco smoke, improving janitorial practices, and altering maintenance procedures. A number of lifting activities

involving heavy loads and awkward postures were observed during this survey; these should be addressed by conducting a comprehensive ergonomic review of counting tasks.

### Recommendations

1. Compressed air should not be used to clean the counting machines and work areas, as this will generate airborne contaminants. A vacuum equipped with a high-efficiency particulate air filter should be used for cleaning. A moistened cloth could also be used for wiping down areas. Dry sweeping should be avoided.

2. A comprehensive review of the HVAC system supporting the count rooms, offices, and break rooms should be conducted by a qualified ventilation engineering firm, and modifications/upgrades should be implemented to ensure sufficient ventilation. The design goal should be to provide a sufficient amount of conditioned outdoor air to each area. Temperature and relative humidity ranges described in ASHRAE Standard 55-1992 should be used as design criteria for these two parameters (see Figure 1). The ASHRAE Standard 62-1999, "Ventilation for

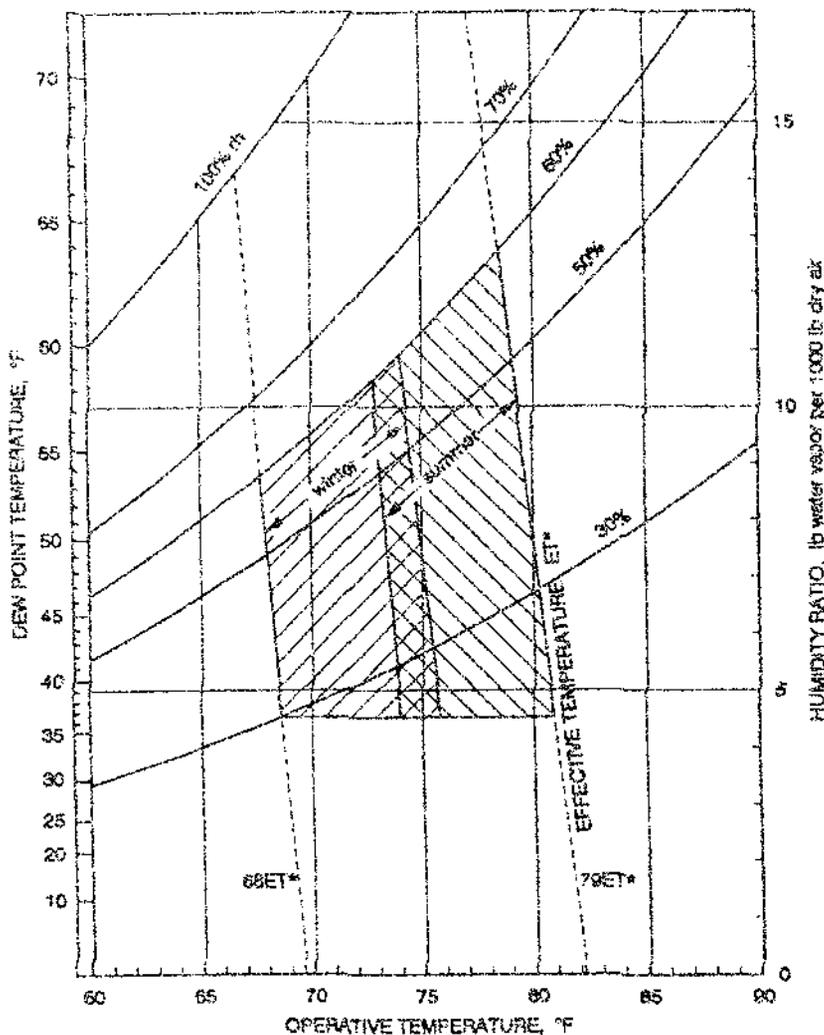


FIGURE 1  
ANSI/ASHRAE Standard 55-1992 thermal environmental conditions for human occupancy.

Acceptable Indoor Air Quality," specifies outdoor air requirements for a variety of commercial facilities.<sup>(9)</sup> While no specific criteria for casino counting rooms is provided, the outdoor air requirements for a casino are 30 cubic feet per minute per person (cfm/p). Additional ventilation is necessary to accommodate smoking. A general default outside air requirement for nonindustrial facilities with no other source of contaminants is 20 cfm/p. The mechanism for isolating tobacco smoke should be improved.

3. Area housekeeping should be improved in both count rooms. The frequency of cleaning should be increased, and all vents, fixtures, tables, etc., should be periodically wiped clean with a moistened cloth. Workers should be encouraged to practice good personal hygiene (thorough hand washing) before eating, drinking, or smoking, and at the end of each shift.
4. The possibility of relocating the Soft Count room to the existing storage room should be investigated. The storage room is much larger, and this may alleviate much of the cramped conditions and stagnant air flow that are currently present in the Soft Count room.
5. An ergonomic evaluation should be conducted to assess manual lifting tasks during coin counting. Some activities involve awkward postures and extensive lifting. Workers should be involved in this review to ensure that all

activities are evaluated and that any modifications made are feasible. Task modifications to reduce lifting and improve posture should be implemented (e.g., evaluate the need to dispense coins into a separate container on the scale and to then dispense the coins back into another container after weighing).

6. Dampening material should be installed to cover the metal load chutes of the coin-counting machines. This will help reduce impact noise. The machine manufacturer should be contacted for information regarding the feasibility of this type of upgrade.

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**EDITORIAL NOTE:** Max Kiefer and Lisa Delaney are with the Atlanta Regional Office of the Hazard Evaluation and Technical Assistance Branch of NIOSH. More detailed information on this evaluation is contained in Health Hazard Evaluation Report No. 2001-0109-2835, available through NIOSH, Hazard Evaluation and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, OH 45226; telephone: (800) 35-NIOSH; fax: (513) 533-8573.

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