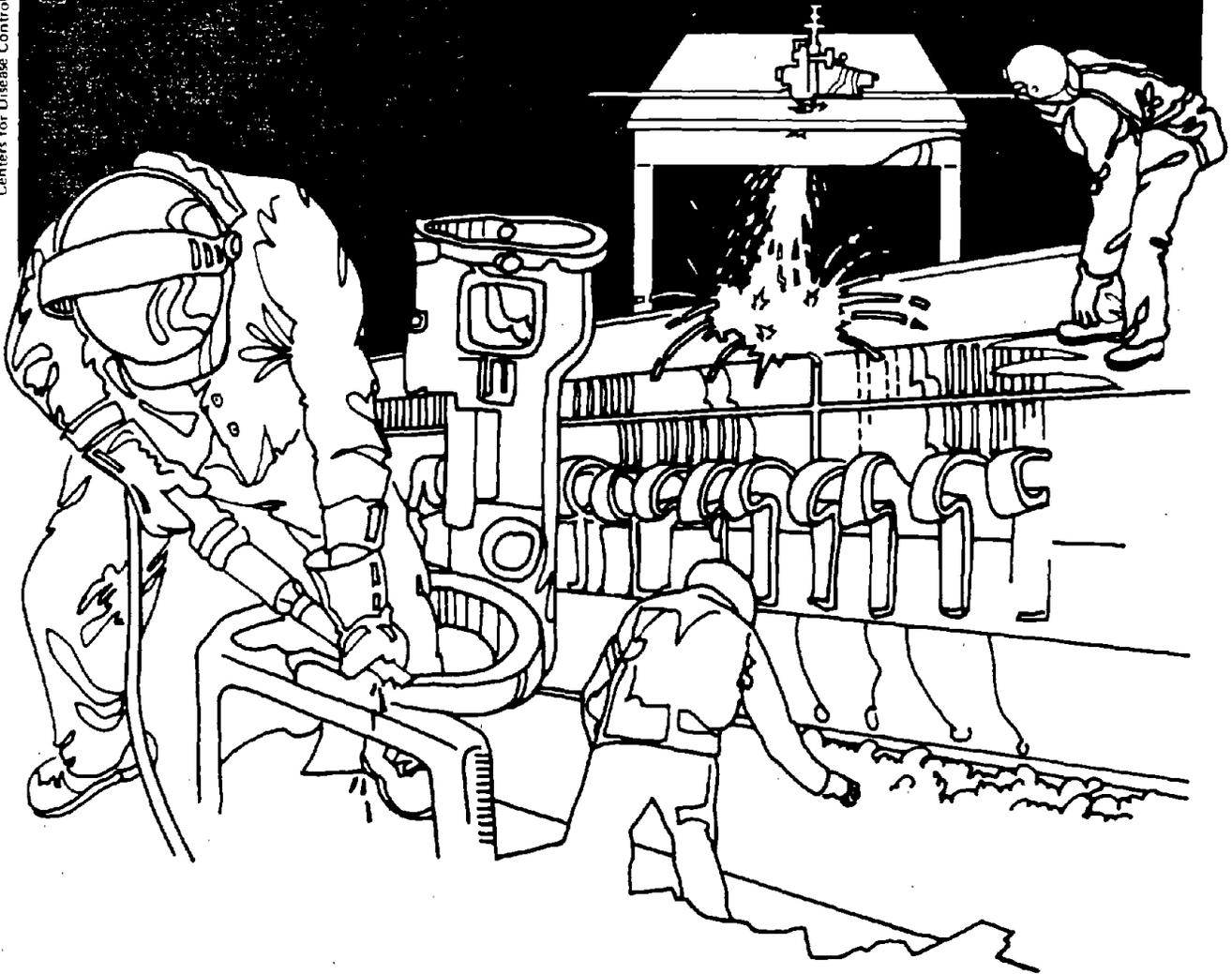




NIOSH



Health Hazard Evaluation Report

HHE 80-189-870
NEENAH FOUNDRY COMPANY
NEENAH, WISCONSIN

REGION-5

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

I. SUMMARY

In June of 1980, Local 121 of the Molders and Allied Workers Union requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate the approximately 74 men employed as chippers and grinders in the cleaning rooms of Plants 2 and 3 of the Neenah Foundry Co. in Neenah, Wisconsin. These men use air hammers and grinding tools to clean metal castings and many were experiencing frequent episodes of cold induced numbness and blanching of their fingers. These symptoms are characteristic of a condition known as Raynaud's Phenomenon in which exposure to cold causes the blood vessels of affected fingers to constrict. The resultant decrease in blood supply causes the fingers to become white and numb. Industrial health surveys have shown that foundry cleaning room personnel and other occupational groups that use vibrating hand tools in their work, (e.g. chain saw using loggers), have prevalences of Raynaud's Phenomenon ranging from 20 to 90% compared to less than 10% of control groups without hand vibration exposure.

In the fall of 1980 NIOSH conducted 3 site visits: a medical evaluation Aug 4-6 and vibration assessments Sept 3 and Sept 23-26. The vibration assessment revealed that the Plant 3 employees had more daily hand vibration exposure than did the Plant 2 employees. Plant 3 employees used air hammers (chippers and scalers) about 2-3 hours per day and the vibration levels of these tools (15-60 g's) were in the same range as the vibration energy of air hammers measured in previous NIOSH studies. Grinding tools were used 4-5 hours per day in Plant 3 and the vibration levels of these tools (15-20 g's) were 15 to 50 times the vibration levels of similar grinding tools previously evaluated by NIOSH.

During the medical evaluation 17 Plant 2 employees, 47 Plant 3 employees and 2 former Plant 3 employees were examined. 57% of Plant 3 and 18% of Plant 2 participating employees reported symptoms of Raynaud's Phenomenon and symptomatic men tended to have decreased sensory abilities in their hands. The lower prevalence of Raynaud's symptoms in Plant 2 may be due to the lower mean years of exposure of Plant 2 employees (Plant 2, 2.3 years; Plant 3, 4.1 years) and the lesser time per day that Plant 2 personnel use vibrating tools.

On the basis of these findings NIOSH determined that a health hazard existed to the circulation of the hands of men employed as chippers and grinders in Plant 3. This hazard will continue until metal cleaning tools are developed that do not subject the user's hands to intense vibration. At the present time, all that can be recommended is to lower hand vibration exposure to the maximum extent possible by improving tool maintenance and modifying work practices and to encourage employees with progressively more severe symptoms of Raynaud's Phenomenon to transfer to areas of the foundry where the employees will not be subjected to hand vibration exposure. Specific recommendations are contained in Section VII.

KEYWORDS: SIC Code ferrous foundry 3321, hand vibration, Raynaud's Phenomenon, vibration induced white finger, chipper, grinder, foundry.

II. INTRODUCTION

On June 27, 1980, the National Institute for Occupational Safety and Health received a request from Local 121 of the Molders and Allied Workers Union requesting NIOSH to evaluate the cleaning room employees in Plants 2 and 3 of the Neenah Foundry Company in Neenah, Wisconsin. This request was prompted by reports that employees in those rooms were experiencing tingling, numbness and blanching in their fingers. On August 4, 5 and 6, 1980, NIOSH medical personnel examined 66 men with a history of employment in the cleaning rooms in question. On September 3, 1980, NIOSH engineers inspected the tools used and the work practices employed in the two cleaning rooms. On September 22 - 24, 1980, NIOSH engineering personnel returned and measured the vibration characteristics of the four types of tools used in Plant 3's cleaning room.

III. BACKGROUND

The Neenah Foundry Company located in Neenah, Wisconsin is one of the nation's largest production foundries. Approximately 1500 people are employed in its 3 plants. Plant 2 makes construction castings such as manhole lids and has about 200 employees, 23 of whom work as chippers and grinders in the Plant 2 cleaning room. Plant 3 makes industrial castings such as transmission covers and employs about 250 people, 51 of whom work as chippers and grinders in the Plant 3 cleaning room. The chippers and grinders use grinding wheels and chisel equipped air hammers (chippers) to remove excess metal from castings. These tools subject the user's arms and hands to significant vibration.

The request stated that many of the cleaning room employees were suffering from symptoms that suggested Raynaud's Phenomenon. Raynaud's Phenomenon is a condition characterized by paroxysmal ischemia (severely decreased blood supply) occurring in the digits (fingers and possibly toes). The digital and palmar blood vessels are abnormally reactive to cold and when an affected person's body or hands become chilled, these vessels can constrict to such an extent that the involved digits lack an adequate blood supply and become white and numb. These digits will usually remain white and numb until the hands are rewarmed but they occasionally can recover spontaneously. During recovery the fingers will usually become red and painful as the circulation returns to the fingers.

Most people with the condition do not have an identifiable underlying disorder that is known to predispose to the development of Raynaud's Phenomenon and these people (over 80% are women) are said to have Raynaud's Disease. The remaining affected individuals are said to have Raynaud's Phenomenon secondary to a disease, anatomic abnormality, or trauma. People at increased risk of developing Raynaud's Phenomenon include those who have a history of a collagen disease (scleroderma, rheumatoid arthritis etc.), a condition that can damage or irritate the nervous innervation of the extremity's blood vessels (poliomyelitis, thoracic outlet syndrome etc.) or conditions that can decrease the lumen

size of the blood vessels supplying the digits (atherosclerosis, thromboangitis obliterans, arterial emboli), or increase the viscosity or sludging tendency of the blood (cryopathies, cold hemagglutinins, etc.). Damage to the extremities from frostbite, lacerations, fractures, surgery or the repetitive trauma that occurs while operating vibrating hand tools, also predispose to the development of Raynaud's Phenomenon by mechanisms that are not well understood at present.

Although it has not received much attention in the United States medical literature, the operation of vibrating hand tools seems to greatly increase the risk of developing Raynaud's Phenomenon. Over 500 studies in the world's medical literature have reported an increased incidence of symptoms of Raynaud's Phenomenon in workers using such tools. Studies conducted among British and Scandanavian workers who were foundry chippers and grinders or chain saw using loggers, have shown prevalences of Raynauds Phenomenon ranging from 20 to 90% depending on the work-force's length of employment and the daily severity of their vibration exposure.

In vibration-induced Raynaud's Disease, commonly referred to as Vibration Induced White Finger (VWF), the symptoms are mild initially; perhaps the tip of one finger will become white and numb when the hand is exposed to extreme cold. As the condition progresses the symptoms occur more frequently and additional fingers become involved. Finally, the majority of fingers on both hands may be involved. If one hand has significantly higher vibration exposure than the other, the hand with the higher exposure usually has more rapidly progressive involvement. The condition, in its advanced stages, can be markedly disabling. The affected person may not engage in any activities that will cause a lowering of body or hand temperature, since the fingers may then lose blood supply and sensation and the affected individual would be unable to grasp tools or other objects. A small proportion of affected people go on to suffer ulceration and gangrene of the fingers because of insufficient circulation.

Many workers exposed to hand vibrations, even those with only several months of exposure, report episodes of numbness and tingling in the hands that occur without concomitant finger blanching. These episodes frequently occur at night and can awaken the worker. They also frequently occur while the person is driving a car. Many men with moderate to advanced white finger symptoms also have decreased hand sensibility to temperature, light touch and pin prick. Men with severe involvement may be able to remove hot bacon from a frying pan without discomfort. The relation of the paresthesias and the decreased sensory ability to the episodic vasospasm is not known. These symptoms may be related to the pathology causing the periodic finger blanching or they may be due to changes in the sensory nerves caused directly by the vibration.

At the present time there is no medical therapy (including surgical sympathectomy and a host of medicines) that has proven effective in the long-term treatment of Vibration Induced White Finger. However, if vibration exposure is stopped before the symptoms are severe, the "white finger" symptoms will usually subside over a period of several years. If vibration exposure is continued in spite of worsening symptoms the affected person may reach a point where cessation of exposure will not be followed by the gradual abatement of symptoms.

IV. EVALUATION DESIGN AND METHODS

A. Vibration Measurements

The vibration characteristics of a tool are usually measured by recording the tool's acceleration in 3 orthogonal directions. The accelerations in each direction are then combined by taking the square root of the sum of the squares of the accelerations in each direction (Acceleration = $\sqrt{a_x^2 + a_y^2 + a_z^2}$). The acceleration thus obtained is an estimate of the magnitude of the vibration that a man's hands would be subjected to if he held the tool at the point of measurement. The unit of measurement for acceleration used in this report is the acceleration of gravity at sea level, the g which is 9.8 meters per second.

Different parts of a tool may have markedly different vibration characteristics. For example, in previous NIOSH studies an air hammer's handle had accelerations in the range of 20 - 40 g's while the air hammer's chisel had an acceleration of 2400 g's.⁹ Therefore, the amount of vibration absorbed by a man's hands while using a chipper will be greatly affected by his contact time with the chisel compared to his contact time with the handle. The vibration absorption will also be affected by how tightly the hand grips the handle or chisel. The tighter the grip the more complete is the coupling between the hand and the vibrating tool, and the greater will be the vibration transmitted to the hand.

Thus, the acceleration levels measured on the tools yield an order of magnitude estimate of the maximum energy that could be absorbed by an operator's hands while using such tools, since he can considerably lessen the vibration absorption by gripping the tool more loosely (consistent with safety) and avoiding as much as possible, contact with the tool parts (such as the chisel) which have high vibratory energy.

The actual tool acceleration measurements used in this evaluation were made using unique vibration measuring and analysis techniques that were developed for previous NIOSH vibration studies⁷⁻⁹. Figure 6 in Appendix A shows the vibration measuring setup. For each of the tools a steel cube with three orthogonally mounted accelerometers was attached to the tool, using an adjustable hose clamp which had been welded to the steel cube. The clamp was placed as close as possible to the place where the worker gripped the

tool. Accelerometers were placed on both handles of the grinders to estimate the vibration exposure to each hand. The placement of each triaxial accelerometer on the tool is indicated by the "A" in Figures 1 - 4 of Appendix A. No attempt was made to measure the acceleration on the chisel of either the chipper or the scaler since the tremendous accelerations present on these implements usually destroy the accelerometers within seconds and previous data was judged to be adequate to estimate these implement's accelerations.

Each accelerometer was calibrated prior to initial measurement and at the end of the days testing. Accelerometers used were piezo-electric crystals (BK 8309 and Columbia 6163). These transducers convert acceleration into a voltage proportional to the acceleration. This voltage signal was sent to an amplifier (B & K 2635) and then recorded by a multichannel FM tape recorder (Honeywell 5600-C). As measurements were being made, a monitoring oscilloscope was observed to insure that only true vibration data was being recorded and that no signal overloading (i.e., charge amplifier clipping) occurred. While the vibration measurements were being made, a monochrome TV camera recorded the worker's hand-arm and body motions on a videotape recorder (Sony AVC 3400).

During the runs measuring vibration of the scaler and chipper, some "accelerometer D.C. Shifting", a commonly occurring problem in this type of testing, was encountered. Therefore, some of the scaler and chipper runs were not useful and were discarded. Special electronic filtering was used in the remaining scaler and chipper runs to obtain valid vibration data.

Fourier computer and spectrum analysis (Nicolet 44A-FFT) which produces a "fingerprint" of the vibration spectrum in a given axis was used to analyze the data from each accelerometer and obtain the total acceleration in that axis. A more complete discussion of numerical techniques used is in Appendix A.

To characterize the vibration exposure from the four basic types of vibrating hand tools used in the Plant 3 cleaning room, a typical tool of each type was chosen for vibration measurement by the cleaning room personnel. Three production castings (one grey iron casting (Brinell Hardness Number BHN-182), one high alloy grey iron casting (BHN-187), and one ductile iron casting (BHN-179)) were provided by the foundry to be used during the tests. During the vibration measurements, the tools were operated by one of two experienced chippers who used the tools according to their usual work practice. In total, 77 actual vibration measurement runs (60 seconds per run) were made and recorded.

B. Medical Evaluation Design and Methods

All workers with a history of vibrating hand tool use, presently employed in the cleaning rooms of Plant 2 and Plant 3 were invited to participate in the study. After informed consent was obtained

each employee answered a questionnaire regarding the types of work he had performed at the Neenah Foundry Co. and prior to his employment at Neenah. Any exposure to vibrating hand tools was specifically recorded as to duration of exposure and types of tool used. A smoking history was also obtained. Then a physician interviewed and examined the patient to identify the existence of any medical condition (as mentioned in Sec III) that could predispose to the development of Raynaud's Phenomenon. The patient was also asked about the ingestion of medications. Then the physician examined the subject's cardiovascular system (blood pressure, peripheral pulses, cardiac auscultation, etc.) and inspected the participants hands and arms looking for signs of past physical trauma (misaligned healed fractures, scars from lacerations, surgery or burns). Another physician then performed a sensory examination of the subject's hands which tested sensibility to light touch, pin prick, a temperature probe heated to 50°C and the Minnesota Disk Temperature Test. The physician also questioned him in detail about possible symptoms of vibration white finger.

Since there is no physical sign or physiologic test that can be used to reliably diagnose the presence of vibration induced white finger, the diagnosis of VWF and the stage (if present) of vibration white finger were determined solely from the history of symptoms reported by the employee. The following scheme¹⁰ was used to establish the stage of the disease. Dr Taylor devised this classification scheme and has used it in more than 20 surveys of employees who use vibrating hand tools.

Stages of Vibration White Fingers (VWF)

<u>Stage</u>	<u>Condition of digits</u>	<u>Work and social interference</u>
0	No signs or symptoms	No complaints
0T	Intermittent tingling	No interference with activities
0TN	Intermittent numbness	No interference with activities
1.	Blanching of a finger tip with or without tingling and/or numbness	No interference with activities
2.	Blanching of one or more complete fingers usually during winter	Interference at home; no interference at work.
3.	Extensive blanching of all fingers bilateral; both summer and winter	Definite interference at work, at home, and with social activities; restriction of hobbies
4.	Extensive blanching of all fingers; both summer and winter	Occupation changed because of severity of signs and symptoms of VWF

Note that the persons with classifications of OT, ON and OTN do not, as yet, have vibration white finger. It is not known if these neurological symptoms are induced by vibration exposure but not related to the vascular changes that cause VWF, or if these symptoms are related to vascular changes and are forerunners of more severe VWF manifestations to follow.

After the second medical examination, the participant was tested for 2 point discrimination of his fingers and he then returned to his work station.

V. Evaluation Criteria

The signs and symptoms experienced by people whose hands are exposed to excessive vibration have been discussed in Section 3. There are at present no standards in the United States that set limits on permissible occupational vibration exposure levels to the hands or arms. There have been no successful efforts by United States manufacturers of hand held chipping hammers to significantly reduce the amount of vibration that those machines impart to the users hands. However, producers of hand held chain saws have succeeded in reducing the average vibration in these machines from the range of 20 g's down to 3 g's. These modifications were made after prevalences of Raynaud's Phenomenon ranging from 20 to 90% were found in the population of chain saw using loggers in England and Scandanavia. Following the introduction of these anti-vibration (AV) saws in Europe and Scandanavia the incidence of Vibration Induced White Finger in new loggers has decreased and the frequency of occurrence and the severity of symptoms in some loggers who had VWF symptoms at the time of the introduction of the AV saws has decreased.¹⁸ Unfortunately there are, as yet, no "AV" chipping hammers which expose the user's hands to levels of vibration that can be considered "safe" and indeed, at the present time there is insufficient data available to establish a safe level.

The results section of this report contain vibration levels of tools similar to those used at Neenah, to enable comparison of Neenah tool vibration levels to the vibration levels of tools used in other foundries in the U.S.A. The measurements on the similar tools were performed in prior NIOSH foundry studies. It must be remembered that the prevalence of VWF symptoms in the cleaning room employees of the previously studied foundries was in the range of 20 - 60%, so clearly these levels may not be considered safe.

VI. Results and Discussion

A. Engineering Vibration Assessment

1. Discussion of Walkthrough Conclusions

The walk-through inspection performed on September 3, 1980 by NIOSH engineering personnel, revealed that employees in both Plants 2 and 3 are on a piecework incentive pay system and work with great speed and effort to clean as many pieces as possible during their work shift. In the Plant 3 cleaning room, most of the industrial castings (transmission covers etc.) are made of either a tough alloy of ductile iron or a variety of grey iron alloys. These metals are hard and the chipping hammer does not effectively remove excess metal from the castings. Consequently, much of the metal removal is done by using either a horizontal or vertical pneumatic grinding wheel. In a typical day, a chipper and grinder will use a grinder for about 4 - 5 hours, the scaler for about 2 hours, and the larger chipping hammer for about 1 hour. In the other foundries studied by NIOSH the chipping hammer was usually efficient in removing the excess metal and was used for approximately 5 hours per day and the grinder was used approximately 1 hour per day.

In Plant 2 the metal cleaning tools used and the working practices used appeared to be similar to those employed in the other foundries that NIOSH has studied. The pieces cleaned in Plant 2 are construction castings, such as manhole covers and sewer grates which do not require thorough cleaning. Much of the metal cleaning is accomplished with a hammer and the remainder done with some use of chipper and grinder. In the judgment of the NIOSH engineers the Plant 2 employees receive less workshift hand vibration exposure than do their counterparts in Plant 3.

2. Vibration Data

The vibration characteristics of the 4 tools commonly used in the Plant 3 cleaning room (air hammer, scaler, horizontal grinder, vertical grinder) were tested. The procedures used were described in Section IV A. A detailed discussion of the engineering results is in Appendix A. A brief summary of the vibration results follows.

The air hammer (chipper) vibration results are summarized in Table 1. That table shows that the total axial accelerations of the handle of the type 2 air hammers previously studied by NIOSH (Item A) ranged from 12 to 65 g's with most measurements in the 15 to 30 g range. The handle and barrel accelerations produced by the Neenah air hammer (Item B) are in the same range as those accelerations. The acceleration on the chisel of the air hammer was not measured at Neenah because the tremendous accelerations on the chisel usually destroy the accelerometers within seconds. The chisel axial accelerations of similar air hammers have been measured to be as high as 2400 g's in the previous NIOSH study and the accelerations on the chisels of the Neenah air hammers are likely to be in a similar range.

These chisel accelerations are important because the design of the chipping hammer requires that the operator hold the chisel to keep it attached to the air hammer and the operator's hands are exposed to tremendous vibration energy while holding the chisel. The remaining items of Table 1 show that the chisels used on the air hammer and the tool operating speed (throttle) can affect the amount of acceleration present on the handle. Item C shows that operating the air hammer at 1/2 throttle decreases the vibration as compared to full throttle operation (Item B). A decrease in vibration energy with 1/2 throttle operation is also seen when an air hammer with a short chisel (6") is operated at half throttle (Item E) instead of full throttle (Item D). Item F shows that operating the tool with intermittent bursts instead of continuously (Item D), increases the handle axial accelerations. In the previous NIOSH study, similar vibration changes were seen in the air hammer vibration energy at half throttle and with intermittent burst operation.

TABLE 1

TYPE 2 AIR HAMMER VIBRATION LEVELS

Run Location (Neenah Run Nos. in parenthesis)	Chisel Length	Operating Condition	Throttle	Handle Axial Acceleration (g)
A) Previous NIOSH Study	Long (12")	Continuous	Full	12.25, 17.55 30.50, 65.96
B) Neenah (73,71)	"	"	"	21.5, 42.2
C) Neenah (77)	"	"	1/2	15.1
D) Neenah (75)	Short (6")	"	Full	19.9
E) Neenah (76)	"	"	1/2	12.0
F) Neenah (74)	"	Intermittent Bursts	Full	25.1

The scaler tool (Neenah employee use about 2 hours/day) is a smaller version of the air hammer that has a chisel firmly attached; thus the operator is not required to constantly hold the chisel. Scalers were not used in the previous foundries studied so no comparative measurements are available. The particular scaler tested had provision only for on-off (full throttle) operation. Acceleration levels on the barrel were 49.7 and 64.6 g's on 2 runs with continuous operation using a 14 inch chisel. Thus the scaler barrel appears to have somewhat higher accelerations than the handle of the air hammer.

Unless major design modifications in the impact tools (chipping hammer & scaler) are made by the tool manufacturers, any significant reduction in the inherent vibration produced by these tools is unlikely. However, some vibration reduction in the impact tools can be achieved by implement selection (e.g. using the short rather than the long chisel when possible) and using continuous operation. Since the chisel can have more than 40 times the vibration energy of the air hammer handle, it is most important to avoid as much as possible, hand contact with the chisel while the air hammer is operating. While reducing the throttle speed decreases the tool's vibration level, it probably prolongs the period required to clean a casting in inverse proportion to the decreased vibration. Thus it is unlikely that routinely operating the impact tools at reduced throttle will lead to a decrease in the amount of hand transmitted vibration exposure per casting cleaned.

Table 2 shows the accelerations for the horizontal and vertical grinders. The accelerations on similar grinding tools measured during the previous NIOSH foundry study are included for comparison. Clearly the acceleration levels for the Neenah grinding wheels are far higher (from 15 to 51 times higher) than the corresponding acceleration levels of the grinding machines measured previously. In the previous study the grinding wheel vibration levels were insignificant compared to the far higher vibration levels present on the impact tools (air hammers). However, in Plant 3 the vertical and horizontal grinders appear to produce vibration levels comparable to the levels found on the handles of the impact tools. Since the employees use the grinder 4 to 5 hours per day these tools produce a significant proportion of the total hand vibration energy exposure experienced by the Plant 3 cleaning room employees.

TABLE 2
HORIZONTAL AND VERTICAL GRINDER VIBRATION LEVELS

<u>Horizontal Grinder</u>	Tool Implement	Total Acceleration g(rms) on Right Handle	Total Acceleration g (rms) on Left Handle
Previous Study	Cup	1.71	2.09
Neenah	Cup	26.42	44.56
<u>Vertical Grinder</u>			
Previous Study	Sanding Wheel	0.97	0.56
Neenah	Sanding Wheel	49.75	24.8

The data in the tables show that the grinder vibration levels at Neenah are significantly higher than the levels found in NIOSH's previous foundry study and we believe (from the data and video tapes) the reasons relate principally to the work practices and the condition of the tools tested. In the previous NIOSH foundry study most metal cleaning was done with the chipping hammer. Since grinding was used principally as a fine finishing operation the grinding tool was not applied with great force to the workpiece (casting). The previously tested grinders were in good working condition, with little or no tool or implement imbalances which might increase the vibration levels. The video tapes and the walk-through tour revealed that at Neenah's Plant No. 3, since the hardness of the metal being cleaned made the chipping hammer inefficient in removing excess metal, the grinding machines were used for approximately 4 - 5 hours per day by each man. Most of the workers gripped the tools very firmly and applied large forces against the workpiece when using the grinding tools. Since the Plant 3 workers must make the various grinders do the jobs of both chipping and grinding, they push themselves and their grinders to get the job done as quickly as possible, because their pay is based on a piecework incentive system. The previously tested grinders were fairly new and in good working condition, with little tool or implement imbalances which might increase the vibration levels, while the Neenah grinding machines generally appeared to have undergone considerable use. The newer condition of those tools and the fact that the workers did not push the grinders into the workpiece with the great force used by the Neenah employees, probably accounts for the markedly lower grinder vibration levels generally found in the previous study.

The proportion of the increased vibration produced by the Neenah grinding tools, that is secondary to the work practice of using great force to push the grinding tool against the work piece, compared to the proportion of the elevated vibration level that is secondary to tool and implement wear and imbalance is not known. However, it is likely that replacement or complete "overhaul" of the grinding machines together with concurrent modifications in the work practices used with grinding tools, could substantially reduce the hand vibration exposure associated with grinder use by the plant 3 cleaning room employees. Such a reduction would be most beneficial, considering the large proportion of the workday that the employees spend using grinding tools.

B. Medical Data

Sixty-four employees of the cleaning rooms (17 Plant 2 and 48 Plant 3) and two former employees of Plant 3 who requested to be examined participated in the study. Table A below shows the overall results of the medical study. Twenty-eight men who had a history of employment in Plant 3 and 3 men who worked in Plant 2 reported experiencing symptoms of Raynaud's Phenomenon.

TABLE A

	Total Employed	No. Inter- viewed	Mean Years of Exposure	Men with VWF
Cleaning Room 2	23	17	2 yrs	3 (18%)
Cleaning Room 3	51	49	4.3 yrs	28 (57%)

Four of the participants had medical conditions that might predispose them to the development of Raynaud's symptoms, such as a history of digit trauma or hand surgery or symptoms suggestive of primary Raynaud's disease. Thirteen other men either had a history of interrupted exposure to vibratory hand tools (which would make an estimate of their equivalent total vibration exposure time difficult) or at the present time did not have significant daily exposure to vibrating hand tools. In order to more clearly evaluate the relation of exposure to the development of white finger symptoms, these 17 workers were not included in the subsequent analyses.

Table B summarizes the results for the 49 remaining workers. It is interesting to note that elimination of the 17 workers did not markedly change the VWF prevalence in either Plant 2 (18% vs 9%) or Plant 3 (57% vs 55%). The mean years of exposure for Plant 2 employees (2 yrs.) is lower than the mean years of exposure for Plant 3 employees (4.3 yrs.). It is probable that the lower mean exposure of the Plant 2 work force and the lesser daily hand vibration exposure experienced by the Plant 2 employees accounts for the difference in the VWF prevalence between Plant 2 (9%) and Plant 3 (55%). Note that the 1 case with VWF in Plant 2 had a short latent interval (time from beginning work to first episode of finger blanching) of only 0.3 years. This short interval suggests that his hands were unusually sensitive to vibration.

	TABLE B		
	Plant 2	Plant 3	Total
Number of Employees After Medical and Exposure Exclusions	11	38	49
Mean Age (yrs)	23	28	27
Mean Exposure (yrs)	2.0	4.3	3.8
Number with VWF	1 (9%)	21 (55%)	22 (45%)
Mean Latent Interval (yrs) (for VWF cases)	.3	2.3	2.2

Further evidence suggesting the important relation between VWF and total vibration exposure is seen in Table C, below, which shows the number of cases and the mean exposure years for each VWF stage for the workers in each plant separately and with the employees of both factories combined. Note that the mean years of exposure for the employees in stages OT, ON, and OTN are combined for clarity. Clearly, as the VWF stage advances in severity the mean years of exposure increases. Notice that the mean exposure for men reporting stage 3 symptoms was 8.6 years. Out of the 38 men from Plant 3 that remained after cases with complicating factors in their history were excluded, 14 men had exposures exceeding 3 years. Only 2 of these 14 men had not experienced VWF symptoms.

TABLE C

Stages of VWF (in subjects currently exposed to vibration with uninterrupted exposure).

VWF Stage	0	OT	ON	OTN	1	2	3	Totals
Foundry 2 Men	3	3	1	3	0	1	0	11
Mean Exposure (yrs)	1.2	2.5				1		2
Foundry 3 Men	8	2	1	6	1	13	7	38
Mean Exposure (yrs)	2	2.4			2.2	4.8	8.6	4.3
Total	11	5	2	9	1	14	7	49
Mean Exposure (yrs)	1.7	2.5			2.2	4.5	8.6	3.8

It is noteworthy that, in the 11 men from Plant 2 that remained after the Plant 2 employees with complicating histories were excluded from the analysis, while only 1 man had developed symptoms of white finger, 7 out of the remaining 10 employees reported experiencing numbness or tingling in their hands. Thus it is probable that they had been affected by their vibration exposure and some of them may begin to develop VWF symptoms, if their exposure to vibration continues. The table also shows that only 11 of the 49 men (22%) reported experiencing no abnormal hand symptoms. The mean exposure of these 11 asymptomatic men was 1.7 years while the mean exposure for the men with numbness or tingling but without white finger symptoms was 2.5 years. This data also suggests that the frequency of symptoms increases with increasing exposure time.

During data analysis it became clear that in Plant 3, the day shift had significantly more cases of vibration white finger than did the Plant 3 evening shift. However, Table D, below shows that the mean exposure for the 15 symptomatic dayshift men and 5 symptomatic evening shift men are quite comparable at 6.2 and 5.7 years respectively. The latent intervals of these symptomatic men are also comparable at 2 and 2.5 years respectively. Note that the three day shift men and 14 evening shift men without white finger symptoms also had similar lengths of exposure (2.1 and 1.9 years respectively). Thus the marked differences between the two shifts in the prevalence of VWF can also be explained by the difference in the workers length of exposure between the day shift and the evening shift.

TABLE D
COMPARISON OF PLANT 3 DAY AND EVENING SHIFTS

	Number Of Men	VWF Present		VWF Not Present	
		Median (yrs) Exposure	Latent (yrs) Interval	Number	Median (yrs) Exposure
Day Shift	16	6.2	2.0	3	2.1
Evening	5	5.7	2.5	14	1.9

As part of the examination, the sensory ability of the participant's hands was tested using cotton wool, pin prick and heat sensation with a warm (50°C) metal rod. Table E below shows the results for the 49 men without complicating factors in their history.

TABLE E
NUMBER OF ABNORMAL RESPONSES

	Light Touch (Cotton)	Pin Prick	Temperature Rod
Non VWF (27 Men)	3 (11%)	1 (4%)	1 (4%)
Stage 1 (1 Man)	0	0	0
Stage 2 (14 Men)	8 (57%)	10 (71%)	3 (21%)
Stage 3 (7 Men)	6 (85%)	7 (100%)	4 (57%)

The examining physician was aware of the person's status with regard to the presence or absence of VWF symptoms, so some observer bias could be present. However, the results suggest that men with VWF tend to have impaired sensibility to light touch, pin prick and temperature. (Although it cannot be detected solely from data in Table E, 86% of men with VWF symptoms had an abnormal response to light touch and/or pin prick). It is of course possible that the sensory changes are secondary to long vibration exposure but are not directly related to the VWF syndrome.

The participant's hand sensory ability was also tested for 2 point discrimination and depth perception of the fingertips, and hand temperature sensibility was examined with the Minnesota Disk Temperature Test. While the men with VWF tended to have slightly more difficulty performing these tests, under the conditions present in this study, these exams did not differentiate well between the men with and without symptoms of vibration white finger.

VII. CONCLUSIONS AND RECOMMENDATIONS

The problem of vibration induced white finger (VWF) is found among cleaning room employees throughout the foundry industry. Its prevalence in each foundry depends on the work force's mean length of time spent working as a chipper and grinder, the vibration characteristics of the tools used, the character of the metal in the castings, the amount of time the employees use those tools during the workshift and the techniques used in handling the tools. The results of this survey demonstrate clearly that the cleaning room employees at Plant 3 are at increased risk of developing symptoms of Raynaud's Phenomenon or VWF. While the prevalence of finger blanching symptoms among the Plant 2 cleaning room employees examined was considerably less than the prevalence in Plant 3, many of the Plant 2 employees report experiencing frequent numbness and tingling in their hands. The large proportion of men with neurological symptoms in Plant 2 suggests that the vibration exposure may be affecting them and that if their exposure continues for a sufficient length of time, additional Plant 2 chippers and grinders may develop symptoms of VWF.

Since the horizontal and vertical grinding tools used at Neenah appear to be significant sources of hand vibration exposure to the Plant 3 cleaning room employees and previous NIOSH measurements indicate that similar grinding tools are available that (with appropriate methods of use) may operate with one fifteenth to one fiftieth of the vibration levels of the Neenah tools, there appears to be an opportunity to decrease the overall hand transmitted vibration exposure of the Plant 3 cleaning room employees by overhauling or replacing the grinding tools in present use and by training the men in the proper methods of avoiding excessive grip force or pressure against the workpiece while using the grinding tools.

Clearly, the ultimate solution is modifying the hand tools to greatly decrease the vibration energy imparted to the user's hands. However, until these engineering modifications are developed, it is possible that

the development and increase in severity of symptoms of vibration induced white finger in employees using grinders and chisel equipped air hammers may at least be delayed by the medical monitoring practices and the changes in the work practices and tool maintenance procedures that are outlined in the following recommendations.

1. The Neenah Foundry Company should make every effort to encourage the manufacturers of chipping hammers and grinding tools to redesign these tools in order to minimize the amount of vibration energy transmitted to the users hands and arms.
2. The present tools, especially the grinding tools should receive periodic maintenance according to manufacturers specifications to minimize their vibration energy during operation. If these tools become so worn that they cannot be maintained so as to operate with minimum vibration, they should be replaced promptly.
3. Some of the air powered tools have an air exhaust that causes the tool and users hand to become cold when the tool is in use. Since VWF affected workers may have attacks precipitated by this cold exhaust air, tool modification to redirect this air exhaust away from the user's hands would be beneficial.
4. All employees working with vibrating hand tools should be examined annually, preferably in the late winter or early spring, by a physician familiar with the condition of Vibration Induced White Finger. Any employee whose VWF symptoms are rapidly worsening or who has severe VWF symptoms should be strongly encouraged to transfer to other employment in the foundry where they will not be using vibrating hand tools.
5. A formal training program should be established to instruct the employees (especially the newly hired employees) in the proper work practices of using vibrating hand tools. The techniques of holding the tools as loosely as possible consistent with safe work practices should be taught. Grasping the tools lightly will decrease the hand machine coupling (and thus the vibration energy absorbed by the hand). Also, the techniques useful in avoiding as much as possible, contact between the hand and the vibrating chisel of the air hammer (chipper) or scaler, should be emphasized since vibration energy measurements performed by NIOSH on similar tools have shown that the vibrating chisel delivers significantly more vibration energy to the hand than does the body and handle of the air hammer.
6. The cleaning room employees should be advised of the following:
 - a. The wearing of stout leather gloves may decrease to some extent the amount of vibration energy absorbed by the hands. Gloves will help protect the hands from the lacerations and trauma frequently incurred while chipping, and finger lacerations and trauma are thought to increase the chances of developing VWF.

There is one glove manufacturer in the United States who is attempting to incorporate vibration absorbing materials into the gloves used by chippers and grinders. It is possible that such gloves may provide additional protection to the user.

- b. If the body's core temperature is kept at an adequate level by wearing suitable clothing and the hands are kept warm and dry the likelihood of experiencing an attack of VWF is greatly decreased.
- c. Since cigarette smoking causes the finger's blood vessels to temporarily constrict, it may be advisable that VWF affected men reduce their smoking frequency.
- d. Many researchers feel that several hours of continuous vibration exposure may be more harmful than the same total time of tool usage interrupted by 10 or 15 minutes every hour. While this supposition has not been definitely confirmed, it may be beneficial to arrange the work schedule to provide such non-vibration exposure periods.

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IX. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Neenah Foundry Company
2. Local 121 International Molders and Allied Workers Union
3. Region V, OSHA
4. Region V, NIOSH
5. Wisconsin State Health Dept.
6. Wisconsin State Labor Dept.

For the purposes of informing the "affected employees", the employer shall promptly "post", the determination report for a period of 30 days in a prominent place near where the exposed employees work.

APPENDIX A
ENGINEERING DATA

VIBRATION MEASUREMENT RESULTS

The vibration data was obtained from the Fourier computer analysis and is summarized in Tables I - IV (Appendix A). Table I is a comparison (using grey iron castings), of the grinding tool vibration levels measured and analyzed by the NIOSH group in a previous foundry study (labeled "previous NIOSH study") to the vibration levels of grinding wheels used at Neenah (run numbers are in parenthesis). The type of grinder (horizontal or vertical) and the actual grinding implement used on the tool (cup, wheel, cone, etc.) is also given. The total equivalent acceleration in g (rms) for all three axis, is given as well as the total acceleration for each individual axis. The accelerometer was attached where the worker would place his hands on the tool. (See Figures 1 - 4) The placement of the triaxial accelerometer on the tool is indicated by the letter "A".

The results summarized in Table I show that the vibration levels for the grinders used at Neenah are considerably higher than the grinder vibration levels obtained in the previous NIOSH studies. The reasons will be discussed later. For the horizontal grinder (using a cup element), Neenah levels (Item B) are approximately 13-20 times higher than in the previous study (Item A). Although the results of the previous study for the coarse/fine wheels (Items C & D) and the Neenah cone element levels are not directly comparable, the Neenah cone vibration levels are two orders of magnitude greater than the vibration levels in the previous study. Similarly, for the vertical grinder the Neenah levels are 40-50 times greater than the previous study.

Table II is a continuation of Table I for the chipper and scaler tools. Note that with impact tools only the axial "Y" direction vibration levels are given since the axial level is a good estimate of the vibration characteristics of the tool. In the case of impact tools, the operating condition (i.e. whether or not the chipping is being done in intermittent bursts or continuous running) is important. Also, tool throttle (i.e. full, 1/2, etc.) and chisel length appear to affect the vibration dose impinging on the workers hands. In this study, no attempts were made to place the accelerometer on the chisel itself, since in all but a few previous cases such placement has resulted in total destruction of the accelerometers in a matter of seconds! Thus, at Neenah, levels were measured only on the tool handles, approximately where the worker places his hands. In table II (using a frequency spectrum of 6.3-1000 Hz), item (A) taken on a previous NIOSH study indicates that with a long chisel (12"), full throttle, and continuous chipping, the chisel level acceleration levels approached 2400 g (rms). Since similar chippers are used at Neenah, there is no reason to believe the vibration levels on the Neenah chippers are significantly lower. Item (B) shows the corresponding acceleration levels at the handle. In the previous study these values range from approximately 12-66 g (rms). The Neenah data falls right in with previous data (21 and 42 g (rms) Item C). It can be seen from Item (D) that performing the same Neenah job at 1/2 throttle, reduces the vibration levels to 15 g (rms). Items (E-H) are particularly striking. First, when the chisels are changed to a more conventional "short chisel" (6"), operating the hammer at full throttle on an intermittent burst basis, produces levels of 25 g (rms) (Item E). Operating the same tool continuously reduces these levels to 19 g (rms) (Item E). Operating this tool continuously at 1/2 throttle further reduces these levels to 12 g (rms) (Item F) and similarly in the previous study to about 4 g (rms) (Item G).

Thus at Neenah, operating the chipping tool at 1/2 throttle continuously dropped acceleration levels at the tool handles by 50%. Similarly if we compare items H and A which were run at 1/2 throttle, chisel levels show a reduction of better than 10:1 compared to full throttle operation.

In the previous NIOSH study scalars, which are a smaller version of the chipping hammer that have a chisel piece that is firmly held in the machine, were not used in the workplace. Therefore, only Neenah scalar data is available (Item I). The particular tool tested had provisions only for on-off (full throttle) operation. Levels were approximately 50-60 g (rms) for continuous scaling as measured on the barrel when using a 14" chisel.

At Neenah, there was concern that the toughness of the ductile iron versus other casting materials might cause more vibration energy to be transmitted to the users hands. The results given in Tables III & IV, however, indicate that for the casting materials tested (i.e. grey iron, ductile iron, and high alloy grey iron) the material itself does not appear to affect the vibration levels measured.

What does appear to affect the vibration levels, however, is the tool and the type and condition of the implement being used on the tool, and how the work is done. In particular, it can be seen from Table III that at the horizontal grinder levels (using cups as implements) ranged for grey iron and ductile iron castings from 26 - 45 g (rms). However, changing the tool implement from a cup to a cone raised these overall levels to the 60 - 80 g (rms) range. (The same worker, the same castings and the same grinder were used). Similarly, Table IV shows the vertical grinder with various implements and castings (again using the same worker, same tool, etc.). The lowest overall levels were obtained when the cutting wheel was used. An "older" grinding wheel and "newer" grinding wheel yielded higher levels. The levels varied by a factor of about 3:1 between the use of the "new" wheel and the "cutting wheel."

The data in the tables show that the grinder vibration levels at Neenah are significantly higher than the levels found in NIOSH's previous foundry study and we believe (from the data and video tapes) the reasons relate principally to the work practices and the condition of the tools tested. In the previous NIOSH foundry study most metal cleaning was done with the chipping hammer. Since grinding was used principally as a fine finishing operation the grinding tool was not applied with great force to the workpiece.(casting) The walk-through tour revealed that at Neenah's Plant No. 3, since the hardness of the metal being cleaned made the chipping hammer inefficient in removing excess metal, the grinding machines were used for approximately 4 - 5 hours per day by each man. On site observations and video tapes of the grinders taken during the vibration measurements revealed that most of the workers gripped the tools very firmly and applied large forces against the workpiece (castings) when using the grinding tools. Since the Plant 3 workers must make the various grinders do the jobs of both chipping and grinding, they push themselves and their grinders to get the job done as quickly as possible, because their pay is based on a piecework incentive system. The previously tested grinders were fairly new and in good working condition, with little or no tool or implement imbalances which might increase the vibration levels while the Neenah grinding machines generally appeared to have undergone considerable use.

The newer condition of the previously tested tools and the fact that these workers did not push the grinders into the workpiece with the great force used by the Neenah employees, probably accounts for the markedly lower grinder vibration levels generally found in the previous study.

Summary of Vibration Measurement Report

1. In Plant 3 the toughness of the metal requires that the majority of the casting finishing work be accomplished by using grinding tools, rather than by using the chipping hammer. The castings in Plant 3 require more complete and precise finishing than do Plant 2 construction castings and video tape and onsite observations reveal that most of the Plant 3 workers grip the grinding tools very firmly and apply the grinder to the workpiece with great force.
2. Employment in the Plant 2 cleaning room appears to entail lesser hand vibration exposure than does work in Plant 3's cleaning room.
3. The "impact tools" (air hammer (chipper) and scaling tools) used at Neenah had roughly the same vibration levels as did the impact tools used at the other foundries NIOSH has studied. Unless major design modifications in the impact tools (chipping hammer & scaler) are made by the tool manufacturers, any significant reduction in the inherent vibration produced by these tools is unlikely. However, some vibration reduction in the impact tools can be achieved by implement selection (e.g. using the short rather than the long chisel when possible) and using continuous operation with reduced throttle providing that the reduced throttle does not unduly slow the pace of the metal cleaning work. Since the chisel can have 40 times the vibration energy of the air hammer handle, it is most important to avoid as much as possible, hand contact with the chisel while the air hammer is operating.

The vibration levels of the grinding wheels, when used with the work practices current at Neenah, appear to be far higher than the levels of similar grinders used at the other foundries NIOSH has studied. The proportion of the excessive vibration that is secondary to the work practice of using great force to push the grinding tool against the work piece, compared to the proportion of the elevated vibration level that is secondary to tool and implement wear and imbalance is not known. However, it is likely that replacement or complete "overhaul" of the grinding machines together with concurrent modifications in the work practices used with grinding tools, could substantially reduce the hand vibration exposure associated with grinder use by the plant cleaning room employees. Such a reduction would be most beneficial, considering the large proportion of the workday that the employees spend using grinding tools.

ENGINEERING TABLES

Table I - Summary

Two study comparison of overall acceleration levels for pneumatic grinders during continuous grinding of grey-iron castings

<u>Study (run #)</u>	<u>Tool and Implement</u>	<u>Hand</u>	<u>Total Acceleration g(rms)*</u>	
A) Previous NIOSH study	Hor. grinder (cup)	Right	1.71	x = 0.69 y = 0.77 z = 1.31
		Left	2.09	x = 0.93 y = 0.85 z = 1.61
B) Neenah (40)	Hor. grinder (cup)	Right	26.42	x = 18.80 y = 8.90 z = 16.3
		(55) "	Left	44.56
C) Previous NIOSH study	Hor. grinder (coarse wheel)	Right	0.75	x = 0.45 y = 0.25 z = 0.52
		Left	0.59	x = 1.0 y = 0.31 z = 1.14
D) Previous NIOSH study	Hor. grinder (fine wheel)	Right	0.65	x = 0.42 y = 0.24 z = 0.40
		Left	0.79	x = 0.37 y = 0.22 z = 0.64
E) Neenah (48)	Hor. grinder (cone)	Left	79.07	x = 60.0 y = 17.9 z = 48.3

Table I - Summary

Two study comparison of overall acceleration levels for pneumatic grinders during continuous grinding of grey-iron castings.

<u>Study (run #)</u>	<u>Tool and Implement</u>	<u>Hand</u>	<u>Total Acceleration g (rms)</u>			
F) Previous NIOSH study	Vert. grinder (sanding wheel)	Right	0.97	x = 0.38	y = 0.69	z = 0.53
		Left	0.56	x = 0.35	y = 0.35	z = 0.23
G) Neenah (15)	Vert. grinder (new wheel)	Right	49.82	x = 46.80	y = 15.10	z = 8.03
H) Neenah (18)	Vert. grinder (old wheel)	Right	49.75	x = 46.4	y = 16.0	z = 8.12
" (25)	"	Left	24.80	x = 23.10	y = 5.50	z = 7.14
I) Neenah (27)	Vert. grinder (cutting wheel)	Right	21.37	x = 15.70	y = 5.04	z = 13.60
" (36)	"	Left	22.45	x = 20.10	y = 7.24	z = 6.89

*Note: Total acceler. g(rms) = $\sqrt{(x_{rms})^2 + (y_{rms})^2 + (z_{rms})^2}$

Table II - Summary. Two study comparison of overall Acceleration levels for Impact Tools (chippers and scalers)

<u>Study(run)</u>	<u>Tool & Implement</u>	<u>Chisel</u>	<u>Acceler. Position</u>	<u>Throttle</u>	<u>Axial(Y)Direction Acceler. g(rms)</u>	<u>Operating Condition</u>
A) Previous NIOSH study	Type 2 Chipping hammer	Long (12")	Chisel	Full	2,388	continuous chipping
B) "	"	"	Handle	"	(12.25,17.55,30.50, 65.96)	"
C) Neenah (73,71)	"	"	"	"	(21.50,42.2)	"
D) Neenah (77)	"	"	"	1/2	15.10	"
E) Neenah (74)	"	Short (6")	"	Full	25.10	Intermittent bursting
" (75)	"	"	"	"	19.90	continuous chipping
F) Neenah (76)	"	"	"	1/2	12.00	"
G) Prev. NIOSH study	"	"	"	"	(3.78,4.05)	"
H) "	"	"	Chisel	"	(104.29,203.34)	"
I) Neenah (63,65)	Scaler impact tool	Long (14")	Barrel	Full	(49.70,61.60)	continuous scaling

Table III. Summary of horizontal grinder acceleration levels during continuous grinding (Neenah)

<u>Run #</u>	<u>Implement</u>	<u>Hand</u>	<u>Casting</u>	<u>axis total g (rms)</u>	<u>Total equivalent acceleration g(rms)</u>
38	cup	RH	ductile	(x)17.6, (y)15.1, (z)15.4	27.83
53	cup	LH	ductile	(x)28.5, (y)30.9, (z)26.5	39.75
40	cup	RH	grey iron	(x)18.8, (y)8.9, (z)16.3	26.42
55	cup	LH	grey iron	(x)30.6, (y)7.98, (z)31.4	44.56
48	cone	LH	grey iron	(x)60.0, (y)17.9, (z)48.3	79.07
49	cone	LH	ductile	(x)44.8, (y)13.0, (z)37.8	60.04

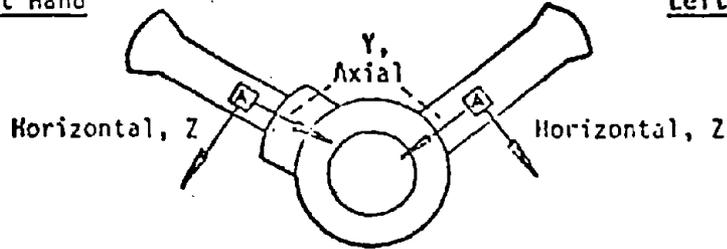
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Table IV. Summary of Vert. Grinder acceleration levels during continuous grinding (Neenah)

Run #	Implement	Hand	Casting	axis total g(rms)	Total equivalent acceleration g(rms)
14	new wheel	RH	Hialloy grey iron	(x)34.6, (y)6.84, (z)6.10	35.79
15	"	"	grey iron	(x)46.8, (y)15.1, (z)8.03	49.82
18	old wheel	"	"	(x)46.4, (y)16.0, (z)8.12	49.75
25	"	LH	"	(x)23.1, (y)5.51, (z)7.14	24.80
19	"	RH	Hialloy grey iron	(x)26.8, (y)8.7, (z)6.73	28.74
21	"	LH	"	(x)21.5, (y)5.31, (z)4.70	22.63
27	cutting wheel	RH	"	(x)15.7, (y)5.04, (z)13.6	21.37
36	"	LH	"	(x)20.1, (y)7.24, (z)6.89	22.45
29	"	RH	ductile	(x)12.3, (y)3.06, (z)9.03	15.56
36	"	LH	"	(x)19.8, (y)17.3, (z)6.04	26.98

Right Hand

Left Hand



Right Hand

Left Hand

X, Vertical

X, Vertical

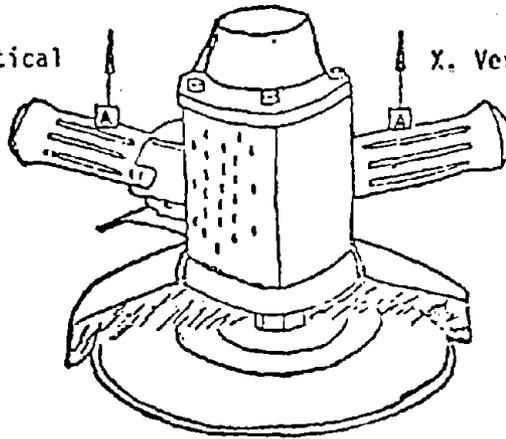


Fig.1 Vertical Grinder and Coordinate System.
(A=Position of Placement of Accelerometer)

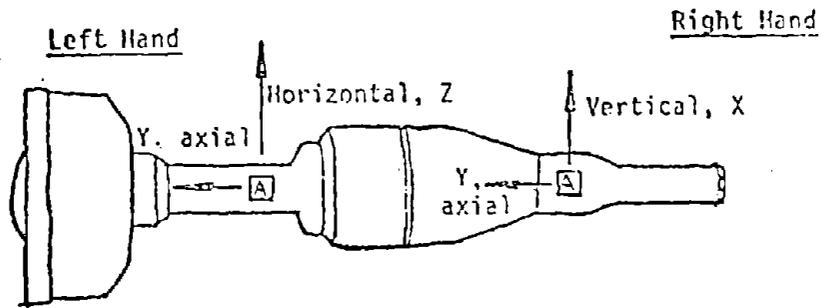
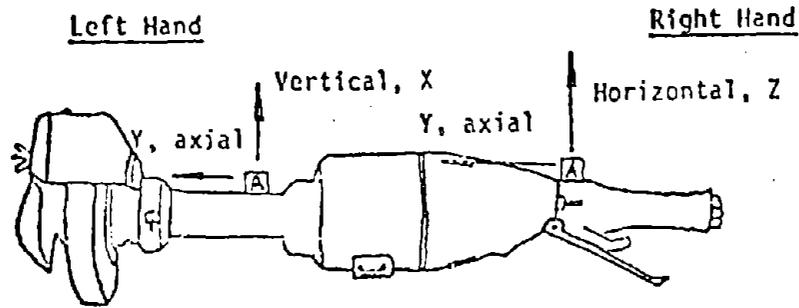


Fig.2 Horizontal Grinder and Coordinate System.
(A=Position of Placement of Accelerometer)

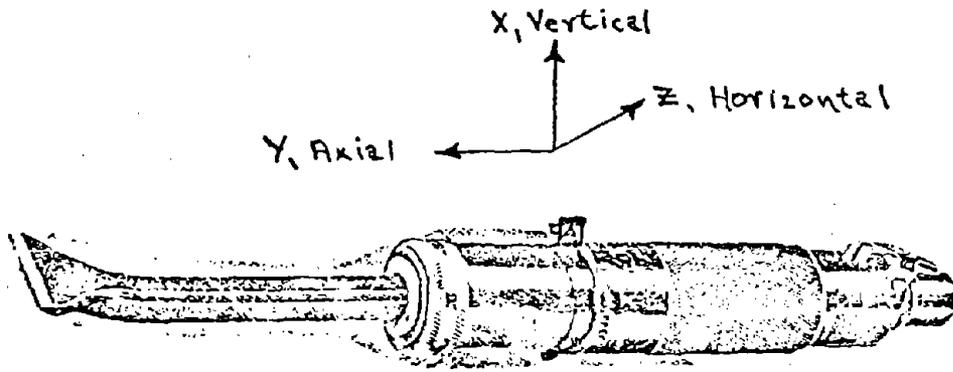


Fig.3 Pneumatic Scaler with Curved Chisel and Coordinate System.

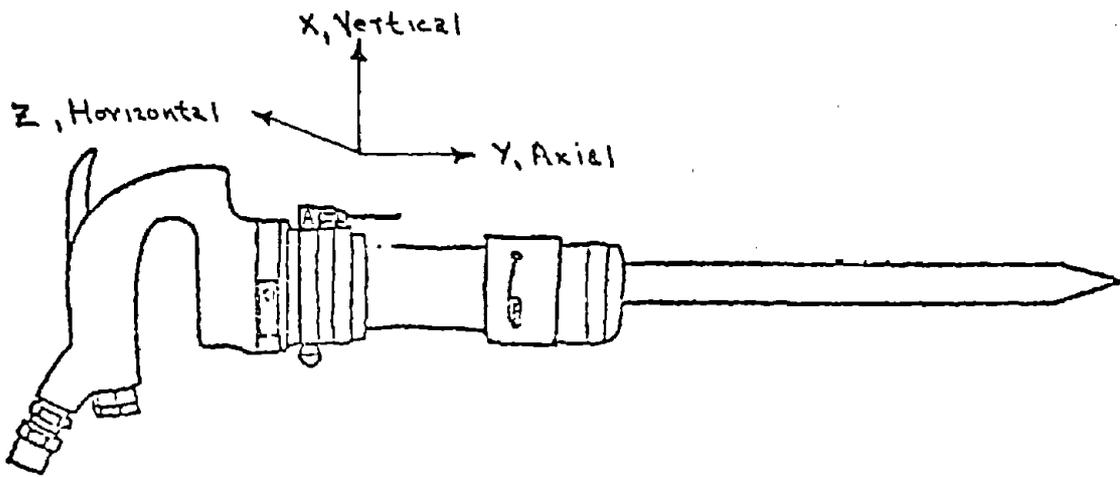


Fig.4 Pneumatic Chipping Hammer and Coordinate System.

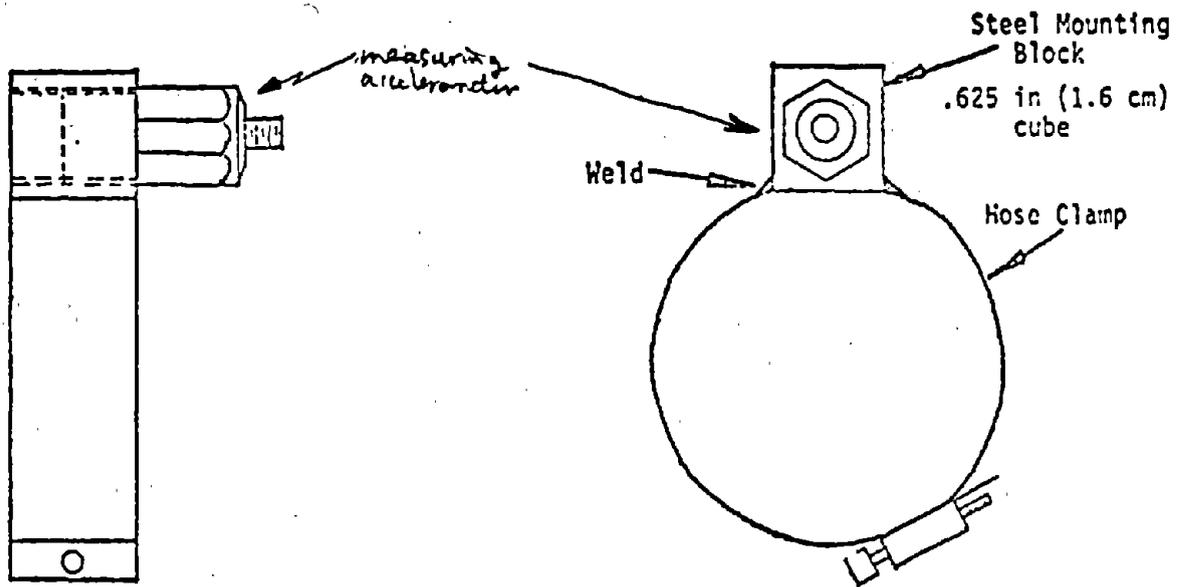
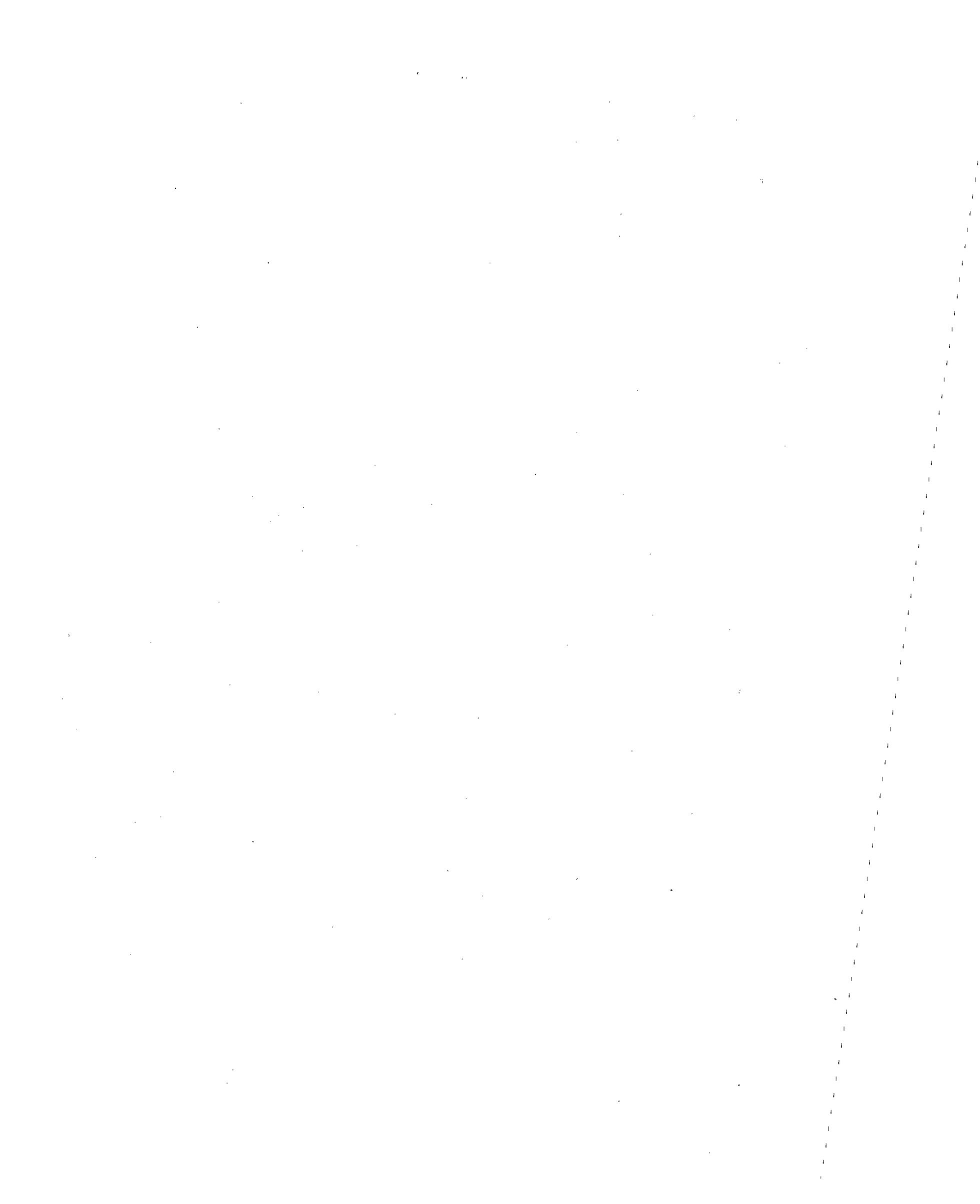


Fig.5 Accelerometer Mounting Block Acceleration Measurements.



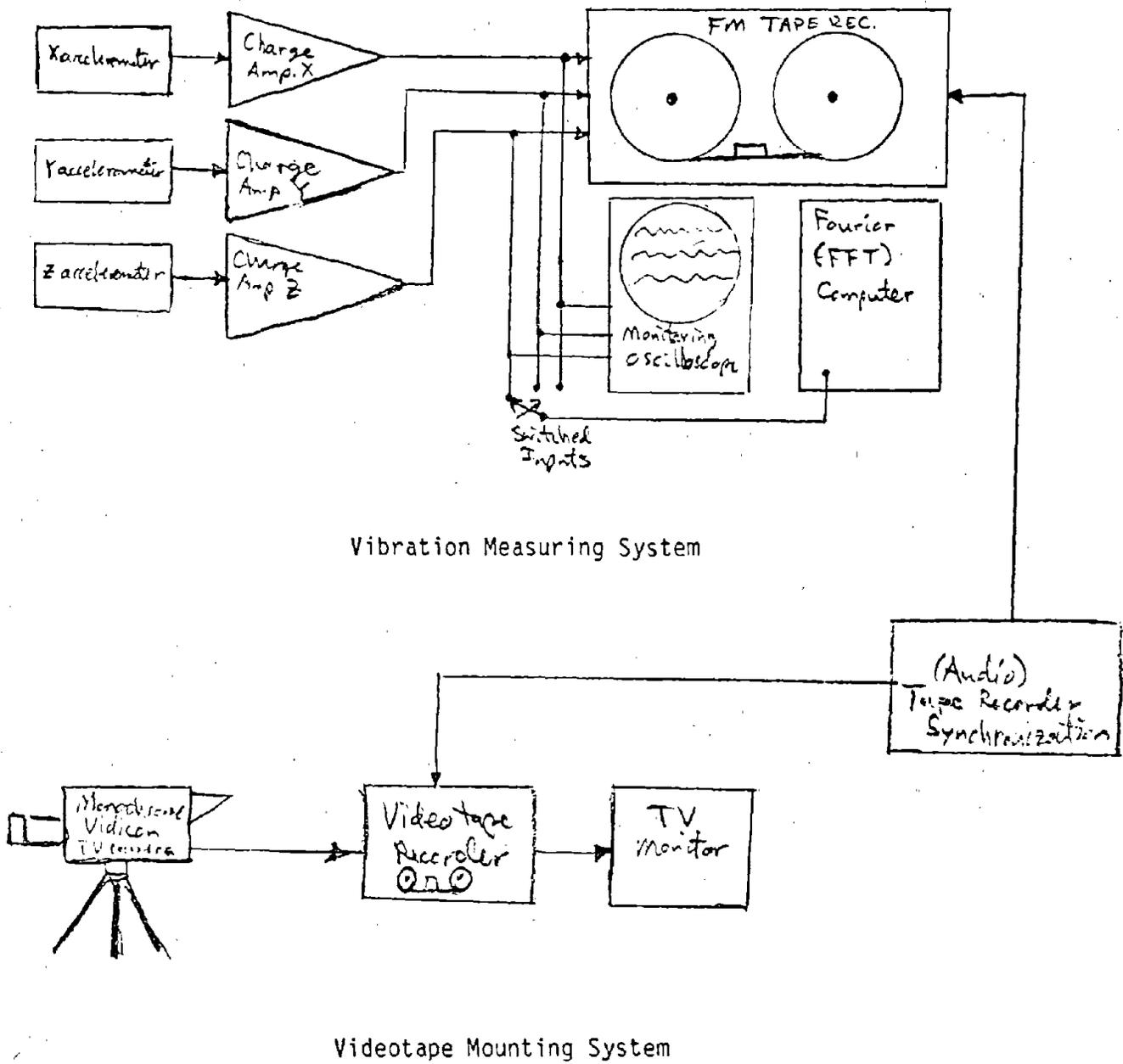
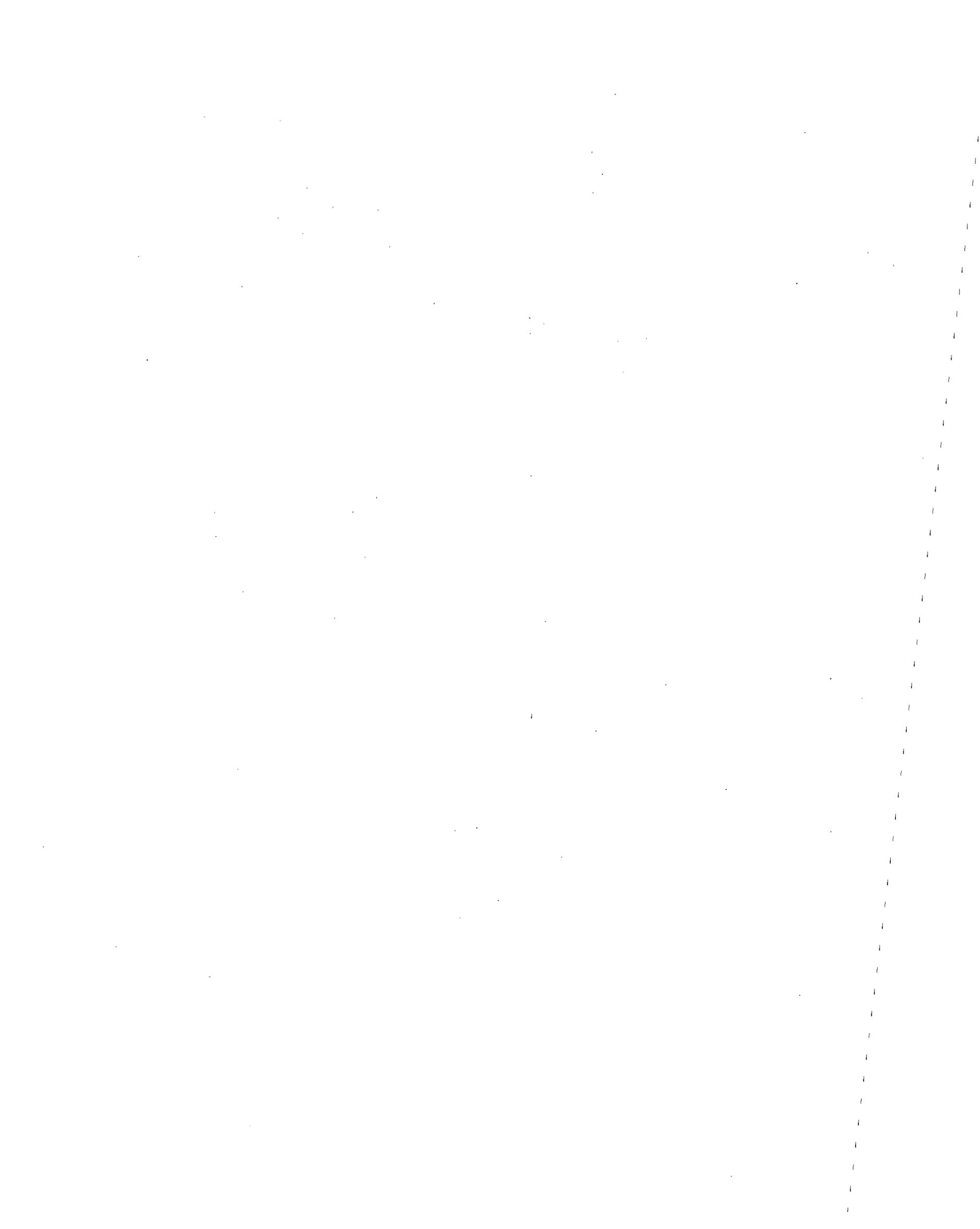


Fig. 6 Neenah Instrumentation Setup



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			14. NA
15. Supplementary Notes NA			

16. Abstract (Limit 200 words) Incidences of Raynaud's Phenomenon were investigated at the Neenah Foundry Company (SIC-3321) in Neenah, Wisconsin, on August 4 to 6, September 3, and from September 23 to 26, 1980. A representative of the molders and Allied Workers Union, Local 121, requested that on behalf of approximately 74 affected chippers and grinders in departments 2 and 3. Vibration measurements revealed that department 3 workers had more daily hand vibration exposure than did the department 2 workers. Department 3 employees used air hammers about 2 to 3 hours per day and the vibration levels of these tools ranged from 15 to 60 acceleration of gravity (g). Grinding tools were used 4 to 5 hours per day in department 3 and the vibration levels of these tools (15 to 60g) were 15 to 50 times the vibration levels of similar grinding tools previously evaluated by NIOSH. Fifty seven percent of the 47 department 3 and 18 percent of the 17 department 2 workers interviewed reported symptoms of Raynauds' Phenomenon. Symptomatic workers also reported decreased sensory abilities in their hands. The authors conclude that a circulatory health hazard existed to the hands of the chippers and grinders in department 3, and that this hazard will continue until tools are designed that reduce vibration. They recommend as an interim measure that tool maintenance be improved, work practices be modified, and severely affected workers be transferred to jobs that entail no vibration exposure.

7. Document Analysis a. Descriptors

Foundries, Hazards-confirmed, Health-surveys, Vibration-diseases, Vibration-control

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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