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TACONITE CRUSHER NOISE REDUCTION-STUDY OF ACOUSTICAL ENCLOSURE FOR SYMONS 7 FOOT, STANDARD HEAD, EXTRA-HEAVY DUTY CONE CRUSHER

PREPARED FOR

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

BY

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FINAL REPORT

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THE STANDARD OF SILENCE

ON

CONTRACT NO. H0387016

Bureau of Mines Open File Report 64-82

INSTALLATION AND EVALUATION OF CRUSHER NOISE CONTROL

SEPTEMBER, 1980

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16. Abstract (Limit: 200 words)

The objective of this study was to evalute the acoustical and cost effectiveness and the operational practicality of prefabricated acoustical enclosures applied to a taconite crusher. The enclosures were designed for durability, ease of assembly, and ease of access for crusher maintenance. Field measurements of noise were made on periphery of enclosures on a secondary crusher at the Jackson County Iron Co. in Black River Falls, Wis. Noise reduction achieved by the enclosures was sufficient to permit reduction of crusher room noise to 90 dbA, provided that other sources are appropriately treated and acoustical absorption is provided in the crusher room. Secondary crusher noise was reduced 10 to 15 dbA by the enclosures.

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FOREWORD

This report was prepared by Industrial Acoustics Company, Inc. under USBM Contract No. H0387016. The contract was initiated under the Federal Mining Health and Safety Program. It was administered under the technical direction of The Pittsburgh Research Center with Mr. Roy Bartholomae acting as Technical Project Officer. Mr. Alan G. Bolton, Jr. was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this contract during the period May, 1978 to September, 1979. This report was submitted by the author in September, 1980.

No patentable inventions were conceived during the course of this Contract.

ACKNOWLEDGEMENTS

The crusher and operation control were provided by Jackson County Iron Company under the direction of Mr. Herb Nyberg, Production Superintendent. Acoustical data were obtained with the operational assistance of Mr. Jack Lock, Shift Superintendent and Mr. Wes Johnson, Safety Director, Inland Steel.

EXECUTIVE SUMMARY

This report presents the results of a study to determine the effectiveness of acoustical enclosures for a taconite crusher. Work was performed for the U.S. Bureau of Mines under Contract No. H0387016.

Enclosures were installed on the Secondary Crusher at the Jackson County Iron Company, Black River Falls, Wisconsin. The Adjustment Level enclosure comprised an IAC Trackwall™ movable wall system designed to provide good sound transmission loss and interior acoustical absorption, withstand assault by heavy rocks and permit easy rearrangement for access to the crusher.

The lower (drive) level enclosure was of IAC Noishield™ panel construction with absorptive interior and with doors and removable sections for easy access to the drive level crusher components.

Tests were made with machinery in the crusher room shut down except for the secondary crusher system. Data were corrected for noise produced by adjacent operations and by parts of the secondary crusher system not treated under this program to determine that the enclosures reduced noise from the crusher by 10 to 15 dBA. This resulted in crusher noise at locations one foot from the enclosures below 90 dBA.

Noise contribution of other sources was determined in dBA and in 1/3 octaves. This formed a basis for recommendations on supplementary noise control measures required to reduce crusher room levels to 90 dBA or less with all machinery operating.

The crusher enclosures evaluated in this project have been in service since June 15, 1979. No deterioration had occurred at the time acoustical data were obtained July 24th and 25th, 1979; and no report has been received to date regarding any operational problems or need for repair or maintenance.

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1. INTRODUCTION

The objective of the study for which this report was prepared is to evaluate the acoustical and cost effectiveness and the operational practicality of prefabricated acoustical enclosures applied to a taconite crusher.

The enclosures were designed for durability, ease of assembly and ease of access for crusher maintenance as well as acoustical performance sufficient to reduce noise from the enclosed sources to less than 90 dBA.

With the enclosure in place, acoustical data were recorded on July 24th and 25th, 1979 at the four corners of each enclosure (drive level and adjustment level) under the following operating conditions:

1. Normal operation
2. Crusher section shut down (background)
3. Enclosed (Secondary) crusher system operating (batch tests)

Data were also recorded inside the adjustment level enclosure.

Tape recordings were analyzed using a graphic level recorder and a real time analyzer to extract data including dBA levels and 1/3 octave levels. These data were compared with similar measurements made by Bolt, Beranek and Newman, Inc. under Contract J0377014 prior to design and installation of the enclosures by Industrial Acoustics Company, Inc.

2. TEST SITE

2.1 General Description

The enclosures investigated are installed on the secondary crusher at Jackson County Iron Company in Black River Falls, Wisconsin. The secondary crusher performs one of a series of operations involved in reducing Taconite ore (large rocks) to pellets with a high concentration of iron for shipment to other plants for further processing.

All of the operations are housed under one roof. The secondary and two similar tertiary crushers are in one large room with their associated sizing screens, conveyors and dust collectors. This room has no acoustically absorptive surfaces and no effective acoustical isolation from the concentrating section on its west side. With all crushing system equipment shut down, background levels in the crusher room are 84 to 87.5 dBA due to noise from the adjacent concentrating section. The primary crusher, located in a shelter attached to the north wall of the crusher room, is isolated from the room by large windows which may be opened for ventilation or communication.

2.2. Normal Operation

Ore is dumped, or bulldozed from the storage yard, into the primary crusher. It then proceeds via conveyors to an elevation above the secondary crusher adjustment level and is discharged via a rock box and feed hopper into the secondary crusher. See plan view, Figure 2.1 and elevation, Figure 2.2.

Ore from the secondary crusher drops onto a secondary sizing screen from which it proceeds by conveyor to two tertiary crushers, tertiary sizing screens and finally to the concentrating section of the plant. The concentrating section includes large tumblers which further reduce the crushed ore before it is introduced to the concentrating process.

2.3 Operation for Enclosure Study

For short periods, it is possible to operate only the secondary crusher with its associated conveyors and sizing screen. This mode of operation was used for "batch tests" to facilitate isolation of noise from the enclosed crusher and its associated equipment.

2.4 Description of Enclosures

Figure 2.3. shows in perspective the Industrial Acoustics Company enclosure installed on the secondary crusher for this study.

The adjustment level enclosure consists of movable, structural/ acoustical wall panels supported on an overhead track system. Known in the architectural field as IAC Trackwall™, this movable panel system incorporates labyrinth and jack-in-place seals to provide a superior level of acoustical integrity. The conventional 4 inch thick Trackwall panel has 14 gauge (0.075 inches thick) unperforated steel sheets on both faces with acoustically absorptive mineral wool sandwiched in between. For this application, 11 gauge (0.120 inches thick) face sheets are used to withstand the abuse associated with rock crushing. The inside face sheet is perforated so that 23% of the face is open to absorb noise inside the enclosure. The mineral wool is protected from dust and moisture by a layer of 0.00125 inch thick polyethelene film which is held out of contact with the perforated face sheet by a layer of expanded metal lath.

The drive level enclosure utilizes IAC Noishield™ construction in an integrated system of fixed, removable and door panels engineered to provide the required noise control without compromising access for maintenance of crusher components. Noishield, a 4 inch thick structural/acoustical panel design, has a 16 gauge (0.064 inches thick) solid face sheet on one side and a 22 gauge (0.034 inches thick) 23% open perforated face sheet on the other side. Protective film and metal lath stand-off, an optional Noishield feature, is included for this application.

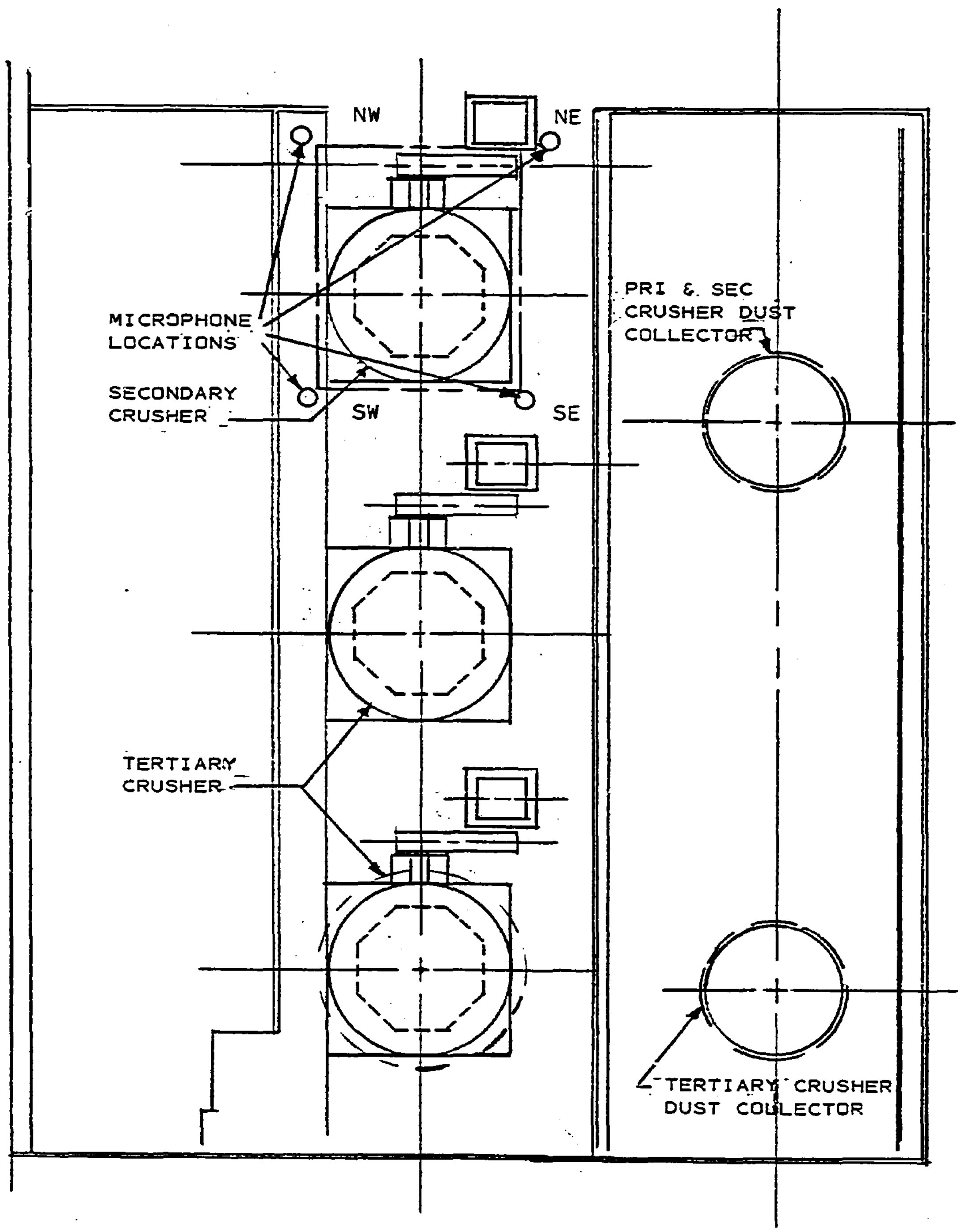


FIGURE 2.1 PLAN VIEW OF CRUSHER DRIVE LEVEL

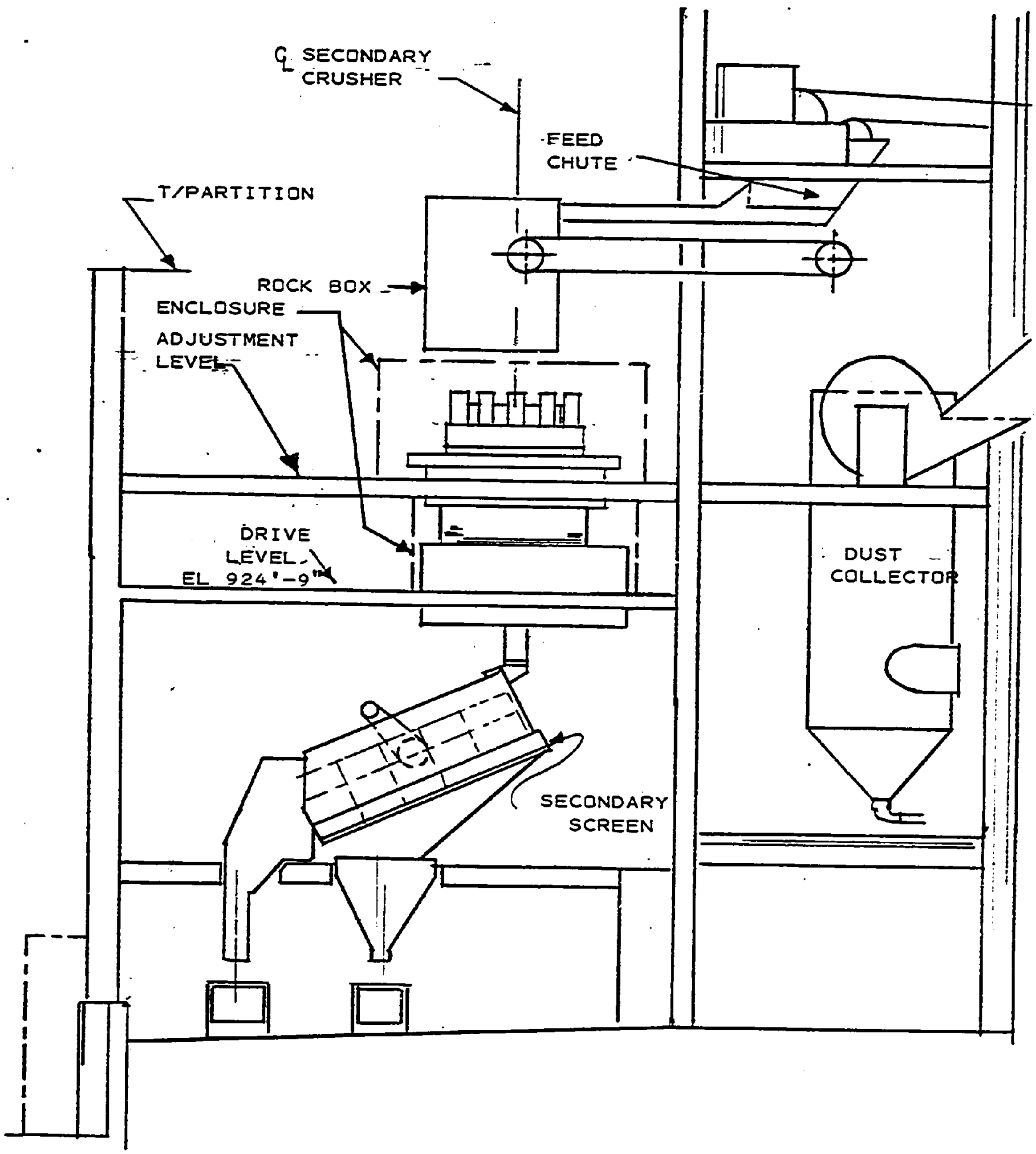


FIGURE 2.2 SECTIONAL VIEW OF CRUSHER SYSTEM

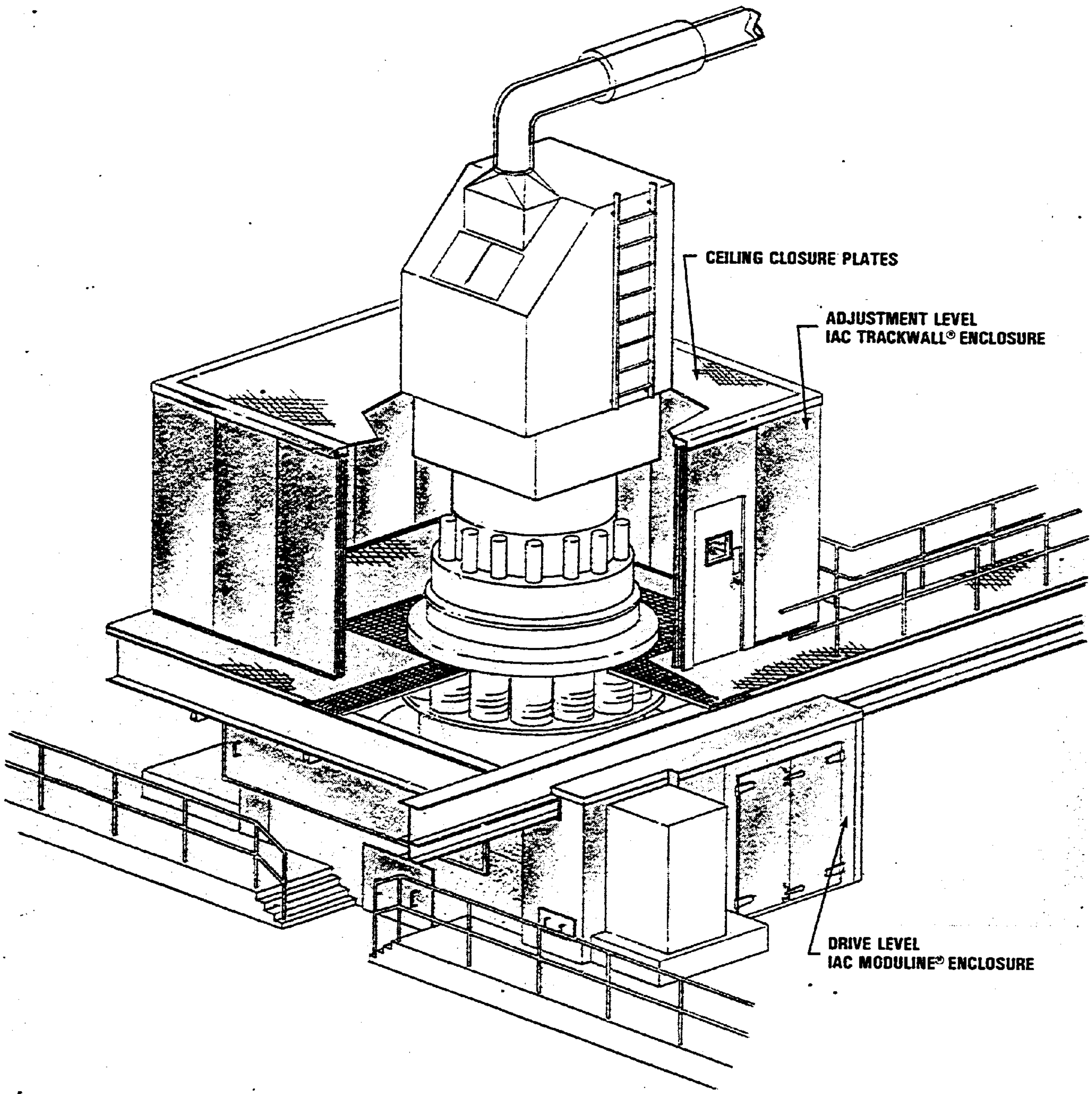


FIGURE 2.3 — PERSPECTIVE VIEW OF ACOUSTICAL ENCLOSURE SYSTEM WITH SEVERAL ADJUSTMENT LEVEL ENCLOSURE PANELS REMOVED AND PORTIONS OF CEILING AND FLOOR CUT AWAY TO SHOW CRUSHER.

3. NOISE MEASUREMENTS & ANALYSIS

3.1 Scope

The subject study required measurement of noise at eight positions - four each at drive level and at adjustment level one (1) foot from NE, SE, NW and SW corners of the enclosure. Measurements were taped during batch runs to permit analysis (1/3 octave and dBA levels) of noise from enclosed areas and from associated secondary crusher system equipment.

3.2 Measurement System

Noise was recorded on a Nagra Scientific Tape Recorder at each of the required data positions. See Figure 3.1 for measurement instrumentation schematic. Noise was recorded during the following operating conditions:

(a) During normal plant operation
(b) With crushing operation shut down (background)
(c) During a batch run (with primary and tertiary crushing systems shut down)

Batch runs were coordinated with the Shift Superintendent, who started a batch run for each position after our signal that the microphone was positioned and continued until we signaled or until it was necessary to clear the tertiary feed conveyors.

3.3 Data Analysis

Taped data were analyzed in the Industrial Acoustics Company Laboratory. See Figure 3.2 for analysis instrumentation schematic. Each taped run was first played into a graphic level recorder to obtain a complete graphic history of dBA and dBC levels experienced during each run.

Simultaneous speaker monitoring permitted us to label voice recordings made during the run to facilitate identification of tape segments with the various noise sources.

After identifying tape segments with equipment contributing to the recorded noise for that segment, a real time analyzer was used to obtain data for clearly defined segments, including dBA and 1/3 octave band levels.

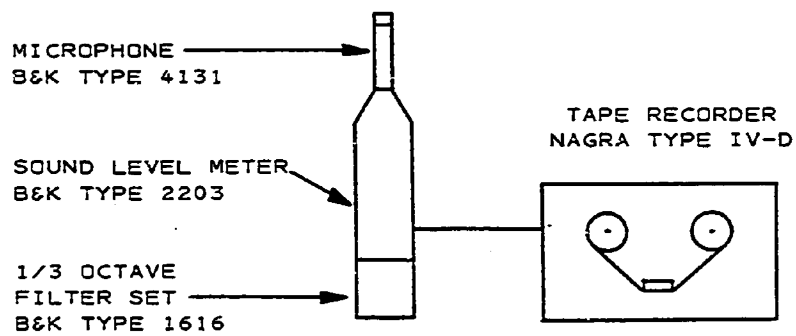


FIGURE 3.1 NOISE MEASUREMENT INSTRUMENTATION

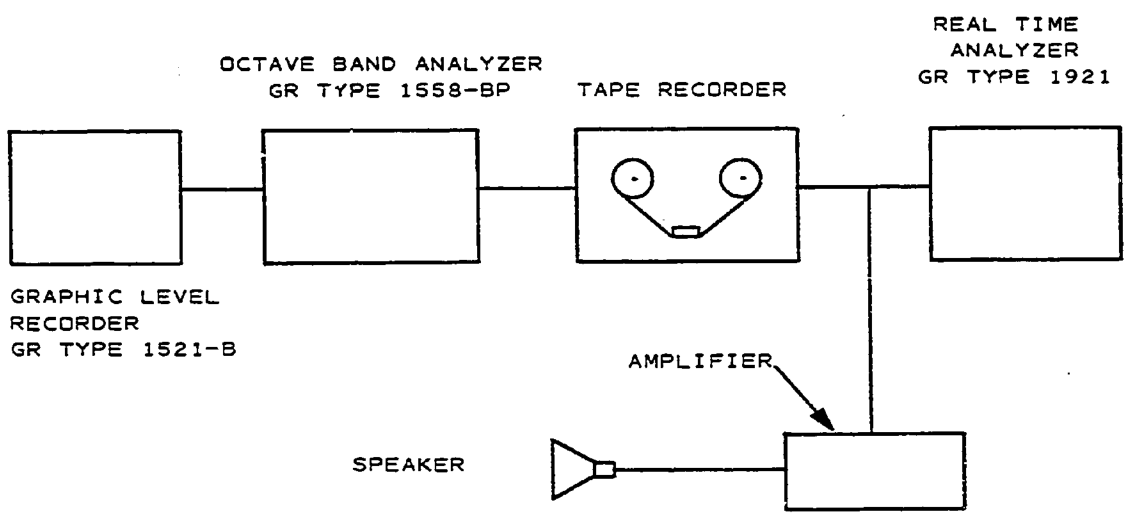


FIGURE 3.2 ANALYSIS INSTRUMENTATION

4. RESULTS OF STUDY

4.1 Introduction and Summary

This study is based on noise level data obtained in and around prefabricated acoustical enclosures installed on the drive level and adjustment level of a Symons 7 foot, Standard Head, Extra-Heavy Duty Cone Crusher used in secondary crushing of taconite ore.

The drive level enclosure was assembled from 4 inch thick acoustical/structural panels (IAC Noishield^{TM}) with various doors and access panels to facilitate crusher maintenance. The adjustment level enclosure consisted of an overhead track system with partial sheet metal ceiling closures and a heavy-duty movable wall system (IAC Trackwall^{TM}). Interior surfaces of both enclosures were acoustically absorptive.

Some of the most important aspects of results presented herein can be summarized as follows:

(a) The enclosures reduce secondary crusher noise 10 to 15 dBA to levels below 90 dBA at data positions around the enclosures. Background, screening and feed system noise were not treated in this program; and all contribute to produce levels of 90 to 95 dBA with the secondary crusher <u>system</u> only in operation.

(b) In normal operation, noise levels at the end of the secondary enclosures adjacent to the unenclosed tertiary crushers was reduced 1 to 3 dBA as expected. At the other end of the secondary enclosure, reductions of 6 to 8 1/2 dBA were measured during normal operation.

(c) Noise levels measured inside the adjustment level enclosure compare favorably with levels measured without the enclosure. Note that interior surfaces of this Trackwall enclosure are acoustically absorptive.

(d) Enclosures for the teritary crushers, similar to those on the secondary crusher, could be expected to reduce noise throughout the drive and adjustment levels to 95 - 100 dBA from the 102 - 106 dBA measured before installation of secondary crusher enclosures. Reduction of primary crusher noise by treatment of its partial enclosure, particularly the common wall and windows, is probably necessary to achieve this reduction.

(e) Sizing screen noise and Rock Box noise are significant sources. Correction could further reduce noise levels in the crushing room to 92 - 97 dBA.

(f) To achieve noise levels of 90 dBA or less in the crusher room, further effective steps would be to:

1. Provide absorptive surfaces within the room.

2. Improve acoustical isolation between this room and the concentrating section.

4.2 Data Summary - dBA

Table 4.1 presents a summary of dBA levels one (1) foot from each corner of enclosures installed on drive and adjustment levels of the secondary crusher. Table 4.2 presents dBA levels available for comparable locations before installation of the enclosures. Data presented are rounded off to 0.5 dBA.

The first line of data in each table presents levels around the secondary crusher during normal operation, i.e.; with primary, secondary, tertiary and associated equipment in the crusher room all in operation. The second line presents background levels which, in each case, are the lowest levels prevailing in the crusher room with all crushers and associated equipment shut down. The 84 to 87.5 dBA background for the various positions is fixed by noise propagated to the crusher room from the adjacent concentrating area of the plant.

Succeeding lines of data are presented in order of increasing dBA level with the enclosures installed. These data were obtained during "batch runs" for which primary and tertiary crushing systems were shut down and the secondary crusher was operated until it had to be stopped to clear the rock deposited on the tertiary crusher feed conveyor. At least one batch run was tape recorded for each of the eight positions. Laboratory analysis of the tape on a graphic level recorder permitted identification of tape segments applicable to the various states of operation as rock was introduced, crushed and screened.

Description of the various operating conditions and discussion of dBA data tabulated are given in paragraphs 4.3 to 4.8.

4.3 Normal Operation

During normal plant operation, noise levels on the south end of the enclosures (adjacent to operating tertiary crushers) were no more than 3 dBA lower than before the enclosures were installed. This was as expected. The report on noise levels without enclosures noted that "successful reduction of secondary crusher noise to levels less than 90 dBA is likely to result in only a 2 - 3 dBA reduction in noise levels on the periphery of this crusher during normal production, when all the machinery in the crusher room is operating."

During normal plant operation, noise levels on the north end of the enclosure were as much as 8 1/2 dBA lower than before the enclosures were installed. These (NE and NW) positions are partially shielded from tertiary crushers by the secondary crusher enclosures. The reductions achieved were better than had been anticipated in view of the fact that the highly reverberant (acoustically reflective) nature of the crusher room was not changed by installation of the enclosures.

4.4 Background Noise

Background noise levels (with all crusher systems shut down) were obtained at all eight locations around the secondary enclosure, and they range from 34 to 87.5 dBA. These background levels can be reduced by treatment of the adjacent concentrating room noise sources, by improving isolation between the two rooms or by adding absorption to the crusher room.

4.5 Crusher Idling

Idling noise from the enclosed secondary crusher (sizing screen shut down) was identified for NW positions on each level. This source adds nothing to background noise for either of these positions indicating that it is at least 14 dBA below background.

4.6 Crusher and Screen Idling

With the enclosed crusher and its sizing screen idling, the increase in NW levels indicates that empty screen noise (corrected for background noise) is about 84 dBA on the adjustment level and 86.5 dBA on the drive level (closer to screen).

It is important to note that NW and SW positions are on open platforms just to the east of screens which are one level below the crusher Drive Level and two levels below the crusher Adjustment Level.

Crusher plus screen idling levels are generally somewhat higher than before the enclosure was installed, possibly because of screen noise reflections off the enclosures which are one (1) foot from the enclosed crusher acoustical measurement locations.

4.7 Rock Box/Feed Hopper and Screen with Rock

Noise created by ore falling into the rock box and feed hopper is clearly audible during the crushing operation. At NW and SW locations, the same is true of screening noise. These sources can be identified on the Graphic Level Recorder plots as sloped segments at the beginning and end of a "Crushing" segment.

As shown in Table 4.1 "Screen with Rock" noise is significant at all locations on the west side of the enclosures, particularly at the NW Drive Level location directly above the screen. Background and feed system noise (Rock Box/Feed Hopper) is also highest at these locations.

4.8 Crushing

With the secondary crusher system in full operation, with the enclosures installed, noise level at the eight measurement locations is 90 to 93 dBA except for a reading of 95.5 at the NW Drive Level location. Contribution of the individual sources indicated by analysis of Table 4.1 is as follows:

	ADUUJUSTMENT LEVEL				DRIVE LEVEL			
	NE	NW	SW	SE	NE	NW	SW	SE
BACKGROUND	85	87.5	87	86.5	86	87.5	86.5	84
SCREENING	87	88.5	88	85.5	88	91.5	–	–
FEED SYSTEM	81	89	89	82	83	88	88	82.5
CRUSHER	86.5	<83	<83	85	87.5	89.5	<89	<88
TOTAL	91.5	93	93	91	92.5	95.5	92.5	90

The individual contributions above were derived as follows:

(a) Background is as measured and recorded in Table 4.1.

(b) dBA levels in Table 4.1 for "Screen with Rock" include background noise. Screening noise levels are derived as levels required for logrithmic addition to "background" to give the measured "Screen with Rock" levels.

No correction was made for crusher idling noise which is apparently not significant as indicated by the two positions for which this source was measured.

(c) Rock Box/Feed Hopper levels in Table 4.1 were similarly corrected, subtracting "crusher and screen idling" levels to get the above Feed System contributions.

(d) Finally, Crusher contribution was derived as the dBA level from this source which would give the Crushing levels in Table 4.1 when added to the other sources.

While there is insufficient data in Table 4.2 for a similar analysis, it would appear that corrected Crusher levels would be about 1 dBA below the "Crushing" levels tabulated. Comparison with levels attributable to the enclosed crusher would indicate that the adjustment level (Trackwall) enclosure is somewhat more effective than the drive level enclosure. It should be noted, however, that this may be misleading due to the reverberant nature of the crusher room, and the fact that the influence of each source and noise path on levels measured at any data location is not known precisely.

4.9 Noise Inside Enclosure

While operating and maintenance personnel would not normally be inside the Drive Level Enclosure during operation, they might be inside the Adjustment Level (Trackwall) enclosures. We therefore obtained noise levels inside this enclosure at the NE location. They are equal to or less than levels measured in the same location before the enclosure was installed, as follows:

(a) Crushing - 100 dBA with enclosure vs.
100 - 101 without enclosure

(b) Idling - 85 dBA with enclosure vs.
88 without enclosure

Note the following:

(a) Actual reduction of inside idling levels is reasonable since the enclosure partially isolates the inside position from screen and feed noise.

(b) The inside surfaces of the enclosures are acoustically absorptive. If they were reflective (or significantly less absorptive), levels inside the enclosure would be substantially higher.

No data were obtained inside the secondary crusher enclosures during normal operation or during operation with the secondary crusher (only) shut down. It is expected that the inside level during normal operation would be around 100 dBA and that it would be less than 95 dBA with the secondary crusher (only) shut down. The latter is of practical significance if this mode of operation can be employed to permit maintenance work on one crusher without shutting down the entire crusher operation (and plant).

4.10 Spectral Analysis

Various segments of the taped data - identified on dBA and dBC graphic level recordings - were played through a Real Time Analyzer to obtain a frequency spectrum of noise for each event, including the specified 1/3 octave band analysis.

Figure 4.1 compares octave band data recorded at the northeast corner of the secondary crusher enclosures with data recorded at comparable positions before the enclosures were installed. In both cases, primary and tertiary crushing systems were shut down. Note that levels recorded with the enclosure include noise from parts of the secondary crusher system which were not treated in this program.

Figure 4.2 compares the range of octave band levels recorded at the eight measurement locations before and after installation of the secondary crusher enclosure. In both cases, all machinery was operating.

Figure 4.3 is a graph of 1/3 octave sound levels at the NW Drive Level position for the following operating conditions:

(a) Background
(b) Crusher and Screen Idling
(c) Screen with Rock
(d) Crushing
(e) Normal operation

All crusher systems were shut down for "Background". All crusher systems are included in "Normal Operation". The other operating conditions are for batch runs during which the secondary crusher system only was operating.

The following should be noted:

(a) Significant noise is projected to the NW Drive Level position with "Screen and Crusher Idling" at all frequencies below 3150 Hz except for those around 250 and 500 Hz. This noise is projected from the sizing screen which is closer to this position than to any other position. While the largest contributions are below 125 Hz, levels at these frequencies are not significant to dBA. A-Weighted screen idling noise can be reduced below background by treatment effective at frequencies above 400 Hz.

(b) Rock on the secondary sizing screen produces NW Drive Level noise at all frequencies which are well above background for the NW Drive Level position. Here again, low frequency levels are not significant to dBA and screen treatment effective at 400 Hz and up is indicated.

(c) With rock in the crusher, as well as on the screen, the increase is 0 to 3.5 dB across the frequency spectrum. This indicates 1/3 octave levels from the enclosed crusher which are from about equal to around 15 dB below levels for "Screen with Rock".

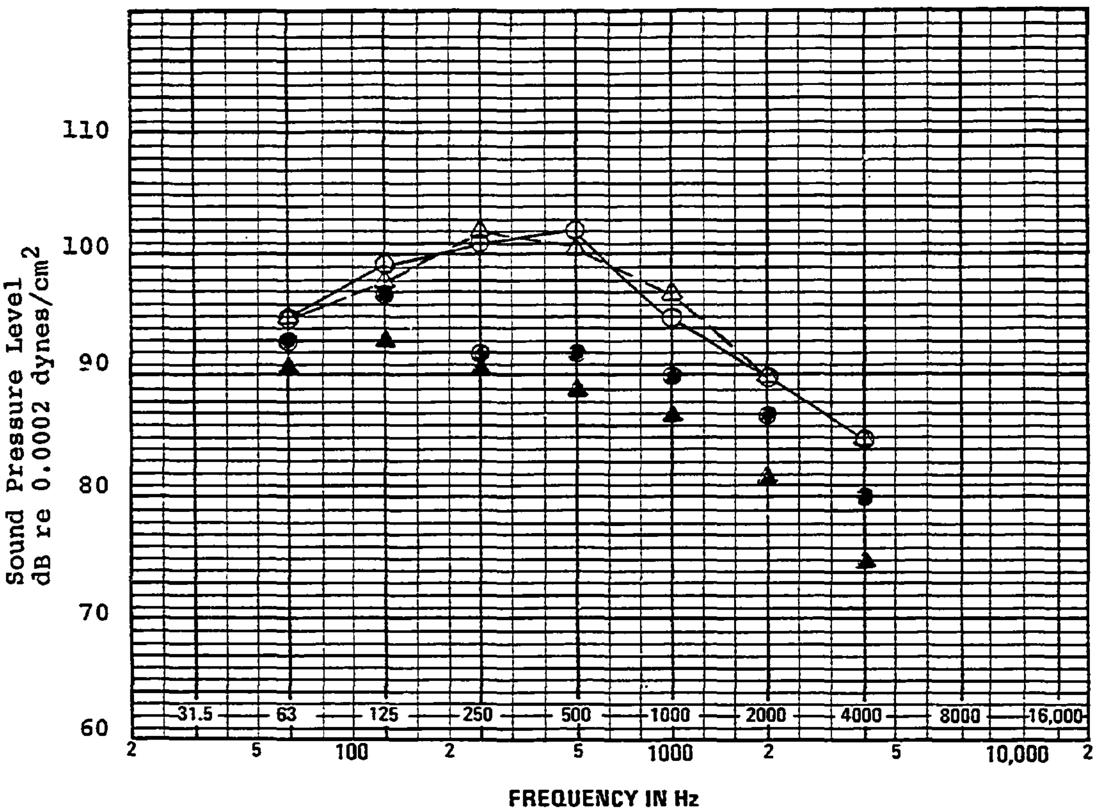
(d) Normal operation noise is within 5 dB of noise with only the secondary crusher system operating. This confirms the previous observation, in discussion of dBA results, that the secondary enclosures effectively shield the NW (and NE) positions from tertiary crusher noise.

Figure 4.4 is a graph of 1/3 octave sound levels at the SE Drive Level position for the same conditions as those plotted in Figure 4.3 except for "Screen with Rock" which we were not able to isolate from the taped data. The following should be noted:

(a) Idling noise adds little to background 1/3 octave levels except around 63 and 1000 Hz. The latter is enough to raise the level by 3 dBA to 86.5 dBA. The 800 and 1000 Hz levels are probably due to inadvertant operation of the dust collector during this run. A batch run at NE Adjustment Level with the dust collector known to be on produced the same levels at 800 and 1000 Hz and 3 dB lower levels with the dust collector known to be off. Please note that the dust collector probably also contributed to other NE and SE "Idling" levels reported herein.

(b) Normal operation noise at the SE Drive Level position is well above that produced by the secondary system (secondary crusher enclosed in either case). This, as previously noted, is because of noise from unenclosed tertiary systems which is reflected from (rather than shielded by) the secondary enclosures at this position.

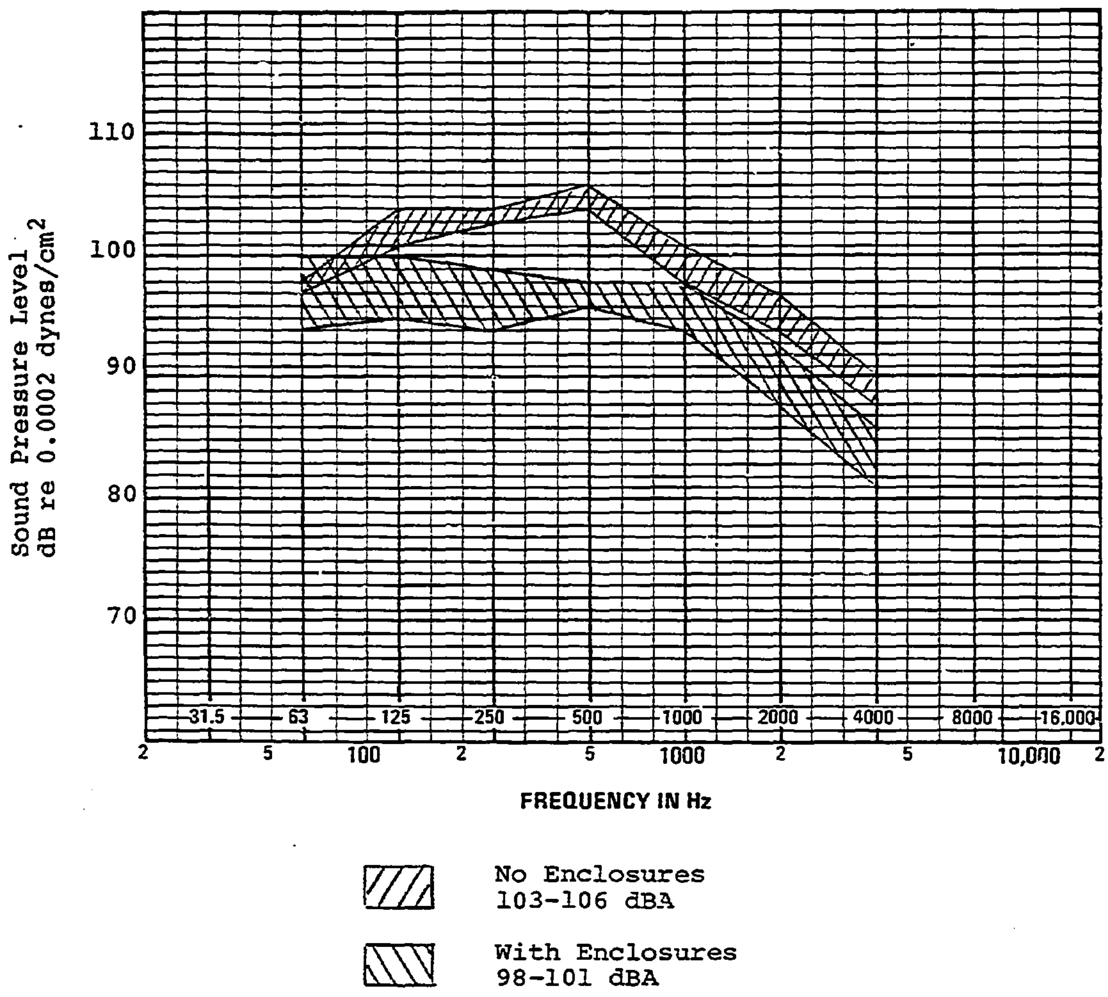
Measurement positions chosen for Figures 4.3 and 4.4 are those at which maximum and minimum dBA levels, (respectively) were measured around the secondary crusher enclosures. In either case, they confirm indications in the dBA analyses that noise from the secondary enclosures is low enough to permit reduction of crusher room noise to 90 dBA by treatment of other sources (and, perhaps, of the room itself to introduce acoustical absorption).



○— Drive Level, no enclosures, 101 dBA
△— Adjustment Level, no enclosures, 101 dBA
●— Drive Level, with enclosures, 94.5 dBA
▲— Adjustment Level, with enclosures, 91.5 dBA

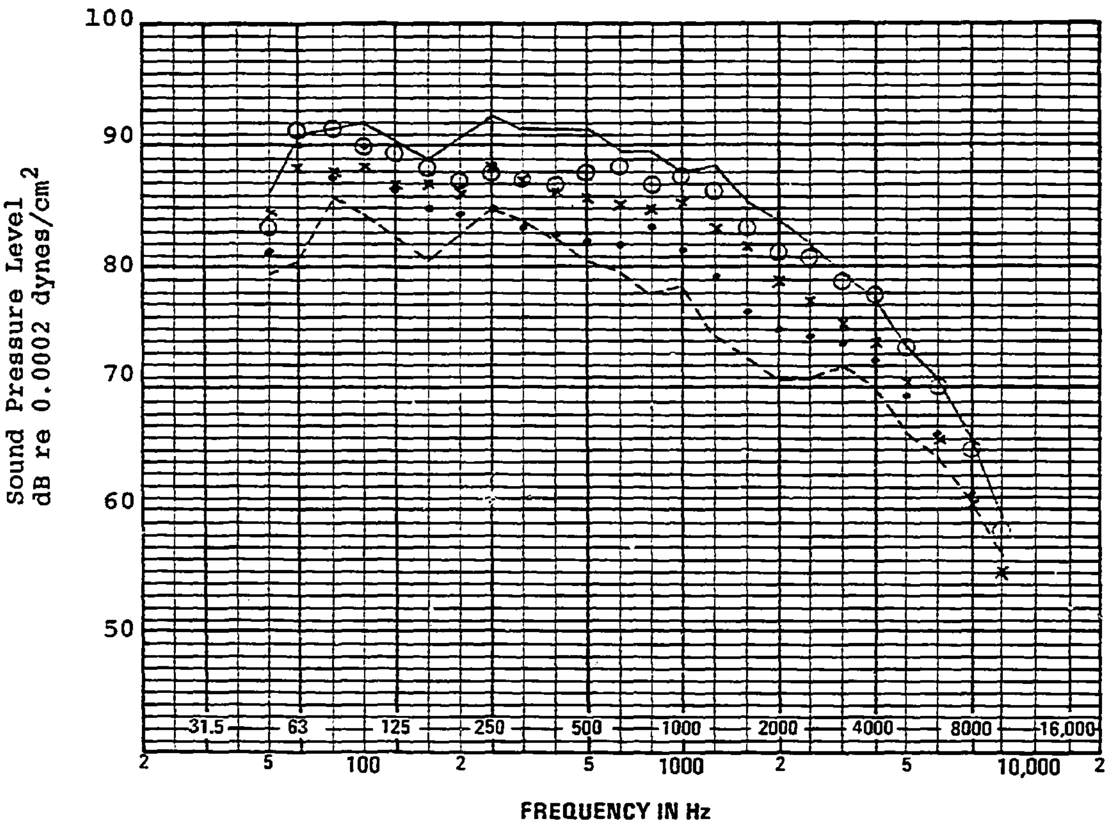
Note: Secondary Crusher System only operating. Levels include noise from parts of Secondary System not treated in this program.

FIGURE 4.1 OCTAVE BAND SOUND LEVELS, NORTHEAST CORNER BEFORE AND AFTER INSTALLATION OF SECONDARY ENCLOSURES



Note: All machinery operating

FIGURE 4.2 OCTAVE BAND SOUND LEVELS, DRIVE LEVEL POSITIONS, BEFORE AND AFTER INSTALLATION OF SECONDARY ENCLOSURES



——— Normal Operation, all machinery operating

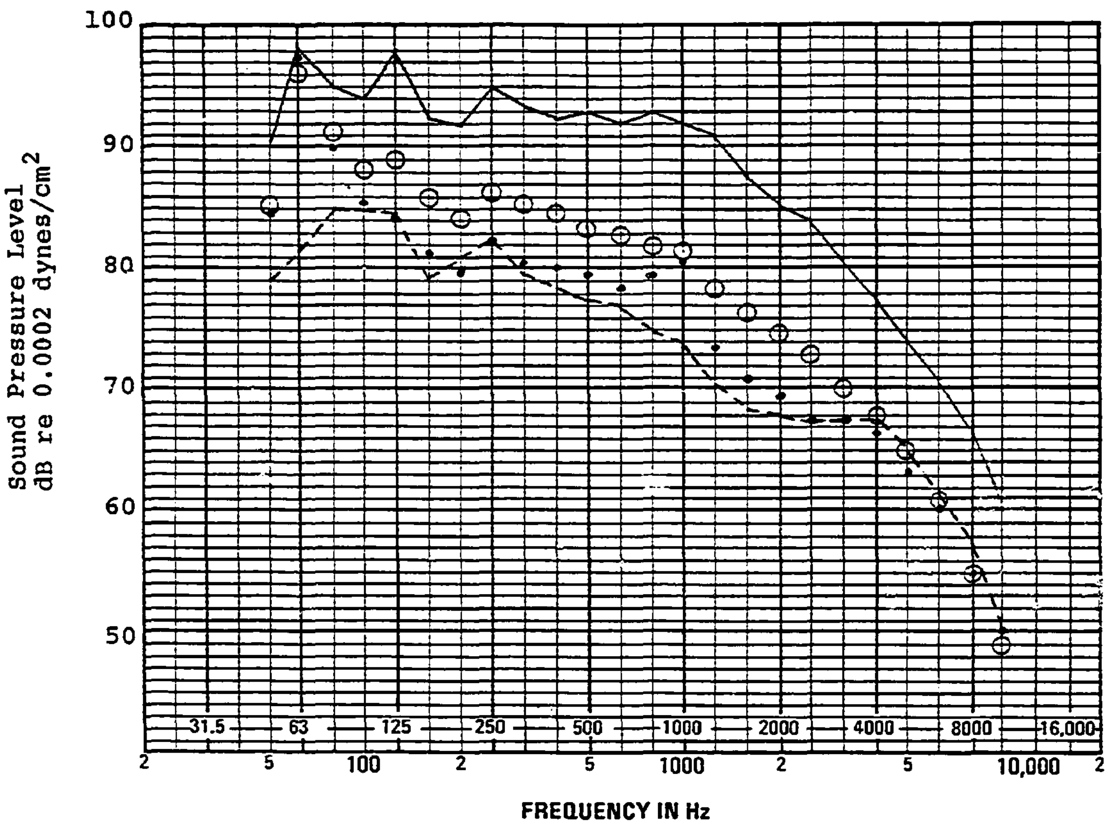
O Secondary Crusher System (only) operating with rock in feed system, crusher and on screen

× Secondary Crusher System operating with rock on screen only

• Secondary Crusher System idling - no rock

— — — Background; all crusher systems shut down

FIGURE 4.3 NW CORNER DRIVE LEVEL. 1/3 OCTAVE BAND SOUND PRESSURE LEVEL WITH SECONDARY CRUSHER ENCLOSURES



—— Normal Operation; all machinery operating

O Secondary Crusher System (only) operating with rock in feed system, crusher and on screen

• Secondary Crusher System idling - no rock

– – – Background; all crusher systems shut down

FIGURE 4.4 SE, DRIVE LEVEL.1/3 OCTAVE BAND SOUND PRESSURE LEVEL WITH SECONDARY CRUSHER ENCLOSURES

TABLE 4.1 MEASURED A-WEIGHTED SOUND LEVELS IN THE VICINITY OF SECONDARY TACONITE CRUSHER WITH ENCLOSURES - JACKSON COUNTY IRON COMPANY, BLACK RIVER FALLS, WISCONSIN - JULY 24-25, 1979

	ADJUSTMENT LEVEL				DRIVE LEVEL			
	NE	NW	SW	SE	NE	NW	SW	SE
NORMAL OPERATION	97	99.5	101.5	101.5	97	97.5	101	100
BACKGROUND	85	87.5	87	86.5	86	87.5	86.5	84
CRUSHER IDLING	-	87.5	-	-	-	87.5	-	-
CRUSHER & SCREEN IDLING	87	89	88	88	89	90	88	86.5
ROCK BOX/FEED HOPPER	88	92	91.5	89	90	92	91	88
SCREEN WITH ROCK	89	91	90.5	89	90	93	-	-
CRUSHING	91.5	93	93	91	92.5	95.5	92.5	90
CRUSHING-INSIDE ENCL	100	-	-	-	-	-	-	-
CRUSHER-IDLING INSIDE ENCL	85	-	-	-	-	-	-	-

NOTE: NORMAL OPERATION INCLUDES ALL CRUSHER SYSTEMS. BACKGROUND WAS MEASURED WITH ALL CRUSHER SYSTEMS SHUT DOWN. OTHER DATA WERE OBTAINED DURING BATCH RUNS WITH PRIMARY AND TERTIARY CRUSHER SYSTEMS SHUT DOWN. SEE PARAGRAPH 4.8, PAGE 19, FOR CORRECTED LEVELS PROVIDING INDIVIDUAL CONTRIBUTION OF SEPARATE SECONDARY CRUSHER SOURCES.

TABLE 4.2 MEASURED A-WEIGHTED SOUND LEVELS IN THE VICINITY OF SECONDARY TACONITE CRUSHER WITHOUT ENCLOSURES - JACKSON COUNTY IRON COMPANY BLACK RIVER FALLS, WISCONSIN - FEBRUARY 1-2, 1977

	ADJUSTMENT LEVEL				DRIVE LEVEL			
	NE	NW	SW	SE	NE	NW	SW	SE
NORMAL OPERATION	103	-	-	102.5	-	104/106	102/103	102/103
BACKGROUND	-	-	-	-	-	82	84	-
CRUSHER IDLING	88	-	84/85	85	91/92	88	85/86	85
CRUSHER & SCREEN IDLING	88	-	84/85	85	-	88	85/86	85
ROCK BOX/FEED HOPPER	94/95	-	92	94	-	-	-	-
SCREEN WITH ROCK	-	-	86	90	-	89/90	87	-
CRUSHING	100/101	-	98	99/100	-	100/101	98/99	-

NOTE: NORMAL OPERATION INCLUDES ALL CRUSHER SYSTEMS. BACKGROUND WAS MEASURED WITH ALL CRUSHER SYSTEMS SHUT DOWN. OTHER DATA WERE OBTAINED DURING BATCH RUNS WITH PRIMARY AND TERTIARY CRUSHER SYSTEMS SHUT DOWN.

DATA IN THIS TABLE WERE OBTAINED UNDER BUREAU OF MINES CONTRACT J0377014, 'NOISE CONTROL IN SURFACE NON-COAL PLANTS AND MILLS - SOURCE DIAGNOSIS AND ABATEMENT TECHNIQUES FOR NOISE CONTROL IN TACONITE PLANTS', BOLT, BERANEK AND NEWMAN, INC.

5. COST ESTIMATES

5.1 Secondary Crusher Enclosures

Current estimated costs (1980 Dollars) for one (1) Drive Level Enclosure and one (1) Adjustment Level Enclosure, same as those used for this study, are as follows:

(a) Components and materials by IAC, Inc.	$ 70,000
(b) Freight	2,000
(c) Installation	8,000
Total -	$ 80,000

Jackson County Iron Company relocated certain piping and raceways to facilitate design reliability and installation of their secondary crusher enclosures. Otherwise, the above costs are for a turnkey operation on a crusher system same as that at Black River Falls.

5.2 Tertiary Crusher Enclosures

Current estimated costs for two (2) Drive Level and two (2) Adjustment Level enclosures on crusher systems same as those at Jackson County Iron Company, Black River Falls plant are as follows:

(a) Components and materials by IAC, Inc.	$136,000
(b) Freight	4,000
(c) Installation	16,000
Total -	$156,000

Costs estimated for these enclosures include approximately 4,700 pounds of structural steel work required to support the tertiary crusher enclosures. They also include removable acoustical ceiling panels for the Adjustment Level enclosures and provision for a tighter interface with crusher feed hoppers.

5.3 Treatment of Other Sources

No attempt has been made to estimate cost for treatment of sources other than the above or treatment of the crusher room to introduce acoustical absorption. We believe that operational factors and limitations imposed by existing structures should be explored with the plant operators before attempting any such estimates.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Assessment of Performance

The secondary crusher enclosures provided noise reductions of 10 to 15 dBA. They provide the acoustical performance required to achieve a crusher room level of less than 90 dBA provided that other sources are appropriately treated.

6.2 Effect of Enclosure Absorptive Characteristics

The high degree of interior acoustical absorption (NRC .95) built into the panels used for these enclosures enhances panel noise reduction and minimizes the significance of leakage paths, treatment of which would other increase cost or complicate maintenance.

The enhancement of noise reduction results from interior absorption of sound which would otherwise build up to produce higher interior levels. Therefore, the "side benefit" of absorption in this application is extremely important. It permits operating or maintenance personnel to work inside the enclosure without experiencing seriously increased levels due to operation of the enclosed equipment. In this case, levels measured inside the Adjustment Level Enclosure were actually less than levels at the same location before installation of the enclosure. The interior absorption also provides for a better shelter from tertiary crusher and other exterior noise for personnel working inside the enclosure.

6.3 Recommendation - Enclosure Improvements

The secondary crusher Adjustment Level enclosure includes a (non-absorptive) steel plate ceiling with several square feet of clearance around the feed hopper. With the other sources present, outside of the enclosures, it is by no means clear that a more closely fitted acoustical ceiling would be a cost-effective means of further reducing crusher room noise levels. We recommend that the possibility be investigated and have included the cost of such enclosure improvements in the tertiary crusher enclosure cost estimates. Basic panel construction used in the enclosures is capable of providing over 30 dBA of noise reduction with all such flanking paths eliminated.

6.4 Recommendations - Other Sources

Rank order of importance of sources, which were not enclosed or otherwise acoustically treated for this study, is as follows:

(a) Tertiary Crusher
(b) Sizing Screens
(c) Crusher Feed System - Rockbox/Feed Hopper
(d) Noise from the adjacent concentrating operation

Applicable types of treatment for the above would be as follows:

(a) Tertiary Crushers - Enclosures similar to those on the Secondary Crusher.

(b) Sizing Screens - The middle frequency noise involved can probably be treated by use of damped steel materials in construction of screens and their housings.

We understand that there has been some investigation of this approach but no suitable design was devised which could be built and maintained within reasonable cost limitations. A more cost-effective approach might be to retain the operationally proven screen designs and to employ more effective (acoustical panel) housings.

(c) Crusher Feed System - Acoustical panel enclosures or panels could be devised. However, the damped steel approach, which has been used in ore transport applications, might be a more practical possibility here than is the case with the sizing screen application.

(d) Noise from Adjacent Concentrating Operations - This source produces levels up to 87.5 dBA in the crusher room. While below 90 dBA, treatment of this source could reduce the extent (and cost) of treating other sources to achieve a crusher room level (from all sources) below 90 dBA. No inspection or other evaluation of existing isolation (walls and penetrations between concentrating and crusher rooms) was made in this study. Improvement might or might not be cost-effective, depending upon -

1. present construction details
2. operational requirements
3. alternative treatment within the crusher room
4. any programs which might be under consideration for reduction of concentrating room noise

An alternative treatment within the crusher room, after treatment of crushing system noise sources, would be use of absorptive panels located near the most significant sources remaining or on the walls. This approach could be combined with insulation of exterior walls to conserve thermal energy.

No mention has been made of the primary crusher which is located in a partial shelter attached to the north wall of the crusher room. No evaluation of this source was made with windows open or closed in the common wall. Treatment, if required, should be fairly simple, concentrating on improving noise reduction of the common wall.

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